The interference of the intestinal microbiota on feeding behavior: A literature review

A interferência da microbiota intestinal sobre o comportamento alimentar: Uma revisão de literatura

La interferencia de la microbiota intestinal en la conducta alimentaria: una revisión de la literatura

RESUMO

Objetivo: Investigar a interação microbiota intestinal e comportamento alimentarem indivíduos obesos. Métodos: Trata-se de uma revisão da literatura através da análise de artigos científicos publicados nos últimos 10 anos (2012/2022), nas seguintes bases de dados: Scielo, PubMed, Google acadêmico e revistas acadêmicas. A pesquisa foi realizada nos idiomas português, inglês e espanhol, obedecendo a ordem: formulação do problema; busca na literatura em bases de dados; avaliação e análise dos dados. Esta seguiu a seguinte ordem: título, resumo e o artigo na íntegra; sendo incluídos os que condiziam com o tema pesquisado. Resultados: Após a busca na literatura seguindo o método estabelecido, foram selecionados 21 artigos, com indivíduos com obesidade e doenças metabólicas relacionadas, onde associaram a modulação intestinal através da utilização de simbióticos, probióticos e prebióticos no tratamento da obesidade. Conclusão:A modulação da microbiota intestinal é eficaz no tratamento da obesidade, e doenças associadas, melhorando episódios de compulsão alimentar.

DESCRITORES: Microbiota intestinal; comportamento alimentar; obesidade; sistema nervoso central.

ABSTRACT

Objective: To investigate the intestinal microbiota interaction and eating behavior in obese individuals. Methods: This is a literature review through the analysis of scientific articles published in the last 10 years (2012/2022), in the following databases: Scielo, PubMed, academic Google and academic journals. The survey was carried out in Portuguese, English and Spanish, following the order: formulation of the problem; literature search in databases; data evaluation and analysis. This followed the following order: title, abstract and full article; including those that matched the topic researched. Results: After searching the literature following the established method, 21 articles were selected, with individuals with obesity and related metabolic diseases, where they associated intestinal modulation through the use of symbiotics, probiotics and prebiotics in the treatment of obesity. Conclusion: The modulation of the intestinal microbiota is effective in the treatment of obesity and associated diseases, improving episodes of binge eating

DESCRIPTORS: Intestinal microbiota; eating behavior; obesity; central nervous system

RESUMEN

Objetivo: Investigar la interacción de la microbiota intestinal y la conducta alimentaria de individuos obesos. Métodos: Se trata de una revisión bibliográfica a través del análisis de artículos científicos publicados en los últimos 10 años (2012/2022), en las siguientes bases de datos: Scielo, PubMed, Google academic y revistas académicas. La encuesta fue realizada en portugués, inglés y español, siguiendo el orden: formulación del problema; búsqueda bibliográfica en bases de datos; evaluación y análisis de datos. Este siguió el siguiente orden: título, resumen y artículo completo; incluyendo aquellos que coincidían con el tema investigado. Resultados: Después de buscar en la literatura siguiendo el método establecido, se seleccionaron 21 artículos, con individuos con obesidad y enfermedades metabólicas relacionadas, donde asociaron la modulación intestinal mediante el uso de simbióticos, probióticos y prebióticos en el tratamiento de la obesidad. Conclusión: La modulación de la microbiota intestinal es eficaz en el tratamiento de la obesidad y enfermedades asociadas, mejorando los episodios de atracón.

DESCRIPTORES: Microbiota intestinal; conducta alimentaria; obesidad; sistema nervioso central.

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INTRODUÇÃO

The human intestinal microbiota is composed of numerous types of bacteria, being mostly formed by two types of phyla: gram-positive bacteria and gram-negative bacteria, called Firmicutes and Bacterioidetes, respectively, performing different attributions, which can be beneficial or harmful to the body, being extremely important for health and disease control, such as nutrient absorption, antigen protection and immune modulation. Its composition is not fully known, but it is known that external factors such as diet, a healthy lifestyle; and internal modulate its composition and function. [1][2]

This intestinal ecosystem also plays an important role in the development and function of the nervous system, performing a communicative role with the brain, through the neural, endocrine, immune and metabolic pathways through the microbiota-gut-brain axis, which also establishes a connection between the intestine and the center of hunger, satiety, which may interfere with eating behavior, in relation to the quality and quantity of the individual's food consumption. [3]

An imbalance in the composition of the intestinal microbiota, called dysbiosis, leads to an exacerbated increase of bacteria considered harmful in the microbiota, where there is a prevalence of these in relation to the beneficial ones, causing toxin production and increased intestinal permeability that result in immunological and hormonal changes, placing the individual in a state of low-grade inflammation. [4]

Dysbiosis affects mood, accelerates and enhances depression, and with similar biochemical mechanisms, it can be associated with changes in eating behavior, contributing to greater selectivity of foods that enhance weight gain. ([5] Therefore, the intestinal microbiome directly influences eating behavior, the production of several hormones that are produced and synthesized in the intestine, significantly serotonin, the hormone responsible for the feeling of well-being, and often called the "happiness hormone" and GABA. (Gamma-Amino Butyric ACID) that interacts in function of regulating the central nervous system. When GABA is inhibited, behaviors considered aggressive and impulsive, anxiety and compulsion are related to this hormone drop, can be observed together with compulsive episodes of food intake, with associated suffering, the individual would seek the sensation of pleasure in the ingestion of more palatable foods and, consequently, more fatty and sugary foods. [6] Such a connection occurs due to the functions of the intestinal microbiota itself, interacting with metabolism, the immune system and most significantly when it comes to behavior: hormone production. This happens because hormones directly interfere with mental health, feelings of pleasure and happiness. [7] The gut-brain axis can modulate behavioral and brain functions, the hypothalamic axis regulates our body's responses to signals of stress, anxiety and mood disorders[7]

It is necessary to restore the balance of the microbiota to control these symptoms and regulate the intestine-brain axis, substances such as probiotics, which are living micro-organisms, may be used, that provide a favorable and selective growth of bacteria considered healthy in the intestine of the individual, exercising the role of inhibition of harmful bacteria and pathogens to the body, thus bringing benefits to the health of the individual when administered correctly and in sufficient doses. The bacteria most commonly used as probiotics are Lactobacilli and Bifidobacteria, but some streptococci and enterococci and even Escherichia coli are also associated with beneficial effects. [8] And the prebiotics that defined by the literature as food ingredients that are not digested, which would provide a favorable and selective growth of bacteria considered healthy in the intestine of the individual, playing the role of inhibiting harmful bacteria and pathogens to the body, thus bringing health benefits. [9] Both act by improving the composition of the intestinal microbiota, thus modulating it, thereby preventing the passage of antigens into the bloodstream.

So prebiotics and probiotics can be used in conjunction and would bring improvements such as: repair and maintenance of the intestinal barrier, increased production of TGF-β and prostaglandin E2 responsible for promoting tolerance of antigen-presenting cells, reduced permeability and decreased systemic absorption of allergens/antigens Enterocytes Increased production of TGF-β and prostaglandin E2 responsible for promoting tolerance of antigen-presenting cells Reduction of local inflammation and promoting tolerance. In addition to contributing to the reduction of chronic inflammation in the body. [10]

synbiotics are produced by living micro-organisms, which when in adequate doses bring benefits to the individual's body, and help in the restoration of the intestinal flora, are characterized by the association of more than one type of probiotics united with prebiotics, essential for proper functioning. They are complementary, carrying a multiplication factor on their isolated actions. One of the functions of synbiotics is the increased resistance of bacterial strains against pathogens that attack the body. Intestinal modulation would occur through a phenomenon called "competitive exclusion", and the strains that proved to be most beneficial were Bifidobacterium bifidum, Lactobacillus rhamnosus, Saccha-

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romyces boulardii and Lactobacillus plantarum. [11]

Therefore, the objective of this study is to investigate the interference of the intestinal microbiota and the effect of the use of prebiotics, probiotics and synbiotics in the modulation of this ecosystem to regulate the intestine-brain axis.

METHOD

A thorough review of the available literature on the intestinal microbiota was carried out, relating it to human eating behavior and the central nervous system. And how intestinal modulation through the use of probiotics, prebiotics and synbiotics become essential in the treatment against obesity.

The investigation followed the following steps: Formulation of the problem; literature search in databases; data evaluation and analysis. Data analysis consisted of reading, in the following order: title, abstract and full article. The search for articles was carried out from February to September 2022 in the Google Scholar, Scielo, PubMed databases, in Portuguese and English using the descriptors: Intestino, disbiose, microbiota intestinal, sistema nervoso central, comportamento alimentar, in addition to their names translated into English: Gut, dysbiosis, gut microbiota, central nervous system, eating behavior. Titles were also searched in Spanish: Obesidad, Microbiota intestinal, Probióticos, Síndrome metabólico. 3856 articles were found, and 34 articles that met the established criteria were selected. Scientific articles of systematic review, meta-analysis and clinical studies, published in the last 10 years (2012/2022) in magazines, newspapers and periodicals were included. The following were excluded from the research: in vitro studies, studies in rodents, studies with unsatisfactory or inconclusive results.

RESULTS

When carrying out the search for articles that portrayed the modulation of the microbiota through the use of probiotics, prebiotics and synbiotics, 8 articles were found in the Scielo database, where articles whose study was not in adult humans or with diseases not related to obesity were excluded, with 7 articles being selected. In the PubMed database, 560 articles were found, where 24 articles were selected that were clear in their methods and consistent with the current study. In the Google Scholar database 3560 results, where after selecting the articles, only participants and obesity-related diseases were selected, whose results were significant, 3 articles were selected.

Of these, 21 articles were selected for the development of the table below, with individuals with obesity and related metabolic diseases participating in the evaluation. In the evaluation, a complete reading of each article was carried out, with the objective of understanding the research methods and their results. Based on the interpretation of the selected studies, the following theme was organized: Intestinal Modulation through the use of synbiotics, probiotics and prebiotics in the treatment of obesity

DISCUSSION

In the evaluated studies, significant improvements were demonstrated in relation to quality of life and symptoms, there were variations in the results in relation to weight loss and improvements in biomarkers, which was related to the types of bacteria chosen for the composition of the probiotics. The cases in which there were greater results, were combined with a change in diet in general with the implementation of diets with higher percentages of protein

Figure 1: Intestinal Modulation through the use of synbiotics, probiotics and prebiotics in the treatment of obesity, 2022.

REFERENCES	Study type	Participants (characteristics)	Intervention performed	Main results
Understanding the Role of the Gut Microbiome and Microbial Metabolites in Obesity and Obesity-Associated Metabolic Disorders: Current Evidence and Perspectives (12)	Systematic review	Obese adults with dysbiosis, metabolic syndrome, type 2 diabetes mellitus, non-fatty liver disease.	Administration of live bacteria.	Studies have shown dysbiosis as a risk factor for metabolic diseases, including obesity, with favorable results after intestinal modulation.
Dietary fat and gut microbiota: mechanisms involved in obesity control.(13)	Systematic review	Obese adults	Administration of live bacteria. Consumption of n-3 polyunsaturated fatty acids (PUFA) and conjugated linoleic acid (CLA) in the microbiota, as opposed to n-6 PUFA and saturated fatty acids.	Dietary fatty acids can change the composition of the microbiota and the consumption of synbiotics promote desirable changes in the microbiota.
Probiotic supplementation and insulin resistance: a systematic review. "Suplementação de probióticos e resistência à insulina: uma revisão sistemática." (14)	Systematic review	Adults with type 2 diabetes mellitus with hypertension and dyslipidemia.	Consumption of high-fiber diet and use of probiotics.	There was an improvement in lipid metabolism, and it promoted less weight gain and a decrease in visceral fat.

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Effects of probiotics and synbiotics on weight loss in overweight or obese individuals: a systematic review "Efeitos de probióticos e simbióticos na perda de peso em indivíduos com sobrepeso ou obesidade: uma revisão sistemática" (15)	Systematic review	Adults in situations of obesity and overweight.	Use of synbiotics and probiotics from 1 to 12 weeks.	There was a decrease in body weight, BMI, waist circumference, body fat mass or fat percentage.
Probiotics as a Complementary Therapy for Management of Obesity: A Systematic Review (16)	Systematic review	Obesity and overweight adults with underlying disorders.	Use of high-dose probiotics from 2 to 26 weeks.	There was a significant reduction in body weight and a decrease in BMI.
Weight-loss interventions and gut microbiota changes in overweight and obese patients: a systematic review (17)	Systematic review	Adults in situations of obesity and overweight, some undergoing bariatric surgery.	Use of probiotics and prebiotics.	Probiotics tended to reduce body weight, improve the intestinal barrier and improve metabolic outcomes.
Probiotics Contribute to Glycemic Control in Patients withType 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. (18)	Systematic review	Adults with type 2 diabetes mellitus.	Use of probiotics for 12 weeks.	There was a reduction in serum cholesterol, glucose reduction and control of metabolic disorders.
Modulation of the Gut Microbiota by Nutrients with Prebiotic and Probiotic Properties. (19)	Systematic review	Adults with obesity and overweight.	Use of probiotics	There was a reduction in fat mass, body weight, waist, hip and waist-to-hip ratio.
Effects of Synbiotic Supplement on Human Gut Microbiota, Body Composition and Weight Loss in Obesity. Nutrients. 2020 Jan (20)	Double-blind randomized clinical study.	20 adults with obesity	Use of synbiotics	Improvement in the composition of the intestinal microbiota associated with a significant improvement in metabolic parameters
Effects of Synbiotic Supplementation on Chronic Inflammation and the Gut Microbiota in Obese Patients with Type 2 Diabetes Mellitus: A Randomized Controlled Study. (21)	Double-blind randomized clinical study.	88 obese adults with type 2 diabetes mellitus	Use of synbiotics	Improves intestinal microbiota composition by increasing Bifidobacterium and Lactobacillus counts and fecal organic acid concentrations in obese T2DM patients. However, there was no significant improvement in inflammatory parameters.
The effects of probiotics and synbiotic supplementation on glucose and insulin metabolism in adults with prediabetes: a double-blind randomized clinical trial (22)	Double-blind randomized clinical study.	120 pre-diabetic adults	Use of probiotics and synbiotics	There was a significant improvement in the glycemic index, in addition to an improvement in the intestinal microbiota.
Modulation of the gut microbiota by probiotics and synbiotics is associated with changes in serum metabolite profile related to a decrease in inflammation and overall benefits to metabolic health: a double-blind randomized controlled clinical trial in women with obesity (23)	Parallel double-blind randomized clinical trial.	32 adult women with obesity	Use of probiotics and synbiotics	There was a significant improvement in metabolic parameters, as well as an improvement in the lipid profile
Effects of a multi species synbiotic on glucose metabolism, lipid marker, gut microbiome composition, gut permeability, and quality of life in diabesity: a randomized, double-blind, placebo-controlled pilot study. (24)	Double-blind randomized clinical study.	26 adults with type 2 diabetes mellitus.	Use of probiotics and synbiotics	There was a significant improvement in type 2 diabetes biomarkers, as well as a reduction in symptoms.
Impact of diet and synbiotics on selected gut bacteria and intestinal permeability in individuals with excess body weight - A Prospective, RandomizedStudy (25)	Double-blind randomized clinical study.	60 overweight adults.	Use of synbiotics	There was an improvement in the intestinal microbiota, as well as a decrease in intestinal permeability. There was no significant improvement in BMI parameters.
Probiotic supplementation attenuates binge and food addiction one year after Roux-en-Y gastric bypass bariatric surgery: A Randomized, Double-Blind, Placebo Controlled Study "Suplementação de probióticos atenua compulsão e vício alimentar um ano após cirurgia bariátrica por Bypass gástrico em Y de Roux: Um estudo Randomizado, Duplo-Cego, Placebo Controlado." (26)	Double-blind randomized clinical study.	101 post bariatric adults.	Use of probiotics.	Decrease in symptoms of addiction to eating behavior, as well as decrease in binge eating.

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Effects of a Diet-Based Weight-Reducing Program with Probiotic Supplementation on Satiety Efficiency, Eating Behaviour Traits, and Psychosocial Behaviours in Obese Individuals. Nutrients.(27)	Double-blind randomized clinical study.	105 obese adults.	Use of probiotics.	There was a decrease in body weight, improvement in the feeling of satiety, eating behavior and mood.
Effects of obesity on depression: A role for inflammation and the gut microbiota. Brain Behav Immun. (28)	Systematic review	Adults with obesity, overweight with symptoms of anxiety and depression.	Use of prebiotics and probiotics.	The use of prebiotics and probiotics are effective in the treatment and prevention of obesity, working to improve the composition of the microbiota, anxiety and eating behaviors.
The effects of co-administration of probiotics and prebiotics on chronic inflammation, and depression symptoms in patients with coronary artery diseases: a randomized clinical trial.(29)	Double-blind randomized clinical study.	96 adults with symptoms of anxiety, depression and coronary heart disease.	Use of prebiotics and probiotics.	There were beneficial effects on anxiety, depression and inflammatory biomarkers.
Effects of Microbiota Imbalance in Anxiety and Eating Disorders: Probiotics as Novel Therapeutic Approaches. (30)	Systematic review	Adults with anxiety and eating disorders.	Use of probiotics.	There were positive treatment effects against anxiety, there were no significant effects against symptoms of depression.
Lactobacillus rhamnosus HA-114 improves eating behaviors and mood-related factors in adults with overweight during weight loss: a randomized controlled trial (31)	Double-blind randomized clinical study.	152 Overweight adults.	Use of probiotics.	There was an improvement in the quality of mood and a decrease in binge eating tendencies, bringing beneficial results from the use of probiotics to induce improvement in metabolic and psychological parameters.
A systematic review on the role of microbiota in the pathogenesis and treatment of eating disorders. Eur Psychiatry.(32)	Systematic review	Overweight adults.	Use of probiotics.	There was an improvement in the composition of the intestinal microbiota with the use of probiotics, reducing dysbiosis and promoting significant therapeutic effects.

Source: authors' data, 2022

and fiber and a reduction in the consumption of refined carbohydrates.

The administration of synbiotics, probiotics proved to be effective in their results [22], in his research, administering a 6g dose of probiotics, synbiotic for 6 months in 120 adults with pre-diabetes, proved to improve the management of symptoms, improvement of the glycemic index, in addition to improving the composition of the intestinal microbiota [23] demonstrated in their study a significant change in the metabolic health of the host, when submitted to 8 weeks of supplementation of 8g of probiotics, synbiotics combined with a hypocaloric diet, with a decrease in glycerol rates, a decrease in inflammation rates and a positive effect on weight reduction and body measurements.

Furthermore, [6] in their studies there was a reduction in fat mass, body weight, waist, hip and waist-to-hip ratio, thus contributing to a reduction in the characteristics and symptoms of obesity, thus demonstrating the efficiency of these compounds in the treatment of obesity.

Despite the considerable changes observed regarding the decrease in body mass and the attenuation of inflammation biomarkers, linked to a classic picture of dysbiosis, [26] and col report that the regulation of appetite and the desire for foods rich in sugars may be more prominent when the intestinal microbiota is unbalanced in terms of its diversity, also having an impact on the regulation of appetite, which is mediated by the interaction between the brain , gastrointestinal system and adipose tissue, where there is direct participation of numerous neuropeptides and hormones controlled by the central nervous system.

Also noteworthy is the fact of the integration of neuronal and hormonal systems that articulate responses according to energy production, presence of metabolites that go beyond the intestinal barrier in case of increased permeability of the same that lead to the stimulation of areas of the brain that are responsible for the regulation of energy homeostasis. These stimuli occur in response to brain-intestine-adipose tissue interaction through efferent pathways that transmit impulses for activation and inhibition of neurons that have orexigenic and anorexigenic characteristics. It is through these mechanisms that the justifications for changing eating behavior unfold, which has a total influence on food choices, also impacting on eating habits [27].

It is worth noting that the direct association between "eating habits" and "eating behavior" is very common, placing them on the same definitional level, which limits the possibility of a better analysis between the two situations, therefore, [28, 29] problematize the category of "eating behavior", understood in the field of Food and Nutrition as a controllable condition, whose repetition leads to changes in habit.

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The decrease in the perception of hunger and satiety is linked to the current obesogenic environment that offers easy access to low-cost and highly palatable foods with a high sugar and fat content that usually stimulate the intake of this type of nutrient, even in the absence of hunger. This behavior, according to [30], is supported by the reward system that is influenced by conscious and unconscious components that are articulated by numerous neuronal pathways.

This complex of neuronal pathways integrates the basic functions of the brainstem with the functions of the cerebral cortex, stimulating the drive for high energy density food [31]. Given this, it can be stated that there is a direct relationship between the metabolic and hedonic system that can trigger excessive food consumption [32]. It is also reported that the hedonic system generally overlaps the physiological system, promoting greater food intake that easily exceeds the energy needs that impact weight gain [33].

In addition, in the brain-intestine axis, many conditions are observed in which dysregulated eating behavior, which is generally associated with hyperphagia due to hormonal dysregulation, such as resistance to leptin, it may also impact the development of eating disorders (anorexia and bulimia) in the context of altered intestinal microbiota [34].

Several mechanisms that point to the alteration of the composition of the intestinal microbiota with compulsion and/or eating disorder have been suggested, among them: the production of a protein sequence of ≥5 amino acids that share an identical structure with numerous appetite-regulating peptides in the host. This structure can stimulate the production of immunoglobulins that can inhibit the degradation of the orexigenic hormone ghrelin [35]. B-caseinolytic protease (ClpB) is synthesized by E. coli bacteria. ClpB is a small structure with protein sequence and α-MSH mimetic antigen. Elevated serum levels of Clpb have been reported in studies of eating disorders, such as anorexia and bulimia nervosa [36].

However, according to [37] et al. the deleterious effect of the pathophysiology caused by the chronic inflammatory process is more elucidated in obese individuals because they have higher concentrations of inflammatory biomarkers that are characteristic of obesity, as well as neuronal dysfunction controlled by the hypothalamus, a brain region recognized as the regulatory center of hunger and satiety.

CONCLUSION

The microbiota is formed from birth and undergoes several changes during life, food choices are fundamental in its composition. A poor composition of the microbiota affects our food choices through gut-brain communication, as the gastrointestinal tract is responsible for releasing several hormones that stimulate insulin secretion and, through neurotransmitters, make contact with the hypothalamus. The hypothalamic axis is capable of influencing food choices, as well as feelings of satiety and hunger.

This review sought to relate the composition of the microbiota with eating behavior, and how the administration of prebiotics, probiotics and synbiotics can act as a complementary treatment against obesity, helping in the parameters of cholesterol, glycemia, decrease in waist circumference and control of systemic arterial hypertension.

With the analysis of the studies above, it was possible to verify that the supplementation of synbiotics, probiotics and prebiotics are effective in the treatment against obesity, thus showing how the nutritionist is fundamental in the treatment and prevention of obesity, assisting in the supplementation of these supplements and guiding the individual to make good food choices.

REFERENCES

1.Van de Sande-Lee S, Velloso LA. Disfunção hipotalâmica na obesidade. Arq Bras Endocrinol Metab. agosto de 2012;56:341–50.

2.Vargas ACC de O, Abreu JD de, Kravchychyn ACP. Aspectos alimentares atuais e alteração da microbiota intestinal em indivíduos com obesidade/ Current dietary aspects and altered gut microbiota in obese individuals. Brazilian Journal of Health Review. 15 de março de 2021;4(2):5336–52.

3.Rauber F, Steele EM, Louzada ML da C, Millett C, Monteiro CA, Levy RB. Ultra-processed food consumption and indicators of obesity in the United Kingdom population (2008-2016). PLOS ONE. 1o de maio de 2020;15(5):e0232676.

4.Wanderley EN, Ferreira VA. Obesidade: uma perspectiva plural. Ciênc saúde coletiva. janeiro de 2010;15:185–94.

5.Cani PD, Knauf C. How gut microbes talk to organs: The role of endocrine and nervous routes. Mol Metab. setembro de 2016;5(9):743–52.

6.Fusco S de FB, Amancio SCP, Pancieri AP, Alves MVMFF, Spiri WC, Braga EM. Ansiedade, qualidade do sono e compulsão alimentar em adultos com sobrepeso ou obesidade. Rev esc enferm USP [Internet]. 11 de dezembro de 2020 [citado 12 de outubro de 2022];54. Disponível em: http://www.scielo.br/j/reeusp/a/VbCfRCz8XWkBF7bTnXhS44G/?lang=pt

7.LANUTRI. Saúde mental e Microbiota intestinal: Qual a relação? [Internet]. Laboratório de Avaliação Nutricional - INJC/UFRJ. 2021 [citado 12 de outubro de 2022]. Disponível em: https://lanutri.injc.ufrj.br/2021/05/17/saude-mental-e-microbiota-intestinal-qual-a-relacao/

8.Moraes ACF de, Silva IT da, Almeida-Pititto B de, Ferreira SRG. Microbiota intestinal e risco cardiometabólico: mecanismos e modulação dietética. Arq Bras Endocrinol Metab. junho de 2014;58:317–27.

DOI: https://doi.org/10.36489/saudecoletiva.2023v13i84p12190-12203

9.Varavallo M, Thomé J, Teshima E. Aplicação de bactérias probióticas para profilaxia e tratamento de doenças gastrointestinais. Semina: Ciências Biológicas e da Saúde. 15 de julho de 2008;29.

10.Souza FS, Cocco RR, Sarni ROS, Mallozi MC, Solé D. Prebióticos, probióticos e simbióticos na prevenção e tratamento das doenças alérgicas. Rev paul pediatr. março de 2010;28(1):86–97.

11.Flesch AGT, Poziomyck AK, Damin DDC. The therapeutic use of symbiotics. ABCD, arq bras cir dig. setembro de 2014;27(3):206–9.

12.Vallianou N, Stratigou T, Christodoulatos GS, Dalamaga M. Understanding the Role of the Gut Microbiome and Microbial Metabolites in Obesity and Obesity-Associated Metabolic Disorders: Current Evidence and Perspectives. Curr Obes Rep. setembro de 2019;8(3):317–32.

13.Coelho OGL, Cândido FG, Alfenas R de CG. Dietary fat and gut microbiota: mechanisms involved in obesity control. Crit Rev Food Sci Nutr. 2019;59(19):3045–53.

14.Salles BIM, Cioffi D, Ferreira SRG. Probiotics supplementation and insulin resistance: a systematic review. Diabetol Metab Syndr. 11 de novembro de 2020;12(1):98.

15.Álvarez-Arraño V, Martín-Peláez S. Effects of Probiotics and Synbiotics on Weight Loss in Subjects with Overweight or Obesity: A Systematic Review. Nutrients. 17 de outubro de 2021;13(10):3627.

16.Shirvani-Rad S, Tabatabaei-Malazy O, Mohseni S, Hasani-Ranjbar S, Soroush AR, Hoseini-Tavassol Z, et al. Probiotics as a Complementary Therapy for Management of Obesity: A Systematic Review. Evid Based Complement Alternat Med. 2021;2021:6688450.

17.Seganfredo FB, Blume CA, Moehlecke M, Giongo A, Casagrande DS, Spolidoro JVN, et al. Weight-loss interventions and gut microbiota changes in overweight and obese patients: a systematic review. Obes Rev. agosto de 2017;18(8):832–51.

18.Rittiphairoj T, Pongpirul K, Janchot K, Mueller NT, Li T. Probiotics Contribute to Glycemic Control in Patients with Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. Adv Nutr. 1o de junho de 2021;12(3):722–34.

19.Druart C, Alligier M, Salazar N, Neyrinck AM, Delzenne NM. Modulation of the Gut Microbiota by Nutrients with Prebiotic and Probiotic Properties123. Adv Nutr. 1o de setembro de 2014;5(5):624S-633S.

20.Sergeev IN, Aljutaily T, Walton G, Huarte E. Effects of Synbiotic Supplement on Human Gut Microbiota, Body Composition and Weight Loss in Obesity. Nutrients. 15 de janeiro de 2020;12(1):222.

21.Kanazawa A, Aida M, Yoshida Y, Kaga H, Katahira T, Suzuki L, et al. Effects of Synbiotic Supplementation on Chronic Inflammation and the Gut Microbiota in Obese Patients with Type 2 Diabetes Mellitus: A Randomized Controlled Study. Nutrients. 8 de fevereiro de 2021;13(2):558.

22.Kassaian N, Feizi A, Aminorroaya A, Jafari P, Ebrahimi MT, Amini M. The effects of probiotics and synbiotic supplementation on glucose and insulin metabolism in adults with prediabetes: a double-blind randomized clinical trial. Acta Diabetol. outubro de 2018;55(10):1019–28.

23.Crovesy L, El-Bacha T, Rosado EL. Modulation of the gut microbiota by probiotics and symbiotics is associated with changes in serum metabolite profile related to a decrease in inflammation and overall benefits to metabolic health: a double-blind randomized controlled clinical trial in women with obesity. Food Funct. 15 de março de 2021;12(5):2161–70.

24.Horvath A, Leber B, Feldbacher N, Tripolt N, Rainer F, Blesl A, et al. Effects of a multispecies synbiotic on glucose metabolism, lipid marker, gut microbiome composition, gut permeability, and quality of life in diabesity: a randomized, double-blind, placebo-controlled pilot study. Eur J Nutr. outubro de 2020;59(7):2969–83.

25.Janczy A, Aleksandrowicz-Wrona E, Kochan Z, Małgorzewicz S. Impact of diet and synbiotics on selected gut bacteria and intestinal permeability in individuals with excess body weight - A Prospective, Randomized Study. Acta Biochim Pol. 16 de dezembro de 2020;67(4):571–8.

26.Carlos L de O, Ramos MRZ, Wagner NRF, Freitas LAC de, Felicidade I, Campos ACL. SUPLEMENTAÇÃO DE PROBIÓTICOS ATENUA COMPULSÃO E VÍCIO ALIMENTAR UM ANO APÓS CIRURGIA BARIÁTRICA POR BYPASS GÁSTRICO EM Y DE ROUX: UM ESTUDO RANDOMIZADO, DUPLO-CEGO, PLACEBO CONTROLADO. ABCD, arq bras cir dig [Internet]. 24 de junho de 2022 [citado 29 de novembro de 2022];35. Disponível em: http://www.scielo.br/j/abcd/a/95rkXVwc4cGLTM5xq8Chgwv/abstract/?lang=pt

27.Sanchez M, Darimont C, Panahi S, Drapeau V, Marette A, Taylor VH, et al. Effects of a Diet-Based Weight-Reducing Program with Probiotic Supplementation on Satiety Efficiency, Eating Behaviour Traits, and Psychosocial Behaviours in Obese Individuals. Nutrients. 15 de março de 2017;9(3):284.

28.Schachter J, Martel J, Lin CS, Chang CJ, Wu TR, Lu CC, et al. Effects of obesity on depression: A role for inflammation and the gut microbiota. Brain Behav Immun. março de 2018;69:1–8.

29.Moludi J, Khedmatgozar H, Nachvak SM, Abdollahzad H, Moradinazar M, Sadeghpour Tabaei A. The effects of co-administration of probiotics and prebiotics on chronic inflammation, and depression symptoms in patients with coronary artery diseases: a randomized clinical trial. Nutr Neurosci. agosto de 2022;25(8):1659–68.

30.Navarro-Tapia E, Almeida-Toledano L, Sebastiani G, Serra-Delgado M, García-Algar Ó, Andreu-Fernández V. Effects of Microbiota Imbalance in Anxiety and Eating Disorders: Probiotics as Novel Therapeutic Approaches. Int J Mol Sci. 26 de fevereiro de 2021;22(5):2351.

31.Choi BSY, Brunelle L, Pilon G, Cautela BG, Tompkins TA, Drapeau V, et al. Lacticaseibacillus rhamnosus HA-114 improves eating behaviors and mood-related factors in adults with overweight during weight loss: a randomized controlled trial. Nutritional Neuroscience. 17 de junho de 2022;0(0):1–13.

32.Carbone EA, D'Amato P, Vicchio G, Fazio PD, Segura-Garcia C. A systematic review on the role of microbiota in the pathogenesis and treatment of eating disorders. European Psychiatry [Internet]. 2021 [citado 29 de novembro de 2022];64(1). Disponível em: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8057489/

31. Nakamura K, Nakamura Y. Hunger and Satiety Signaling: Modeling Two Hypothalamomedullary Pathways for Energy Homeostasis. Bioessays. 2018 Aug;40(8):e1700252,

32. Al-Zubaidi A, Iglesias S, Stephan KE, Buades-Rotger M, Heldmann M, Nolde JM, Kirchner H, Mertins A, Jauch-Chara K, Münte TF. Effects of hunger, satiety and oral glucose on effective connectivity between hypothalamus and insular cortex. Neuroimage. 2020 Aug 15;217:116931.

33. Campos A, Port JD, Acosta A. Integrative Hedonic and Homeostatic Food Intake Regulation by the Central Nervous System: Insights from Neuroimaging. Brain Sci. 2022 Mar 24;12(4):431.

34. Cassioli E, Rossi E, Squecco R, Baccari MC, Maggi M, Vignozzi L, Comeglio P, Gironi V, Lelli L, Rotella F, Monteleone AM, Ricca V, Castellini G. Reward and psychopathological correlates of eating disorders: The explanatory role of leptin. Psychiatry Res. 2020 Aug;290:113071.

35. Shevchouk OT, Tufvesson-Alm M, Jerlhag E. An Overview of Appetite-Regulatory Peptides in Addiction Processes; From Bench to Bed Side. Front Neurosci. 2021 Dec 9;15:774050.

36. Dominique M, Lucas N, Legrand R, Bouleté IM, Bôle-Feysot C, Deroissart C, Léon F, Nobis S, do Rego JC, Lambert G, Déchelotte P. Effects of Bacterial CLPB Protein Fragments on Food Intake and PYY Secretion. Nutrients. 2021 Jun 29;13(7):2223.

37. Pagano ES, Spinedi E, Gagliardino JJ. White Adipose Tissue and Circadian Rhythm Dysfunctions in Obesity: Pathogenesis and Available Therapies. Neuroendocrinology. 2017;104(4):347-363.

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