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Relationship between the diet and psychiatric diseases such as depression, anxiety and attention-deficit hyperactivity disorder (ADHD)

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ABSTRACT

Introduction: Some people try to treat psychiatric diseases such as attention-deficit hyperactivity disorder (ADHD), depression and anxiety by practising some diets. But do they even work and have any scientific confirmation?

The aim of the study: The aim of this study is to find out the relationship and influence of the diet on psychiatric diseases such as ADHD, depression and anxiety.

Material and method: The research of the scientific articles was made on a database of PubMed and Google Scholar.

Description of the state of knowledge: The results indicate that the lack of some nutrients such as vitamins B1, B2, B3, B6, B12, C, A, D, E, folic acid, zinc, iodine, selenium, iron, calcium, potassium, phosphorus, magnesium and chrome may increase the risk of having depression symptoms. Unhealthy diet full of trans fats, red meat and lacking of fruit and vegetables may also lead to depression. Similar results were found due to the anxiety level and the diet. When it comes to ADHD, children with this disease had lower level of vitamins B₁₂, B₆, D and folic acids. Among the newly diagnosed celiac disease people, the majority showed ADHD symptoms. After the introduction of the gluten-free diet, the symptoms of the disease subsided.

Summary: The results show the huge influence of the diet on the diseases such as depression, anxiety and ADHD.

Key words: attention-deficit hyperactivity disorder, depression, anxiety, diet;

1. INTRODUCTION

The number of people receiving the help of psychiatrists has been increasing dramatically in recent times. In 2011-2014 in Poland, the number of people with mental problems increased by 150,000, to 1.2 million patients. In environmental care there was an increase from 9.6 thousand up to 29.8 thousand psychiatric patients [1]. The result of these changes is the search for more unconventional methods of treating patients than pharmacotherapy. New factors are being sought to improve patients, and one of them is diet. The number of publications on the impact of nutrition on the treatment of patients with mental disorders is growing rapidly. Researchers deal with depression, anxiety disorders and attention deficit hyperactivity disorder (ADHD).

The broadly understood development of civilization, high speed of life, pursuit of money, satisfying one's own ambitions, and thus the lack of time often leads to a change in eating habits. Fast food, high-calorie and highly processed foods are factors that have a negative impact on mental health and are risk factors for civilization diseases, including depression and anxiety disorders that are becoming global epidemics [2]. We consume more and more high-energy and highly processed products that do not provide basic nutritional values, which leads to overweight and obesity. They are undoubtedly a global social problem. Despite the increase in daily caloric intake, the lack of food ingredients that have a beneficial effect on the work of our nervous system - B vitamins, zinc or magnesium. The consumption of vegetables, fruits, valuable fiber and cereal products is also falling [3]. Alcohol abuse and smoking also contribute significantly to our mental health, and combining them with an incorrect diet is a serious risk factor for mental illness.

Our brain consumes a significant portion of the energy provided with food. Essential amino acids, fats, vitamins, minerals and trace elements are necessary for its optimal work. There are many documented studies on the positive effects of diet on the treatment of depression [7]. There is a mood disorder manifested by persistent sadness and a lack of interest. It affects hundreds of millions of people around the world. It can appear at any age, and lack of treatment can result in suicidal tendencies. The patient suffers seriously, his life is disrupted, he has no energy to function. Depression is also manifested by emptiness, irritable mood and anhedonia (complaining about the patient's inability to feel pleasure and joy). Patients have low self-esteem, sleep problems, gastrointestinal disorders and often guilt. Depression is a complex phenomenon with a multifactorial etiology, it can take from mild to severe, often correlating with other mental disorders. Nearly 60% of patients do not seek medical help because of misconceptions or lack of awareness about this disease entity. It is a common opinion in society that mental health disorders are unacceptable and may hinder professional and personal life. Antidepressants have good efficacy, but the response to treatment is individually dependent. It is often difficult to choose the right treatment regimen for the patient. Therefore, other ways are being sought to improve mental health and reduce depression [4] [5].

Recently, there have also been publications dealing with the topic of the impact of nutrition on the occurrence of attention deficit hyperactivity disorder (ADHD). It is a mental disorder that occurs in early childhood. Its prevalence rate is 4-5% (children aged 4-17). It is characterized by hyperactivity, lack of attention and impulsiveness. The diagnosis of ADHD is usually made at school age, but its symptoms already appear in early childhood. The disorder is classically characterized by signs of inattention, impulsiveness and hyperactivity. The disease is common and persistent and is one of the most common diagnoses in children's educational institutions. People suffering from this disease have problems with education, functioning in society, other mental illnesses at the teenage age and as young adults. The disorder is particularly important in today's society because it is one of the most common diagnoses in educational and psychological institutions of children [6].

The last of these disorders are unnoticed and under-treated anxiety disorders. They often start as early as childhood or adolescence. This applies particularly to specific and social phobias [8]. According to research, up to 33.7% of the population suffers from lifetime anxiety disorder. There is no evidence of a significant spread of anxiety disorder in recent years. Anxiety disorders often coexist with other anxiety disorders and mental disorders. The most common of them are: panic disorder with or without agoraphobia, generalized anxiety disorder, social anxiety disorder, specific phobias and isolated anxiety disorder [9]. Pathologically increased anxiety can arise in many disease entities, not just in anxiety disorders. Anxiety is a basic and essential emotion that ensures human survival. It can be a warning signal about somatic disease, thanks to which a person knows about the pathological process taking place in his body.

Anxiety disorders are chronic; however, there is a natural decline in prevalence rates with older age [8].

2. MATERIALS, METHODS AND AIM

The research of the articles was done to find out the relationship between the diet and psychiatric diseases such as ADHD, depression and anxiety. The review of the publication included the latest research from 2019. The PubMed and Google Scholar were used in the research.

3. THE INFLUENCE OF DIET ON A DEPRESSION

Looking for results, you can see how much interest in studying is the impact of diet on depression. Research is carried out in different countries of the world, in different age groups of the respondents, or in people consuming different diets.

The quality of the diet and its effect on depression has been studied by Japanese scientists. Ryo Okubo et al. in their study, they found that the high quality of the Japanese diet has no statistically significant effect on reducing the likelihood of developing depression. The quality of food consumed was assessed using an 80 point scale according to which obtaining the maximum number of points meant the highest quality. The test points they obtained for the right amount of consumed products, which were assigned to 8 different categories, among others: grain dishes, vegetable dishes, fish and meat dishes, milk, fruits, total energy, snacks and alcoholic beverages, and ratio of white to red meat . Despite the fact that they didn't find statistic correlation for the main topic of their work, they claimed that the highest ratio of white to red meat can reduce the probability of suffering from depression. The reduction in the likelihood of developing depression was as much as 40% between the group of subjects eating equal amounts of white and red meat compared to the group whose amount of white meat in relation to red was 4: 1. It is worth noting, however, that 90% of white meat consumed by the subjects concerned meat obtained from fish [10]. Staying for a moment with the Japanese diet, you should not forget about the seaweed consumed by the Japanese. It turns out that consuming them significantly reduces the odds ratios for depressive symptoms [11].

Wanting to further analyze the impact of fish on the reduced likelihood of developing depression, the key was to find studies that checked the effect of micro and macroelements on depression incidence. In one of them, Sánchez-Villegas A. et al. checked the deficiencies of micronutrients intake such as vitamins B1, B2, B3, B6, B12, C, A, D, E, folic acid, zinc, iodine, selenium, iron, calcium, potassium, phosphorus, magnesium and chrome. In patients with a ≥ 4 micronutrients deficiency, they indicated a statistically significant increase in the risk of developing depression [12]. Another similar study on reproductive age women showed that there is a significant correlation between the increase in vitamin D levels in women and the decrease in the incidence of depression. However, no statistically significant correlation was found between calcium and magnesium levels and depression. It is also interesting that the level of vitamin D in the examined women was in 57% of them severely low and in 25% of them moderately low [13].

Newer studies also show that changing the diet to a healthier one within 3 weeks of its duration has reduced depression. In this study, people with depressive symptoms were selected following a routine, not very varied diet. A three week meal plan was introduced for one of the groups that included healthy foods. Comparison of the two groups with the CESD-R and DASS-21-Depression scale indicated a statistically significantly reduced depression after a 3-week healthy diet of the subjects to the control group [14].

Other study that considered the breakdown of a diet as healthy with the consumption of fruit, vegetables and fish compared to an unhealthy diet rich in red and processed meat, potatoes, hot chips, cakes, deserts and ice cream, showed that only the dependence of a healthy diet was statistically significant. causing a decrease in the level of depression in older adult women of Australian origin, where there is no statistically significant correlation between diet and the level of depression in adult men from Australia [5].

The latest surveys also showed that the majority of observed stress, anxiety, depression or insomnia occur in students who in 82.3% consume a bad diet. And a bad diet was significantly linked to stress, anxiety and depression, but not to insomnia [16].

Last year, several studies were conducted on the effects of a diet high in various fats on depression. First of all, a positive correlation was found between dietary trans fat intake and depression symptoms in premenopausal women 42-52 years old in a cross-sectional study [17]. Other researchers, in turn, concluded that long-chain omega-3 has virtually no effect on depression or anxiety disorders [18]. A recent study looked at the effects of high-sugar high-saturated-fat (HSHF) and high-sugar (HS) diets on depression in 5 years. People who used HSHF diets showed more signs of depression. However, there was no effect of either HSHF or HS diet on recurrent episodes of depressive symptoms in patients. Similarly, none of the diets - HSHF or HS had any effect on the appearance of incidence of depressive symptoms [18]. It is also interesting that the first studies on lipids noticed a negative correlation between cholesterol levels and depression, suicide and behavioral disorders. And some studies have found that these patients have reduced levels of ω -3 polyunsaturated fatty acids in erythrocytes [19].

The impact of a diet high in fat on depression was also presented in an animal model, where the occurrence of depression symptoms in the offspring of mice fed a high-fat diet was confirmed [20]. Similar conclusions were made in experiments where depression in offspring appeared on the maternal model of obesity induced by high fat diet [21]. Interestingly, one of the newer studies found that adult mice consuming a high fat diet had a lower percentage of rate dependent depression than the group of adult mice consuming the control diet [22].

4. THE INFLUENCE OF DIET ON AN ANXIETY

Just like about depression, a number of studies were conducted in 2019 on the impact of diet on the occurrence of anxiety symptoms.

In the first study, in anxiety assessment a standardized Korean BAI scale created by Kwon et al was used, which was to focus on both somatic and cognitive symptoms. It was found that the quality of the diet has a positive effect on smaller symptoms of depression, higher quality of life and on physical, psychological and social relationships. However, no effect of diet quality on anxiety was reported [23].

Studies in mice showed the effect of diet and body weight on anxiety. It was found that a diet high in fat induced anxiety behavior. Moreover, the use of metformin in another diet of mice confirmed the reduction of the negative effect on anxiety. However, this was not statistically significant. The level of anxiety in mice was determined using two tests - OPT (Open field test) and EMP (Elevated plus maze test). In addition, researchers found that the anxiety-reducing effect of metformin may be dependent on the effect of metformin on AMPK pathway. Metformin would then activate the AMPK pathway in the brain by acting anti-anxiety way [24].

Staying on a high fat diet, Winther et al. found that rats consuming just such a diet during pregnancy and breeding their offspring may pass on anxiety behavior in subsequent generations - with an emphasis on the F₂ male population. It was found that it could be associated with corticotropin-releasing hormone receptor 2 mRNA, which significantly increased Hippocampal Crh-r2 mRNA levels in these individuals [25].

Another experiment conducted in rats was to check the effect of several unhealthy diets on the induction of anxiety. A positive correlation was found between high-lard and high-sucrose diet and induction of anxiety behavior as opposed to high-olive oil diet. What is more, there was no correlation between body weight and hormones such as insulin or leptin, and anxiety behaviors [26].

The latest diet study in the Mediterranean area has examined the effects of many factors, including the Greek diet, on the symptoms of anxiety disorders. The impact of consuming large amounts of energy on anxiety symptoms was highlighted. In addition, the effect of female sex, family status and depression as predisposing factors for the manifestation of anxiety disorder were confirmed. Again, the scientists came to the same conclusion that a diet high in saturated fat along with a large amount of sugars has a positive correlation with anxiety symptoms [27].

The impact of micro and macroelements was also investigated by several research teams last year. One of them managed to study the effects of a diet rich in and low in sodium among patients with diabetes and chronic kidney disease. A low sodium diet resulted in fewer symptoms of depression and anxiety disorders than a high sodium diet. What's more, patients who consumed little sodium were also characterized by lower calorie intake, and vitamins B1, B2, B3, B6, and B9. However, they did not differ in the amounts of vitamins C, D, E and K. It is worth noting that both rich and low-sodium diets contained the same amount of fats, vegetables, eggs, dairy products (proteins) and sugars [28].

The effects of vitamins have also been studied by Kafeshani M et al. In over 3,000 adults, they found that only women have high vitamin B6 levels that significantly reduce the likelihood of not only depression but also anxiety disorders [29]. A positive effect on the mood was confirmed by 11 of 18 articles on B vitamins and the placebo effect [30]. Vitamin D and paricalcitol are similarly important in the antidepressant and anxiety effect in a WAG / Rj rats study [31]. What is more Matsuo et al stated that reducing anxiety behavior in rats it is not affected by a diet rich in vitamin E [32].

An interesting study was made by Salehi-Abargouei A. et al. where three types of diets were studied among almost 4,000 Iranians. The first type of diet included a large amount of amino acids, cobalamin, zinc, phosphorus, saturated fatty acids, cholesterol and pantothenic acid. The other included thiamin, folate, selenium, iron, starch, maltose, betaine, calcium, riboflavin, and niacin and was a contrast to a diet rich in mono-unsaturated fats, vitamin E and polyunsaturated fats. The third in turn, rich in fruits and vegetables, included large amounts of copper, vitamin C, glucose, fructose, potassium, dietary fiber, sucrose, vitamin A, magnesium and vitamin K. It turned out that the first diet had a positive effect on reducing mental disorders including anxiety disorders [33].

Consumption of high amounts of zinc, copper and manganese proved to be statistically significant in reducing the risk of depression and anxiety disorders. Moreover, no such correlations have been found between the symptoms of depression and anxiety disorders and the consumption of larger amounts of magnesium, calcium and iron [34].

Consumption of unrefined grains and vegetables reduces the severity of symptoms of depression and anxiety. In turn, lack of alcohol consumption can aggravate these symptoms. The severity of fear symptoms can be reduced by eating fruit and vegetables [35].

5. THE INFLUENCE OF DIET ON AN ATTENTION-DEFICIT HYPERACTIVITY DISORDER

Just as with anxiety disorders and depression, with ADHD, scientists also studied the impact of diet on its development or worsening of symptoms.

One of the latest publications from this year is one that examines the effects of a few food diet (FFD), which eliminates many diet and addictive ingredients on ADHD in right-handed boys aged 8-10. Patients who were born before 36 weeks of pregnancy, were on a vegetarian / vegan diet, used any antiviral, antifungal or antibiotic drugs in the last 6 months and boys with other disorders and diseases such as autoimmune diseases or dyslexia were rejected from this study. The boys underwent a 5-week FFD diet. For now, the experiment has just begun, and statistical analysis will be carried out when sufficient statistical data and results of the FFD diet on ADHD in boys are obtained [36]. However, the impact of FFD on ADHD and related research appeared even in 2007 in the Benton meta-analysis [37].

A case-control study by Taiwanese researchers compared 216 children with ADHD with a control group. The sick and healthy were grouped by age, sex, height, weight and BMI. The results showed the difference in micro- and macroelements between the two groups. Children with ADHD had significantly lower levels of vitamin B12, folic acid and vitamin B6. As for minerals, reduced values relative to the control group were observed with ferritin, and higher with inorganic phosphorous (Pi). Recent - fats have shown that children with ADHD had lower levels of monounsaturated fatty acids, and higher saturated and polyunsaturated fatty acids [38].

When it comes to the diet of Taiwanese children with ADHD and control group, the first group had significantly lower consumption of vegetables, fruits, meat, milk (regular and soy), fish and eggs, while consuming more than the control group of poorly nutritious eating such like fried food, ice cream, candies, chocolates, sweetened drinks, and instant soups. Also the preferences of children suffering from ADHD pointed to unhealthy food [38]. Of course, the diets used by these children in a dependent way influenced the results of the levels of vitamins, minerals and fats that they tested. Thanks to these results, a significant and negatively correlated relationship was determined between: monounsaturated fatty acids / saturated fatty acids ratio, B vitamins and minerals, and the diagnosis of ADHD [38].

Another study compared daily intake of omega-3 long-chain polyunsaturated fatty acids (LC-PUFA). LC-PUFA is used in the therapy of children with ADHD, and naturally occurs in larger amounts in seafood (especially fish) and in some nut varieties. Fuentes-Albero et al. found that the overall level of daily LC-PUFA consumption was lower than recommended in both groups - ADHD patients and control group, however, it was statistically significantly lower in children with ADHD. This difference was due to the amount of fish consumed, as there were no statistical differences in eating nuts by both groups. Moreover, significantly higher BMI was observed in children with ADHD [39].

50 Iranian children with ADHD were compared to a healthy control group containing the same number of healthy children. The study checked if their vitamin D levels were different. There was no significant difference between the groups when it comes to sex, age, weight, BMI, daily dairy intake, or

sun exposure. However, a statistically significant difference was found in the levels of vitamin D and parathyroid hormone between the two groups. Children with ADHD had lower levels of this vitamin and in turn higher levels of this hormone. Sufficient vitamin D levels were dominant in the control group, and most vitamin D deficiencies were found in children with ADHD [40].

Also interesting seems to be a study that compared celiac patients. Among 31 newly diagnosed, as many as 26 patients significantly worse assume themselves in the Adult ADHD Self-Report Scale v1.1 Symptoms Checklist (ASRS) survey than the healthy control group. After using a gluten-free diet, their survey results improved significantly, and there was no statistically significant difference between them and between the control group [41].

Similarly to other nutritional components, sugar consumption in 6-year-old children with ADHD compared to the control group was checked. This showed that a higher level of sucrose consumed was associated with increased symptoms of ADHD in patients. Similarly observed in 11-year-old boys. However, no association was found between the amount of sucrose consumed in girls and their disease symptoms [42].

Another 2019 study also looked at the relationship between sugar intake and ADHD. More than a thousand children meeting two basic criteria were selected: those suffering from ADHD and with the completed KiGGS survey (German Health Interview and Examination Survey for Children and Adolescents) in which the responses included the consumption of candies and fruit chewing gums and the frequency of their eating. An identical control group, not suffering from ADHD, was also selected, which also answered the KiGGS questions and primarily matched the sex and age groups. And although the hyperactivity score was compared to the amount and frequency of consuming candies and fruit gums, linear regression line correlate just with frequency, and not with amount. Of course, the authors themselves suggest a further impact of hyperactivity on the development of ADHD symptoms [43].

6. SUMMARY

There have been many studies in the last few years that have looked for relationships between diet and various disorders.

According to recent studies, a positive white-to-red meat ratio should be remembered in the diet, which reduces the risk of developing depression [10]. The articles also included those that raised the subject of a high-fat diet and the value of omega-3 fatty acids. On this subject, a number of experiments using mice and rats were carried out. High-fat diet during pregnancy meant that offspring more often showed pro-anxiety behavior - especially the male population [25]. The rat also found a positive correlation between high-lard and high-sucrose diet and induction of anxiety behavior as opposed to high-olive oil diet [26]. Studies on rodents are not separate only for this species, because studies of the Greek diet partly confirm the above experiments. It was found in them that a diet high in saturated fat with a large amount of sugars had a positive correlation with anxiety symptoms, however, it was also influenced by female gender and family status [27].

Female sex turns out not to be more sensitive to deficiencies of various minerals and vitamins. They increase the risk of depression and anxiety. Therefore, it is necessary to ensure that the diet is rich in micro- and macroelements as well as vitamins. It was found that high levels of B vitamins in women have a significant impact on reducing the likelihood of developing depression [12] [13].

Vitamin D plays a special role among them, the deficiency of which not only increases the risk of the above mental states but also is more often found in children with ADHD compared to the control group [40]. Such children have a predisposition to an unhealthy diet full of fried food, sweets, sweetened drinks, and instant soups, which can be associated with these children's results such as lower levels of vitamin B12, folic acid and vitamin B, monounsaturated fatty acids, and higher saturated and polyunsaturated fatty acids [38].

All these articles indicate the importance of a varied diet in the proper functioning of the mind. It should also be emphasized that a well-chosen diet can reduce depression, anxiety and ADHD symptoms.

References

- [1] Narodowy Program Ochrony Zdrowia Psychicznego na lata 2017– 2022. Rozporządzenie Rady Ministrów z dnia 8 lutego 2017 roku.
- [2] Hidaka BH. Depression as a disease of modernity: explanations for increasing prevalence. *J Affect Disord.* 2012 Nov;140(3):205-14.
- [3] Baxter AJ, Patton G, Scott KM, Degenhardt L, Whiteford HA. Global epidemiology of mental disorders: what are we missing? *PLoS One.* 2013 Jun 24;8(6):e65514. doi: 10.1371/journal.pone.0065514.
- [4] Bondy Brigitta. Pathophysiology of depression and mechanisms of treatment. *Dialogues Clin Neurosci.* 2002 Mar;4(1):7-20.
- [5] Suma P. Chand; Hasan Arif. Depression. StatPearls Publishing; 2020 Jan-
- [6] Marguerite Matthews, Joel T. Nigg, and Damien A. Fair Attention Deficit Hyperactivity Disorder *Curr Top Behav Neurosci.* 2014; 16: 235–266.
- [7] Berk M, Williams LJ, Jacka FN, O'Neil A, Pasco JA, Moylan S, Allen NB, Stuart AL, Hayley AC, Byrne ML, Maes M. So depression is an inflammatory disease, but where does the inflammation come from? *BMC Med.* 2013; 11: 200, doi: 10.1186/1741-7015-11-200.
- [8] Ströhle A¹, Gensichen J, Domschke K. The Diagnosis and Treatment of Anxiety Disorders. *Dtsch Arztebl Int.* 2018 Sep 14;155(37):611-620.
- [9] Bandelow B, Michaelis S. Epidemiology of anxiety disorders in the 21st century. *Dialogues Clin Neurosci.* 2015 Sep;17(3):327-35.
- [10] Ryo Okubo, Yutaka J. Matsuoka, Norie Sawada, Masaru Mimura, Kayo Kurotani, Shoko Nozaki, Ryo Shikimoto, and Shoichiro Tsugane, Diet quality and depression risk in a Japanese population: the Japan Public Health Center (JPHC)-based Prospective Study. *Sci Rep.* 2019; 9: 7150.
- [11] Guo F, Huang C, Cui Y, Momma H, Niu K, Nagatomi R. Dietary seaweed intake and depressive symptoms in Japanese adults: a prospective cohort study. *Nutr J.* 2019;18(1):58. Published 2019 Oct 7. doi:10.1186/s12937-019-0486-7
- [12] Sánchez-Villegas A, Pérez-Cornago A, Zazpe I, Santiago S, Lahortiga F, Martínez-González MA. Micronutrient intake adequacy and depression risk in the SUN cohort study. *Eur J Nutr.* 2018 Oct;57(7):2409-2419. doi: 10.1007/s00394-017-1514-z.
- [13] Hamideh Mohaddesi, Marzieh Saei Ghare Naz, Maryam Najarzadeh, Mitra Yeganehpour, Hamidreza Khalkhali, Correlation between Depression with Serum Levels of Vitamin D, Calcium and Magnesium in Women of Reproductive Age. *J Caring Sci.* 2019 Jun; 8(2): 117–119.

- [14] Francis HM, Stevenson RJ, Chambers JR, Gupta D, Newey B, Lim CK. A brief diet intervention can reduce symptoms of depression in young adults – A randomised controlled trial. *PLoS One*. 2019 Oct 9;14(10):e0222768.
- [15] Hart MJ, Milte CM, Torres SJ, Thorpe MG, McNaughton SA. Dietary patterns are associated with depressive symptoms in older Australian women but not men. *Br J Nutr*. 2019 Sep 25:1-20. doi: 10.1017/S0007114519002435.
- [16] Ramón-Arbués E, Martínez Abadía B, Granada López JM, Echániz Serrano E, Pellicer García B, Juárez Vela R, Guerrero Portillo S, Saéz Guinoa M. [Eating behavior and relationships with stress, anxiety, depression and insomnia in university students.] *Nutr Hosp*. 2019 Oct 28. doi: 10.20960/nh.02641.
- [17] Li D, Tong Y, Li Y. Associations of dietary trans fatty acid intake with depressive symptoms in midlife women. *J Affect Disord*. 2020 Jan 1;260:194-199. doi: 10.1016/j.jad.2019.09.008.
- [18] Vermeulen E, Knüppel A, Shipley MJ, Brouwer IA, Visser M, Akbaraly T, Brunner EJ, Nicolaou M. High-Sugar, High-Saturated-Fat Dietary Patterns Are Not Associated with Depressive Symptoms in Middle-Aged Adults in a Prospective Study. *J Nutr*. 2018 Oct 1;148(10):1598-1604. doi: 10.1093/jn/nxy154.
- [19] Theodoropoulou S, Gialouris AG. [Lipids and mental disorders: Evidence, uncertainties and perspectives]. *Psychiatriki*. 2019 Apr-Jun;30(2):129-141. doi: 10.22365/jpsych.2019.302.129.
- [20] Gawlinska K, Gawlinski D, Przegalinski E, Filip M. Maternal high-fat diet during pregnancy and lactation provokes depressive-like behavior and influences the irisin/brain-derived neurotrophic factor axis and inflammatory factors in male and female offspring in rats. *J Physiol Pharmacol*. 2019 Jun;70(3). doi: 10.26402/jpp.2019.3.07.
- [21] D'Asti E, Long H, Tremblay-Mercier J, Grajzer M, Cunnane SC, Di Marzo V, Walker CD. Maternal dietary fat determines metabolic profile and the magnitude of endocannabinoid inhibition of the stress response in neonatal rat offspring. *Endocrinology*. 2010 Apr;151(4):1685-94. doi: 10.1210/en.2009-1092.
- [22] Nguyen GL, Putnam S, Haile M, Raza Z, Bremer M, Wilkinson KA. Diet-induced obesity decreases rate-dependent depression in the Hoffmann's reflex in adult mice. *Physiol Rep*. 2019 Oct;7(20):e14271. doi: 10.14814/phy2.14271.
- [23] Lee JE, Kim YJ, Park HJ, Park S, Kim H, Kwon O. Association of recommended food score with depression, anxiety, and quality of life in Korean adults: the 2014-2015 National Fitness Award Project. *BMC Public Health*. 2019 Jul 17;19(1):956. doi: 10.1186/s12889-019-7298-8.
- [24] Ji S, Wang L, Li L. Effect of Metformin on Short-Term High-Fat Diet-Induced Weight Gain and Anxiety-Like Behavior and the Gut Microbiota. *Front Endocrinol (Lausanne)*. 2019 Oct 18;10:704. doi: 10.3389
- [25] Winther G, Eskelund A, Bay-Richter C, Elfving B, Müller HK, Lund S, Wegener G. Grandmaternal high-fat diet primed anxiety-like behaviour in the second-generation female offspring. *Behav Brain Res*. 2019 Feb 1;359:47-55. doi: 10.1016/j.bbr.2018.10.017
- [26] Nakajima S, Fukasawa K, Gotoh M, Murakami-Murofushi K, Kunugi H. Saturated fatty acid is a principal cause of anxiety-like behavior in diet-induced obese rats in relation to serum lysophosphatidyl choline level. *Int J Obes (Lond)*. 2019 Oct 21. doi: 10.1038/s41366-019-0468-z.

- [27] Masana MF, Tyrovolas S, Kolia N, Chrysohoou C, Skoumas J, Haro JM, Tousoulis D, Papageorgiou C, Pitsavos C, Panagiotakos DB. Dietary Patterns and Their Association with Anxiety Symptoms among Older Adults: The ATTICA Study. *Nutrients*. 2019 May 31;11(6). pii: E1250. doi: 10.3390/nu11061250.
- [28] Leong J, Yang G, Lembrikova K, Moy M, Leventer S, Fazli J, Wilson C, Markell M. Sodium Intake in Inner-City Patients with Diabetes and Chronic Kidney Disease (CKD): Relationship to Age, Depression/Anxiety, and Diet Quality. *Current Developments in Nutrition*, Volume 3, Issue Supplement_1, June 2019, nzz051.P04-112-19, <https://doi.org/10.1093/cdn/nzz051.P04-112-19>
- [29] Kafeshani M, Feizi A, Esmailzadeh A, Keshteli AH, Afshar H, Roohafza H, Adibi P. Higher Vitamin B₆ Intake is Associated with Lower Depression and Anxiety Risk in Women but not in Men: A large Cross-Sectional Study. *Int J Vitam Nutr Res*. 2019 Jun 11:1-9. doi: 10.1024/0300-9831/a000589.
- [30] Young LM, Pipingas A, White DJ, Gauci S, Scholey A. A Systematic Review and Meta-Analysis of B Vitamin Supplementation on Depressive Symptoms, Anxiety, and Stress: Effects on Healthy and 'At-Risk' Individuals. *Nutrients*. 2019 Sep 16;11(9). pii: E2232. doi: 10.3390/nu11092232.
- [31] Aygun H, Ayyildiz M, Agar E. Effects of vitamin D and paricalcitol on epileptogenesis and behavioral properties of WAG/Rij rats with absence epilepsy. *Epilepsy Res*. 2019 Nov;157:106208. doi: 10.1016/j.eplepsyres.2019.106208.
- [32] Matsuo K, Watanabe T, Takenaka A. Effect of dietary vitamin E on oxidative stress-related gene-mediated differences in anxiety-like behavior in inbred strains of mice. *Physiol Behav*. 2019 Aug 1;207:64-72. doi: 10.1016/j.physbeh.2019.04.026.
- [33] Salehi-Abargouei A, Esmailzadeh A, Azadbakht L, Keshteli AH, Afshar H, Feizi A, Feinle-Bisset C, Adibi P. Do patterns of nutrient intake predict self-reported anxiety, depression and psychological distress in adults? SEPAHAN study. *Clin Nutr*. 2019 Apr;38(2):940-947. doi: 10.1016/j.clnu.2018.02.002.
- [34] Nakamura M, Miura A, Nagahata T, Shibata Y, Okada E, Ojima T. Low Zinc, Copper, and Manganese Intake is Associated with Depression and Anxiety Symptoms in the Japanese Working Population: Findings from the Eating Habit and Well-Being Study. *Nutrients*. 2019 Apr 15;11(4). pii: E847. doi: 10.3390/nu11040847.
- [35] Gibson-Smith D, Bot M, Brouwer IA, Visser M, Giltay EJ, Penninx BWJH. Association of food groups with depression and anxiety disorders. *Eur J Nutr*. 2019 Apr 3. doi: 10.1007/s00394-019-01943-4.
- [36] Stobernack T, de Vries SPW, Rodrigues Pereira R, Pelsser LM, Ter Braak CJF, Aarts E, van Baarlen P, Kleerebezem M, Frankena K, Hontelez S. Biomarker Research in ADHD: the Impact of Nutrition (BRAIN) - study protocol of an open-label trial to investigate the mechanisms underlying the effects of a few-foods diet on ADHD symptoms in children. *BMJ Open*. 2019 Nov 5;9(11):e029422. doi: 10.1136/bmjopen-2019-029422.
- [37] Benton D. The impact of diet on anti-social, violent and criminal behaviour. *Neurosci Biobehav Rev*. 2007;31(5):752-74. Epub 2007 Mar 4.
- [38] Wang LJ, Yu YH, Fu ML, Yeh WT, Hsu JL, Yang YH, Yang HT, Huang SY, Wei IL, Chen WJ, Chiang BL, Pan WH. Dietary Profiles, Nutritional Biochemistry Status, and Attention-Deficit/Hyperactivity Disorder: Path Analysis for a Case-Control Study. *J Clin Med*. 2019 May 18;8(5). pii: E709. doi: 10.3390/jcm8050709.

- [39] Fuentes-Albero M, Martínez-Martínez MI, Cauli O. Omega-3 Long-Chain Polyunsaturated Fatty Acids Intake in Children with Attention Deficit and Hyperactivity Disorder. *Brain Sci.* 2019 May 23;9(5). pii: E120. doi: 10.3390/brainsci9050120.
- [40] Fasihpour B, Moayeri H¹, Shariat M, Keihanidoust Z, Effatpanah M, Khedmat L. Vitamin D deficiency in school-age Iranian children with attention-deficit/hyperactivity disorder (ADHD) symptoms: A critical comparison with healthy controls. *Child Neuropsychol.* 2019 Sep 13:1-15. doi: 10.1080/09297049.2019.1665638.
- [41] Kristensen VA, Valeur J, Brackmann S, Jahnsen J, Brunborg C, Tveito K. Attention deficit and hyperactivity disorder symptoms respond to gluten-free diet in patients with coeliac disease. *Scand J Gastroenterol.* 2019 May;54(5):571-576. doi: 10.1080/00365521.2019.1608467.
- [42] Del-Ponte B, Anselmi L, Assunção MCF, Tovo-Rodrigues L, Munhoz TN, Matijasevich A, Rohde LA, Santos IS. Sugar consumption and attention-deficit/hyperactivity disorder (ADHD): A birth cohort study. *J Affect Disord.* 2019 Jan 15;243:290-296. doi: 10.1016/j.jad.2018.09.051.
- [43] Wolff N, Reimelt C, Ehrlich S, Hölling H, Mogwitz S, Roessner V. On the positive association between candy and fruit gum consumption and hyperactivity in children and adolescents with ADHD. *Z Kinder Jugendpsychiatr Psychother.* 2019 May;47(3):228-238. doi: 10.1024/1422-4917/a000609.