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INFLUENCE OF THE MICROBIOME ON THE QUALITY OF HUMAN LIFE

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Abstract

The current challenges of health care systems in the world, dedicated to various health problems, are increasingly characterized by a holistic approach to health. Health is closely related to physiologically proper functions and organs and perceptual coordination mechanisms that affect interactions between body systems and organs. One of them is the human microbiome, which consists of microbes that form a biocenosis that can appear from person to person. The aim of the presented study is based on the content analysis of literature sources to show the significant relationship between the human microbiome and nutritional needs, metabolic rate and selected measures of health. The main used method was a systematic review, which includes a critical and reproducible summary of the results of available publications on the human microbiome. The results point to the possibilities of medicine to contribute to the recognition of new possibilities of using the physiological properties of a healthy organism for therapeutic purposes in the field of lifestyle, such as the solution of overweight and obesity, metabolic syndrome, inflammation and chronic allergies. Bacteroides fragilis inducing an anti-inflammatory response has been shown to have a protective reaction. Research suggests that the occurrence of an allergic reaction in children is associated with a reduction in the amount of Lactobacillus and Bifidobacterium bacteria. The results of analyzed studies report that the development of bronchial asthma in children after the first year of life depends on the intestinal flora in the neonatal period. Conclusions: Human microbiome research is an important part of identifying ways to modify style elements and interventions to prevent diseases of civilization.

Keywords

Health; quality of life; microbiome

1 INTRODUCTION

The World Health Organization defines human health as physical, mental and social well-being. Contemporary challenges of health care systems in the world are dedicated to various health problems, however, they are more and more often characterized by a holistic approach to health. This requires taking into account many definitions representing health in various aspects of maintaining health or striving for it, by populations of people of different ages and functioning with disabilities (Leonardi, 2018). Health is the physiologically correct functioning of systems and organs, and the ability to maintain it is an active process involving distinct adaptive mechanisms that coordinate interactions between the body's systems and organs (Ayres, 2020). Homeostasis is the body's ability to maintain health and the proper functioning of the body in the face of changing external or internal factors.

The gut-brain axis is a coordinated communication system that maintains homeostasis and influences higher cognitive functions and emotions. It plays a significant role in neurological and behavioral disorders (Saulnier et al, 2013). Among the sensory and motor neurons innervating the intestines, there are afferent nerve cells, nociceptor cells whose pericaryions are found in the dorsal and nodal ganglia and are linked to several types of cells in the intestinal wall, such as epithelial, vascular, and immune cells. The possibility of two-way exchange of signals between nerve cells performs immunoregulatory functions; controlling the body's response to pathogens and modulating the sensations related to gastrointestinal dysfunctions, by activating

immune cells and glial tissue in the peripheral and central nervous system.

The development of research on the human microbiome has contributed to a change in the views of clinicians on its importance for maintaining health (Young, 2017). Research has shown that most microorganisms form an ecosystem with the human body that benefits the host-microorganism system. Thanks to this system, the production of nutrients and immune components that protect against pathogenic microorganisms takes place.

1.1 The human microbiome

The term microbiota (or microbiome) was introduced at the turn of the 20th and 21st centuries by Joshua Lederberg. It is used to determine the total number of microorganisms present in and on all multicellular organisms (Szewc, 2017). The conducted research indicates many functions of the human body's ecosystem. It has been shown to participate in the pathogenesis of many diseases and ailments (Sirisinha, 2016).

Bacteria inhabiting the human body form functional assemblies that are able to communicate with each other and the host organism (Rakowska et al., 2016). They have a quorum sensing system, thanks to which stimuli coming from the external environment or from the host are processed in the cytoplasm of the bacterial cell. Through the action of such a mechanism, the number of bacteria is established, actions are synchronized and responses to stimuli are coordinated. It is estimated that the weight of bacteria inhabiting the mucous membranes of the body is approx. 2 kg (Strzępa and Szczepanik, 2013). The intestinal flora is the most numerous and at the same time the most physiologically active. For example, the large intestine hosts microorganisms that constitute up to 50% of the intestinal content. In the physiological state, the most abundant bacteria are *Firmicutes (64%), Bacteroidetes (23%), Proteobacteria (8%) and Acinetobacter (3%)* (Binek, 2012). The composition of the flora varies in individual sections of the digestive tract. For example, the esophagus and stomach are areas of limited development of the bacterial flora. There may be few organisms in them, such as *Helicobacter pylori, Lactobacillus, Enterococcus, Clostridium, Veillonella*. In the physiological state, there is no development of inflammation in the places where microorganisms occur, which is a consequence of the presence of numerous mechanisms that prevent the passage of bacteria beyond the gastrointestinal tract, and also against the development of inflammation if they enter another environment (Strzępa and Szczepanik, 2013). The securing factors include: mucin contained in the mucus of the intestinal epithelium, tight connection of epithelial cells, the so-called intestinal barrier tightness, which is favorably influenced by interleukin 10, transforming growth factor β, insulin-like growth factor 1. On the other hand, interferon γ, tumor necrosis factor, interleukins will have a negative effect; 2, 4 and 13. Severe damage to the intestinal barrier will impair the functioning of the system. This can occur as a result of the presence of pathogenic flora, ischemia or hypoxia in the body. The result will be the occurrence of diarrhea, translocation of bacteria outside the system environment, which may lead to the development of sepsis, especially in the case of impaired functioning of the immune system (Binek, 2015). A protective factor is also the presence of immunoglobulin A (IgA), which has the ability to opsonize, i.e. a mechanism of non-specific immunity, which prevents translocation of bacteria through the intestinal membrane.

1.2 Dysbiosis

Dysbiosis is a sudden change in the composition of the microbiota that leads to disease symptoms. Factors causing it are, for example, a change in diet, a change in the functioning of the immune system, such as a change in lifestyle or stress, as well as antibiotic therapy. Numerous studies (Strzępa and Szczepanik 2013) indicate the destructive effect of antibiotic therapy on the physiological flora of the human body. There is a change in the proportions of the main types of bacteria inhabiting the digestive system. These changes persist up to 2 years after the end of treatment (Wołkowicz et al., 2014). Selected sources indicate that the recovery to the physiological state takes a much longer period of time. It is

related to a reduced resistance to infections with pathogenic bacteria. It is worth mentioning that the newborn microflora is the most susceptible to disturbances in homeostasis. In such a young, developing organism, the process of colonizing the bacterial flora and creating interactions between the host and commensal bacteria has only just begun. Additionally, there is a problem of drug resistance of pathogens, as the death of the physiological flora creates niches for the development of bacteria that are initially resistant to a given antibiotic.

2 AIM

The aim of the presented study is based on the content analysis of literature sources to point out the important relationship between the human microbiome and nutritional needs, metabolic rate and other measures of health.

3 METHODS

The method of systematic review was used. The review process has been well designed and planned to reduce bias and eliminate irrelevant and low quality studies on the topic of human microbiome. A protocol and criteria for inclusion and exclusion were developed, followed by a literature search and screening of abstracts of the studies identified in the search and subsequently selected complete texts. A synthesis of evidence and a critical and reproducible summary of the results of available publications on the subject were performed. Methods of analysis, synthesis, induction and deduction were chosen and applied to the method of anchored theory in the sense of studying the concept as the main category, as well as causal and operational thinking.

4 RESULTS AND DISCUSSION

4.1 The influence of the microbiota of the digestive system on the human body

Microorganisms inhabiting the intestines are an extremely diverse and complex ecosystem (Szewc, 2017). The intestinal mucosa, covered with villi and microvilli, constitutes a significant area of the human body. Due to its importance, it ensures the maintenance of the organism's homeostasis. The most important functions are immunomodulating, metabolic and structural (Jandhyala et al., 2015). It has been shown that disturbances in the physiological composition of the microbiota are correlated with dysfunctions such as autoimmune, allergic, metabolic diseases such as obesity, type 1 diabetes mellitus, neurodevelopmental and mental disorders; depression, irritable bowel syndrome or non-alcoholic hepatitis.

The research conducted in this area concerns the possibility of modifying the bacterial flora, restoring its biological balance, and transferring microbiota (Szewc, 2017). All in order to maintain a healthy ecosystem balance. In 1954, the term probiotic was introduced by Ferdinand Vergin. He conducted comparative studies related to the harmful effects of antibiotics on microorganisms in the digestive system and the beneficial effects of certain types of microorganisms on the entire ecosystem. In 1965, the definition of a probiotic already included a number of microorganisms that stimulated the growth of other species of bacteria. In the following years, these definitions were still modified. Current, given by the World Health Organization, states that they are live microorganisms that, when given in an appropriate amount, have a beneficial effect on the health of the host. In the event of disturbed intestinal microbiological balance, in selected diseases, intestinal microbiota transfer is used, i.e. the so-called fecal transplant from a related donor (Evrensel et al., 2016). The growing number of metabolic diseases caused by intestinal dysbiosis prompts us to undertake further research on intestinal microbiota transfer procedures from healthy, tested donors for people with disorders.

Physiological bacterial flora is involved in the synthesis of vitamin K, the production of biotin and folic acid, as well as the absorption of magnesium, calcium and iron ions (Mroczyńska et al., 2011). Ensures obtaining energy from the breakdown of polysaccharides. Bacteria also take part in the production of fatty acids, which are a source of energy for intestinal epithelial cells, ensuring its continuity. They are a source of butyric acid, which affects the continuity of the epithelium and is anti-inflammatory by reducing the concentration of pro-inflammatory

cytokines. They induce the formation of mucin, which protects the epithelium from toxins and pathogenic bacteria.

The literature on the subject emphasizes the importance of bacterial microflora for human health and functioning (Malferheiner, 2016; Skrzydło-Radomańska, 2016; Rakowska et al., 2016). The closest relationship was observed in inflammatory bowel diseases; in the gastrointestinal tract of Crohn's disease patients. The cell membrane of Bacteroidetes and Proteobacteria bacteria contains lipopolysaccharide, which strongly stimulates the immune system. Another disease that depends on the microflora is diverticular disease and functional disorders of the digestive system. Another related to the microbiome is obesity (Heiman, 2016). Nutrition is the most important factor in shaping the body flora. The epidemic of civilization diseases results from the reduction of dietary diversity, which results in the depletion of the physiological flora. The food you eat goes to the intestines, where it is transformed into particles absorbed into the blood. The prevalence of incorrect nutrition rules; High-carbohydrate and high-fat diets, and above all highly processed diets, deprive the microbiome of the necessary nutrients, which makes it impoverished, and the developing dysbiosis leads to the development of many diseases, e.g. obesity. The flora of the developing child is influenced by the nutritional habits of the mother - women during pregnancy and also in the pre-conception period (Kinsner, 2018; Kinsner and Kazimierska, 2018). The flora is also influenced by additives used in food to improve the taste, texture, aroma and prolong its shelf life (Supreme Chamber of Control, 2018). The permissible doses used for food should not be harmful, however, as the Report shows, as much as 14% of the tested samples of food products exceed the permissible standards. In addition, when establishing the standards, the accumulation of these substances is not taken into account, and the deposition in the tissues leads to many dysfunctions, including inflammation. Chronic inflammation can lead to diseases within the intestine, causing eg Lesniewski-Crohn disease, ulcerative colitis or irritable bowel syndrome, metabolic and autoimmune diseases. In obese people, an increase in the percentage of *Firmicutes* as compared to the *Bacteroidetes* type has been demonstrated. This condition is related to the fact that *Firmicutes* bacteria largely metabolize nutrients, which predisposes them to obesity. A relationship between the amount of adipose tissue and the microbiome was also observed in mice that had been deprived of the physiological flora, and instead, flora was transplanted from obese individuals. After two weeks, they had a significant increase in body fat. Studies have also shown a relationship between the microbiota and the development of colorectal cancer. Bacteria that produce butyric acid with its help inhibit the growth of cancer cells, and also induce apoptosis, i.e. death of these cells. Others are involved in the synthesis of toxic and carcinogenic compounds.

The composition of the microbiome is associated with the development of allergies in people with a genetic predisposition (Strzępa and Szczepanik, 2013). In this case, *Bacteroides fragilis* inducing an anti-inflammatory response has been shown to have a protective reaction. Research suggests that the occurrence of an allergic reaction in children is associated with a reduction in the amount of Lactobacillus and Bifidobacterium bacteria. There are also reports that the development of bronchial asthma in children after the first year of life depends on the intestinal flora in the neonatal period.

4.2 The influence of the microbiome on the oral cavity

The oral cavity plays a significant role in picking up and grinding food. The ingested food is soaked in saliva and ground in order to effectively assimilate the necessary nutrients in all sections of the gastrointestinal tract. Physiologically, the oral mucosa and the salivary glands - innervated paired organs - are involved in this. The oral cavity is a specific environment for the colonization of various types of bacteria. Such an environment is created thanks to the supply of food, water, and various pollutants and pathogens ingested with them. In the state of physiological immunity of the organism, typical microorganisms in the oral cavity do not pose a pathogenic risk. However, due to the imbalance

of the microflora composition, pathological conditions may appear. With a slight intensification of changes, they may appear locally and periodically. Oral bacteria colonize from the birth of a new organism. Initially, these were Gram-positive cocci, S. salivarius, Gram-negative Lactobacillus and selected anaerobic bacteria (Gliński and Kostro, 2015). The bacteria in the mouth are diverse; others on the surface of the teeth (most often lactic acid bacteria) and in the interdental gaps, others on the surface of the tongue and the walls of the mouth. The composition of the physiological bacterial flora may slightly change under the influence of food intake or oral hygiene. However, most of the microorganisms remain constant regardless of these differences. As the organism develops and grows, the microflora changes. In adults, it includes aerobic bacteria (*Strepto-coccus spp., Pasteurella multocida subsp. Multocida, P. multocida subsp. Septica, P.multocida subsp. Gallicida. P.canis, Moraxella spp., Flavo-bacterium sensu lato, Pseudomonas spp., Corynebacterium spp., Neisseria anima-loris, N.veaveri, N. zoodegamatis, Ureaplasma spp., Bergeyella zoohelcum, Mycomlasma feliminutum, Nocardia spp., Capnocytophaga Canimorsus, C. cynodegmi*), and anaerobic bacteria (*Bacteroides spp., Porphyromonas spp., Wolinella spp., Peptostreptococcus an-aerobius, Clostridium spp., Actinomyces viscosus, Eusobacterium spp.,).* The oral microflora is characterized by properties such as the ability to adherence and to congregate and, consequently, to form bacterial biofilms. Aerobic and anaerobic bacteria, their metabolic products and salivary glycoproteins form a sticky deposit on the tooth surface, which leads to the development of dental plaque. The bacteria and the metabolic products they emit penetrate the gingival gap between the tooth and the free edge of the gum, and along with the growing layer of sediment, change its conditions into microaerophilic, i.e. those that facilitate the colonization of the oral cavity by pathogenic bacteria causing lesions. Emerging infections accumulate Gramnegative proteolytic bacteria, such as *Prophyromonas spp.* and *Tannerella spp*. In such a situation, the bacteria change the interdental gap into a deep pathological gingival pocket, which in turn may initiate periodontitis. The oral cavity connects with the upper respiratory tract, which is inhabited mainly by gram-positive bacteria, with a composition similar to the skin.

4.3 The influence of microbiota on the nervous system

The interplay between the gut and the brain is currently under intense consideration. It has been established so far that early disturbances of the intestinal flora related to the way of feeding in the neonatal and infancy period, perinatal conditions, and exposure to drugs may cause dysfunctional states in response to stress in later life. Studies on mice have shown intestinal dysbiosis, unsealing of the intestinal barrier, disturbances in the synthesis of tryptophan, dopamine and serotonin in the presence of early separation from the mother and chronic stress. The result of such changes in the body may be an increased concentration of cortisol, as well as the appearance of depressive and anxiety behaviors (Foster et al., 2017; Kornatovska and Rehor, 2021). Patients with depressive disorders were diagnosed with an incorrect ratio of *Proteobacteria, Bacte-roidetes, Actinobacteria to Firmicutes*.

Some bacteria are able to produce neuroactive substances which affect how the brain functions. The communication of the microbiota with the central nervous system occurs primarily through the vagus nerve, the hypothalamic-pituitary-adrenal axis, the immune system or metabolites produced by the micro-biota. Especially in recent years, a number of relationships between the substances produced by the bacteria that make up the microbiome and the functioning of the brain have been observed. It has also been noticed that the intestinal microbiota may participate in neurodevelopmental and neurodegenerative processes. Moreover, these studies reveal a relationship between the functioning of the microbiome and mental functioning, which is particularly reflected in depressive and anxiety disorders. A relationship has also been observed between the functioning of the digestive system and mental condition - stressors or an inadequate diet may contribute to a change in the composition of the intestinal microbiota, which may affect the functioning of the brain and mind.

The literature also describes the relationship of the microbiome with autism spectrum disorders (Binek, 2015). A change in the intestinal flora has been noticed in children with autism. A 10-fold increase in the number of Clostridium bacteria compared to healthy children was diagnosed. These bacteria produce neurotoxins that cause symptoms in the form of functional disorders. The intestinal microbiome influences the development of the brain, and the effect of the action is a change in behavior, and by affecting the central nervous system also on the response to stress (Gliński and Kostro, 2015).

5 CONCLUSIONS

Research and the microbiota of the human body have been going on almost from the beginning of the development of microbiology. The development of biology and medicine contributes to the recognition of new possibilities of using the physiological properties of a healthy organism and using them for therapeutic purposes of sick people. The development of molecular, breeding and diagnostic techniques is of great importance in scientific research. All scientific studies will contribute to the creation of new therapeutic agents and methods for patients, such as probiotics or transfers of the microbiome to the organism in need, which will translate into the quality of life of people with health disorders.

6 REFERENCES

Ayres, J.S. (2020). The Biology of Physiological Health. *Cell, 181*(2):2, p. 50-269. DOI: 10.1016/j.cell.2020.03.036.

Binek, M. (2012). Mikrobiom człowieka – zdrowie i choroba. *Postępy Mikrobiologii, 51*, p. 27-36.

Binek, M. (2015). Znaczenie jelitowych mikrobiontów w utrzymaniu ogólnej homeostazy gospodarza. *Postępy Mikrobiologii, 54*(3), p. 207–216.

Evrensel, A., Ceylan, M.E. (2016). Fecal Micriobiota Transplantation and Its Usage in Neuropsychiatric Disorders. *Clinical Psychopharmacology and Neuroscience, 14*(3), p. 231-237.

Foster, J.A., Rinaman, L., Cryan, J.F. (2017). Stress & the gut-brain axis: Regulation by the microbiome. *Neurobiology Stress, 7*, p. 124-136.

Gliński, Z., Kostro, K. (2015). Mikrobiom – charakterystyka i znaczenie. *Życie Weterynaryjne, 90*(7), p. 446-450.

Heiman, M.L., Greenway, F.L. (2016). A healthy gastrointestinal microbiome is dependent on dietary diversity. *Molecular metabolism, 5*(5), p. 317-320. DOI: 10.1016/j.molmet.2016.02.005

Jandhyala, S.A., Talukdar, R., Subramanayam, C., et al. (2015). Role of the normal gut microbiota. *World Journal Gastroenterol, 21*(29), p. 8787-8803. DOI: 10.3748/wjg.v21.i29.8787.

Kinsner M, Kazimierska A. (2018). Programowanie metaboliczne. *Postępy Nauk o Zdrowiu, 2*, p. 5-18.

Kinsner, M. (2018). *Programowanie metaboliczne.* Praca licencjacka (niepublikowana). Warszawa: Wyższa Szkoła Rehabilitacji.

Kornatovska, Z., & Rehor, P. (2021). Live strong with chronic disease, disability, impairment. České Budějovice: University of South Bohemia, NewWestminster: Hanson College.

Leonardi, F. (2018). The Definition of Health: Towards New Perspectives. *International Journal of Health Services, 48*(4), p. 735-748. DOI: 10.1177/0020731418782653.

Malfertheiner, P. (2016). *Zaburzenia mikrobioty w chorobie uchyłkowej*. Poznań: XVII Kongres Polskiego Towarzystwa Gastroenterologii.

Mroczyńska, M., Libudzisz, Z., Gałęcka, M., Szachta, P. (2011). Gut microorganisms and their metabolic activity. *Gastroenterology Review/Przegląd Gastroenterologiczny, 6*(4), p. 218-224. DOI:10.5114/pg.2011.24304.

Najwyższa Izba Kontroli. (2018). Nadzór nad stosowaniem dodatków do żywności, lata 2016-2018 (I kwartał). Warszawa.

Rakowska, M., Lichosik, M., Kacik, J., Kalicki, B. (2016). The impact of the microbiota on

human health. *Pediatria i Medycyna Rodzinna, 12*(4), p. 404-412. DOI: 10.15557/PIMR.2016.0040.

Saulnier, D.M., Ringel, Y., Heyman, M.B., Foster, J.A., Bercik, P., et al. (2013). The intestinal microbiome, probiotics and prebiotics in neurogastroenterology. *Gut Microbes, 4*(1), p. 17-27. DOI: 10.4161/gmic.22973.

Sirisinha, S. (2016). The potential impact of gut microbiota on your health: Current status and future challenges. *Asian Pacific Journal of Allergy and Immunology*, 34(4), p. 249-264. DOI: 10.12932/AP0803.

Skrzydło-Radomańska, B. (2016). *Nowe dowody w IBS i rola mikrobioty*. Poznań: XVII Kongres Polskiego Towarzystwa Gastroenterologii.

Strzępa, A., Szczepanik, M. (2013). Wpływ naturalnej flory jelitowej na odpowiedź immunologiczną. *Postępy Higieny Medycyny Doświadczalnej, 67*, p. 908-920. DOI:10.5604/17322693.1064563

Szewc, M. (2017). Badania nad mikrobiotą jelitową i metodami jej modyfikacji w ujęciu historycznym. *Acta Medicorum Polonorum, 7*(2), p. 54-62. DOI: 10.2883/jamp.2017.10.

Wołkowicz, T., Januszkiewicz, A., Szych, J. (2014). Mikrobiom przewodu pokarmowego i jego dysbiozy jako istotny czynnik wpływający na kondycję zdrowotną organizmu człowieka. *Medycyna Doświadczalna i Mikrobiologia, 66*(3), p. 223-235.

Young, V.B. (2017). The role of the microbiome in human health and disease: an introduction for clinicians. *BMJ, 356*, p. 831. DOI: 10.1136/bmj.j831.

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