

PROBIOTIC STRAINS AS THE ELEMENT OF NUTRITIONAL PROFILE IN PHYSICAL ACTIVITY- NEW TREND OR BETTER SPORTS RESULTS?

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ABSTRACT

A diet, individually customized to the needs of sportsmen and sportswomen prepares them better for competition and achievement of better sports results. However, disorders of the gastrointestinal tract and frequently recurrent upper respiratory tract infections pose a common problem observed among athletes of disciplines such as triathlon, cycling and marathon. Diarrhea, splashing in the intestines or gastrointestinal bleeding make it difficult to start and win in the race. Recently researchers have paid special attention to the therapeutic effect of probiotic strains on the human body. Various probiotic strains may have a beneficial effect on elimination of disorders mentioned above among athletes of these disciplines. Still, researchers continue looking for answers to the question how a specific probiotic strain is able to reduce the risk of the gastrointestinal tract and the respiratory system disorders appearing during training or competition. Attention is also drawn to the possible impact of probiotics on the physical capacity athletes and their athletic performance. Probiotic strains properly applied may have a positive influence on the athletes' bodies, but still randomized controlled trials are required to prove this thesis.

Key words: *probiotics strains, diet, physical activity, intestinal barrier function, respiratory-tract illness.*

STRESZCZENIE

Sposób żywienia, indywidualnie dobrany do potrzeb zawodników różnych dyscyplin sportowych pozwala na lepsze przygotowanie sportowców do startów oraz osiąganie lepszych wyników sportowych. Jednak częstym problemem obserwowanym wśród zawodników dyscyplin takich jak triathlon, kolarstwo czy maraton, są zaburzenia ze strony przewodu pokarmowego oraz często nawracające infekcje górnych dróg oddechowych. Biegunki, przelewanie w jelitach czy krwawienie z przewodu pokarmowego, uniemożliwiają start oraz zdobywanie zwycięstw. Badacze w ostatnich latach zwracają szczególną uwagę na wpływ probiotykoterapii na organizm człowieka. Poszczególne szczepy probiotyczne mogą mieć korzystny wpływ na niwelowanie wspomnianych zaburzeń pojawiających się w grupach sportowców. Nadal poszukuje się odpowiedzi na pytanie jaki szczep probiotyczny jest w stanie zmniejszyć ryzyko występowania zaburzeń ze strony przewodu pokarmowego oraz układu oddechowego, pojawiających się w trakcie treningów czy zawodów. Zwraca się również uwagę na możliwy wpływ probiotyków na wydolność fizyczną zawodników oraz ich wyniki sportowe. Prawidłowo zastosowana probiotykoterapia może wpływać korzystnie na organizm zawodników, jednak nadal potrzeba randomizowanych badań potwierdzających tę tezę.

Słowa kluczowe: *szczepy probiotyczne, dieta, aktywność fizyczna, bariera jelitowa, choroby górnych dróg oddechowych*

INTRODUCTION

Nowadays, 'probiotics' is a term which more and more frequently appears in the subject of nutrition and athletes support. The latest definition of the term probiotics presented by the International Scientific Association for Probiotics and Prebiotics - ISAPP, a modification of the one created by FAO/WHO in 2001, defines as "live microorganisms which when administered in adequate amounts, have a beneficial effect on the health of the host". Microorganisms

which usually occur in fermented food, where health benefit has not been demonstrated in randomized placebo-controlled trials must be separated from this definition. Probiotics are not dead bacteria strains and products containing them, either [22, 32].

PROBIOTICS IN SPORTS

In recent years, plans of nutrition for athletes of different sports contain probiotics supplements. Physical activity, despite many benefits of health

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effects on the human body, can cause negative effects [7]. The intensity and type of effort in endurance or strength sports can increase the risk of nausea, vomiting, abdominal pain and diarrhea. There are also disorders of the upper respiratory tract, chronic inflammation or risk of injury [37]. Thus, researchers have attempted to examine the effect of probiotic strains on the microbiota modulation, the incidence of gastro-intestinal disorders, respiratory diseases, where the incidence of these disorders increases in training periods, mainly in autumn-winter and spring. Interestingly, the impact of probiotic strains on the athletes endurance has been observed in different sports. However, specific strains of probiotics have not been defined neither their dose or the type of physical activity where the actual health benefits can be established. Still the research continues aimed at evaluating the effect of probiotic strains on the body weight of the athletes, inflammation present in the body or its performance.

GASTROINTESTINAL DISORDERS AND INTESTINAL BARRIER IN ATHLETES

Symptoms appearing during or after the intense physical activity such as abdominal pain, diarrhea, feeling bloating in the intestines, blood in the stool, may be caused by inadequate blood supply to the digestive tract during exercise or competition [8]. Gastroesophageal reflux disease (a disorder also often reported during intense efforts), can be caused by the increased pressure in the abdominal cavity, the reduced pressure of the lower esophageal sphincter or changes in hormone secretion [23]. All these symptoms cause extreme discomfort in athletes of different sports. The literature mostly mentioned sports disciplines such as marathon runners, triathletes, cyclists or athletes [8]. Fearing these symptoms, they can change their menu. Those who are afraid of eating certain food or products, may reduce the nutritional value of the diet and do not provide adequate amounts of essential nutrients [40,16].

In *Rehrer's* et al. study analyzing the relationship between gastrointestinal problems and way of nutrition triathletes, the consumption of foods high in protein and fat was found to cause vomiting mainly during the physical effort. Moreover, hypertonic drinks could also contribute to intensification of this symptom [31]. Another factor may be consuming meals rich in dietary fiber (insoluble fraction) before competition which may increase the risk of these unfavorable symptoms of the digestive system. In assessing the impact of a diet on the physical performance of athletes, carbohydrate intake is regarded beneficial compared to protein. Higher dietary intake of foods rich in carbohydrates and at the same time reducing

the consumption of proteins in just three days can improve performance, extend the time for obtaining energy from intensive, anaerobic processes up to 2-7 minutes [13]. In addition, it is believed that glutamine supplementation may be beneficial in increasing the resistance of athletes (used at a dose > 3-6 g/day), however a further study is required. Similarly, further research into the impact of probiotic supplementation on the functioning of the immune system is necessary. Athletes appropriate nutritional education and their cooperation with nutritionists facilitates personalizing and balancing their diets. Additionally, if necessary, it is possible to apply the appropriate supplementation, and use of probiotic strains according to the impact on the sports discipline and individual adaptation to the athletes requirements [3,15].

Another vital issue related to sports players' intestinal problems is proper functioning of intestinal epithelial cells responsible for both appropriate transport and absorption of nutrients, water and electrolytes, as well as protection against disease-causing pathogens with an important role of the intestinal barrier function [34]. The function of the intestinal barrier may be limited by certain medications, especially non-steroidal anti-inflammatory drugs (NSAIDs), proton pump inhibitors (PPI), high physical activity, high fat diet or stress [10]. In the assessment of gut barrier function and the possible occurrence of intestinal 'permeability', biomarkers such as C-reactive protein (CRP), calprotectin, tumor necrosis factor (TNF- α) and zonulin may be used [2]. These indicators are applied to assess inflammation in the body, mainly focusing on the "permeability" and inflammatory bowel disease. In addition, it is believed that the impaired function of the intestinal barrier may contribute to the development and intensification of autoimmune diseases [12].

The study analyzing the mechanism of zonulin effect on the sports players' bodies showed that it can help to alleviate the symptoms of autoimmune diseases [11,12]. Zonulin acting on the junctions of the small intestine cells makes it possible to use medicines or vaccines more effectively, which could not be used by the body in normal conditions. Apart from a role of genes and environmental factors in the development of autoimmune diseases, intestinal permeability may also have a significant impact. At present researchers are looking for mechanisms of zonulin effects that could have real diagnostic and therapeutic benefits. Correct diagnosis and using the selected probiotic strains may be beneficial for prevention of symptoms of autoimmune diseases, or intestinal problems assessed frequently in sports players.

In the randomized study carried out by *Lamprecht* et al. from 2012, it was determined that taking probiotic strains *B. bifidum W23*, *W51 B.lactis*,

E. faecium W54, W22 *L. acidophilus*, *L. brevis* W63, *Lc. lactis* W58 for 98 days resulted in a decrease in the concentration of zonulin and the ratio of TNF- α [25]. In this study, however, no changes were reported in the concentration of α -1-antitrypsin in the blood. Another randomized study was performed in 2011 among the physically active cyclists and triathletes [38]. The study group consisted of women (n=35) and men (n = 64), aged 35-36 years. Sports players took the probiotic bacterial strain -*Lactobacillus fermentum* (PCC®) at a dose of 1×10^9 CFU for 11 weeks. The study showed a decrease in the average: interleukin 6 (IL-6) (average of 0.92 in men vs 1.22 in the placebo group), tumor necrosis factor TNF- α (average 1.27 in men vs 1.66 in the placebo group). In women, the study demonstrated the following values of IL-6 (an average of 0.71 in the study group vs 2.29 in the placebo group) and TNF- α (1.15 in the study group vs 1.72 in the placebo group). In this analysis, it was estimated that supplementation of probiotic strain *Lactobacillus fermentum* (PCC®) may be beneficial for the reduction of inflammation and pain of the gastrointestinal tract in men occurring mainly during intensive exercise with high loads. Still, the test results differ depending on the strain used, the dose and type of physical activity. The study of *Kakkonen* et al. conducted among 141 marathoners evaluated the effect of probiotic strain *Lactobacillus rhamnosus* GG (LGG) on the incidence of pain, gastrointestinal tract disorders and respiratory tract infections. After three - month research, there was no effect of the probiotic on the incidence of both respiratory tract infections and disorders of the gastrointestinal tract [24]. As it is apparent from the studies published, the effect of probiotic strains on the body of the athlete may vary. However, the conditions of taking probiotic preparations, their composition and dosage were not assessed thoroughly enough to answer the question about the beneficial effects of the bacteria on the incidence of gastrointestinal disorders.

PROBIOTICS AND THE INCIDENCE OF RESPIRATORY TRACT INFECTIONS

Apart from gastrointestinal problems, chronic inflammation and diseases of the upper respiratory tract can make it difficult for athletes to train and take part in competitions [19]. In addition, physical activity during different weather conditions can cause Upper Respiratory Tract Infection (URTI). The high risk of diseases of the respiratory system may decrease levels of IgM and IgA immunoglobulins. Effective assessment and regular tests enable to assess correctly a risk of URTI in athletes and consequently to introduce equate treatment and training [17].

Researchers are still looking for probiotic strains which can advantageously decrease the incidence of

upper respiratory tract infections. According to the research published recently in the databases, such as MEDLINE, Web of Science, the Cochrane Central Register of Controlled Trials (CENTRAL), probiotics can have a beneficial effect on the prevention of the upper respiratory tract infections (URTI), reduced severity of symptoms and the use of antibiotic therapy [20]. The study conducted by *Cox* et al., in 2008 evaluated the effect of a probiotic strain *Lactobacillus fermentum* VRI-003 given to twenty healthy runners for four months at a daily dose of 1.2×10^{10} CFU. The study was randomized controlled and the placebo group received neutral for health substances. The occurrence of respiratory infections was assessed via cytokine concentration in serum levels of immunoglobulin A (IgA) and subjective daily evaluation of the health and performance of the physical activity. The study found a shorter course of the upper respiratory tract infection in patients in the study group (30 days) compared to the placebo group (72 days), however there were neither significant variations in the results of IgA, IgA1, IL-4 and IL-12 nor differences in the physical activity of sports players and their sports results. Interestingly, this study concluded that probiotics might influence the blood level of interferon-gamma (IFN-gamma) compared to the placebo group, however, the mechanism of this effect was not shown [6].

A similar conclusion was observed in the study from 2006, in which athletes were given another probiotic strain *Lactobacillus acidophilus* at a dose of 2×10^{10} cfu for month. A significant increase was proved in the serum levels of IFN-gamma ($p = 0.03$). The study compared the effect of the probiotic on the organisms of healthy and fatigued athletes, showing a significant increase in IFN-gamma levels from 7.8 pg/ml to 32.1 pg/ml in the group of fatigued sports players. This knowledge may allow athletes to prepare better for the competition and reduce the risk of diseases and infections they are exposed to at this time [5]. The study using a strain of *Lactobacillus salivarius* evaluated the effect of 4- month supplementation at a dose of 2×10^{10} CFU in women and men training for races. However, the supplementation with this strain was not found to influence positively the average incidence of respiratory diseases (statistically insignificant results, similar results in the study group and the placebo group: 1.6 vs 1.4). Similarly, the levels of leukocytes, neutrophils, monocytes, or IgA were found to be statistically insignificant [18]. Thus, the effect of different probiotic strains on the bodies of athletes of both genders can differ as well as the response of the organism and the incidence of respiratory diseases can be different/can vary.

Though researchers' interest has been focused on the strains of *Lactobacillus* lactic acid for a long time, nowadays more and more studies are carried out

with the use of *Bifidobacterium* strains. There are two groups of microorganisms, which are usually evaluated in the study. The Australian study conducted in 2014 evaluated the effect of probiotic strains on 465 healthy active people; men (n = 241) and women (n = 221) aged 35-36 years. The study participants were divided into 3 groups, the first group received strain *Bifidobacterium animalis subsp. lactis* BI-04 (BI-04) 2.0×10^9 CFU, the second group - *Lactobacillus acidophilus* NCFM and *Bifidobacterium animalis subsp. lactis* Bi-07, 5×10^9 , and the third group was given a placebo. The study assessed the effect of the above-mentioned strains and the reduced incidence of inflammatory symptoms of upper respiratory tract and gastrointestinal disorders. The conclusions obtained in the study showed that the strain of *Bifidobacterium animalis subsp. lactis* BI-04 might reduce the risk of incidence of upper respiratory tract diseases. However, no such effect was observed in group II given the strains of *Lactobacillus acidophilus* NCFM and *Bifidobacterium animalis subsp. lactis* Bi-07 compared to the placebo group. The study did not assess significant changes in the incidence of gastrointestinal disorders in the groups. In addition, patients taking BI-04 strain showed a lower/ weaker response to a physical effort and its frequency than the group receiving NCFM and BI-07 compared to those on placebo [39]. Most of the studies about the therapy with probiotics, published in recent years, have referred to athletes of endurance and speed sports. Unfortunately, there is not much literature about team sports. In 2014, the Journal of Science and Medicine in Sport published the study assessing the effect of probiotic bacteria on the incidence and severity of infections of the upper respiratory tract [21]. Almost half of the surveyed players (14 of 30), suffered from neither infections nor URTI symptoms of the gastrointestinal tract compared to the placebo group (6 of 30 people). In the study presented by Lollo et al., probiotics may have a beneficial effect on reducing the risk of respiratory disease and increase the immunity and lower the incidence of gastrointestinal disorders [26]. Probiotics may also contribute to the increased efficiency of the body [30].

Summing up the overview of the currently available literature about probiotics, the strains of *Lactobacillus* and *Bifidobacterium* have been regarded to have the most beneficial effect on sports players' health. The high number of studies conducted with the use of these strains may also be another advantageous proof. There are still contradictory data about the impact of these strains on the incidence of URTI infections, however, their beneficial influence on severity and duration of these infections is underlined in most publications referred to [35].

PROBIOTICS, ALLERGIES AND A RESPONSE TO TRAINING

The effect of probiotics on the modulation of gut microflora and incidence of allergies has become another problem the researchers have attempted to deal with [1]. The results of research conducted in 2007 suggested that supplementation with the probiotic strain *Lactobacillus* GG (LGG), had no effect on both the alleviation of allergy symptoms and changes in the biochemical results in the group of 141 marathon runners. The prevalence of asthma (6 of 139 people), allergic rhinitis (24 of 139 people), food allergy (7 of 139 people) or atopic dermatitis (6 of 139 people) was estimated twice (at the beginning and end of the studies- after 3 months), using a subjective questionnaire about health and symptoms suggesting diseases mentioned above. In biochemical studies, the levels of eosinophils, ECP (serum eosinophil cationic protein) and IgE were analyzed in the blood, however, no statistically significant changes were determined. Though the study was carried out during the pollen season, no effect of probiotics on athletes' bodies was observed [29].

Training in cold and hot climates can adversely affect the organism of endurance sports athletes (marathon runners, triathletes and cyclists). In the study carried out 2014, the effect of the preparation of many probiotic strains containing *Lactobacillus*, *Bifidobacterium* and *Streptococcus* was examined in 10 healthy runners. The product was used for 4 weeks preparation. Then the response of the athletes' organism response was assessed during training until fatigue (about 80% efficiency) at 35 Celsius degrees and 40% humidity. In addition, were administered to players sugars: lactulose and rhamnose were administered to athletes. Intestinal disorders were determined based on the presence of these compounds in the urine after training. The study showed that supplementation with the preparation containing many probiotic strains extended the duration of a physical effort (37 minutes vs 33), while the body temperature remained identical in the study group and the placebo group. Estimated, the serum concentrations of IL-6 and IL-10, increased after training but the values were not statically significant in the study and control group. Additionally, the concentration of urinary lactulose and rhamnose decreased slightly as well as intestinal discomfort [33]. Studies of the probiotics taken by athletes of different sports emphasize that they can have a beneficial effect on their bodies. However, in a systematic review of the literature it is difficult to assess the dose and the exact strain, which will be tailored/customized to a given research group. This remains a very individual issue.

THE INFLUENCE OF PROBIOTICS ON OXIDATIVE STRESS AND INFLAMMATION OF THE BODY

In different sports, the athlete's body is exposed to oxidative stress, and attacked by reactive oxygen species [28]. Researchers are looking for solutions to reduce oxidative stress, and consequently decrease the incidence of inflammatory diseases. In the studies published in 2011 by *Martarelli et al.* the effect of probiotic strains *Lactobacillus rhamnosus* IMC 501® and *Lactobacillus paracasei* IMC® 502 (109 CFU) was determined on the body of players for 4 weeks during the intense physical activity. The study involved 24 athletes with 12 of them receiving a mixture of the two probiotic strains and the other 12 taking a placebo. The plasma level of reactive oxygen species and antioxidant capacity were assessed in the athletes, while taking into account the probiotic bacteria, resistance to oxidative stress and antioxidant capability were evaluated based on *in vitro* studies. Additionally, feces was examined before the study and after 4 weeks of the study. The results showed that the intense physical activity caused an oxidative stress and probiotic supplements could increase the plasma concentration of antioxidants, neutralizing reactive oxygen species [28].

DIETARY SUPPLEMENTS CONTAINING PROBIOTICS AND FERMENTED FOODS

In an athlete's diet, dairy products are a good source of wholesome proteins mainly in the form of cottage cheese, yogurt or cheese-as an additional source of calcium. It is wrongly assumed that these products contain probiotic strains. In fact, these products can contain fermented, lactic acid bacteria but they should not be called probiotics [22,36]. Studies show different results of their usage by athletes. In the study conducted among 98 women and 177 men in 2013 year, it was found that only 47.5% of men and 40.8% of women provided the correct amount of milk and milk products in their diets [14]. Other Polish research concerning the knowledge and use of milk and dairy products in a daily diet of rowers [9,40] and triathletes [27] showed similar results stating that at least 2 meals contained dairy products and 75% of the respondents used a dairy products regularly in their diet.

In recent years, researchers have also evaluated the difference between the use of whey beverage and probiotic in 21-day-old rats. They were divided into 10 groups which were given: probiotic yoghurt, natural yoghurt, probiotic whey beverage with probiotic strains- *S. thermophilus*, *L. bulgaricus*, *L. acidophilus*

and *B. longum*, whey beverage and control. The study determined that these strains may have a good effect on the improvement of the immune system. Dairy products with probiotics gave a better result compared to the whey (even better than whey probiotic), mainly increased antioxidants [26]. The study proved a beneficial effect of probiotics on the immune system.

SUMMARY

Recently there has been a growing interest in the subject of probiotics strains. The impact of new probiotic strains on the bodies of healthy, sick and the very physically active people is assessed in many studies. Probiotic bacteria may have a beneficial effect on the incidence of gastrointestinal or respiratory diseases in the athletes of different sports. It is believed that probiotics can prevent the diseases such as diabetes and obesity. The latest studies published in 2016 year suggest that probiotics may eliminate signs of aging as well [4]. The quantity of probiotic bacteria present in the body may be equal to the number of cells in the body. Therefore special attention must be paid to the development of normal intestinal microflora, a rational, balanced diet and physical activity, which may also influence (microflora) modulation. Every sports nutritionist should take advantage of this knowledge, because it enables to understand better disorders athletes suffer from and prepare better nutritional plans for starts and recovery.

Conflict of interest

The authors declare no conflict of interest.

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