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THE INFLUENCE OF GUT MICROBIOTA ON PERFORMANCE IN ATHLETES

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ABSTRACT

Introduction and objective: The gut microbiota, consisting mainly of bacteria, plays a key role in human health, including athletes. Its composition can be modulated by diet, antibiotics, stress, and physical activity. The aim of this paper is to present the influence of the gut microbiota on athletes' performance and to assess the potential benefits of probiotic supplementation.
Review methods: The literature search for this review was performed using the PubMed database and other available literature sources and the following keywords: gut microbiota, physical activity, competitive athletes, gut barrier defense mechanisms.
A brief description of the state of knowledge: The gut microbiota has protective functions, fermenting undigested carbohydrates, synthesizing vitamins, and metabolizing lipids. Studies suggest that the microbiota can improve metabolic and immune function, which reduces mental fatigue and improves performance in athletes. Probiotic supplementation can increase endurance, aerobic capacity, and recovery from exercise, as well as reduce gastrointestinal symptoms. Probiotics may also affect the mental and cognitive health of athletes through mechanisms related to the gut-brain axis.
Conclusions: The gut microbiota plays a significant role in the health and performance of athletes. Probiotic supplementation can provide a variety of benefits, including improved performance, recovery, and mental health. Additionally, it can improve the bioavailability of key nutrients such as branched-chain amino acids (BCAAs), supporting muscle recovery and performance. However, further research is needed to determine the optimal doses and strains of probiotics, as current evidence, although promising, remains limited and not fully validated.

KEYWORDS

Gut Microbiota, Physical Activity, Competitive Athletes, Gut Barrier Defense Mechanisms

CITATION

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1. Introduction

The intestinal microbiota is a community of microorganisms located in the intestines, consisting mainly of bacteria. It is estimated that this population can reach approximately 100 trillion organisms [1]. Their primary roles include protecting against pathogens, fermenting undigested carbohydrates into short-chain fatty acids (SCFAs), synthesizing vitamins, and participating in lipid metabolism [2]. The intestinal microbiota begins to mature in childhood, but its development can be influenced by various factors. Dietary interventions, antibiotic use, mode of delivery, stress, and physical activity can all significantly affect its composition [3]. There is scientific evidence that the intestinal microbiota is involved not only in local processes but also in broader physiological functions, such as maintaining the integrity of mucous membranes and epithelial cells. Additionally, it plays a role in the immune and nervous systems through the gut-brain axis [4].

Optimizing performance is a standard goal for every athlete. Various forms of physical activity are essential not only for maintaining a healthy lifestyle but also serve as a foundation for the prevention and treatment of many diseases. Studies suggest that the gut microbiota, by improving metabolic and immune functions, may help reduce mental fatigue [5]. Although diet has the greatest impact on shaping the composition of the gut microbiota, it can also be modulated by physical activity. This occurs, among other mechanisms, through increased hormone release and the redirection of blood flow from the intestines to skeletal muscles [6]. The population of gut microorganisms can change depending on the type, intensity, and duration of training. As a result, the enzymatic potential of the microbiota may shift, exerting systemic effects on the body [6]. It has been shown that athletes, in response to increased energy intake, exhibit higher production of short-chain fatty acids (SCFAs). This increase is also associated with overall improvements in physical performance [7]. Moreover, these athletes demonstrate an expanded number of metabolic pathways, not only related to energy demands but also to vitamin and amino acid metabolism [8].

In recent years, the role of the gut microbiome in health has become an increasingly explored topic, with growing evidence supporting the idea that its influence may be significant. Randomized controlled trials have been conducted using probiotics to improve athletic performance. These studies have shown enhanced endurance following probiotic supplementation in sports such as cycling, running, and swimming [9]. Moreover, in another study, after a 6-week period of probiotic use, a 6% increase in aerobic capacity was observed [10].

Many of the mechanisms by which the gut microbiota may influence athletic performance have not yet been fully elucidated. So far, several potential pathways have been suggested to support this hypothesis. One such mechanism is improved recovery following intense physical exertion [11]. Additionally, increased absorption of nutrients from the diet has been observed [12], along with a reduction in digestive issues [13]. The growing body of evidence on the supportive role of probiotics in sports highlights the need for a comprehensive literature review to summarize the available findings and to encourage further research in this area.

2. Protection in sports

In a healthy, disease-free body, communication occurs between the gut microbiota and the immune system, providing a specific form of protection. However, when stress arises or dietary changes occur, the composition of the gut microbiota can be altered. Furthermore, bacterial metabolites or fragments that pass through the epithelium into the mucosa may contribute to dysbiosis, which in turn can trigger the development of low-grade inflammation [14].

Physical exertion alone can negatively impact the integrity of the gastrointestinal epithelium. During intense exercise, blood flow is redirected from the visceral organs to active tissues such as muscles. As a result, intestinal hypoperfusion may occur, potentially leading to damage caused by ischemia. This is especially relevant during competitions, where athletes often experience gastrointestinal symptoms that can limit their performance. These issues are potentially linked to inflammation in the gut, which, over time, may lead to long-term consequences [15].

It is estimated that 30 to 50% of athletes may experience various gastrointestinal symptoms, including abdominal pain, cramps, nausea, bloating, and others. A dysfunctional microbiome that contributes to low-grade inflammation may weaken both the immune system and overall metabolism [16].

Another common issue among athletes is frequent pain, leading many to use over-the-counter pain medications, which are not neutral to the gastrointestinal tract and may contribute to its damage. Nonsteroidal anti-inflammatory drugs (NSAIDs), as well as both opioid and non-opioid analgesics, can significantly affect the intestines by impairing the function of the natural protective barrier. One of the mechanisms by which NSAIDs negatively affect the gastrointestinal tract involves disrupting mitochondrial function and impairing electron transport in the respiratory chain, leading to reduced ATP synthesis. Additionally, NSAIDs can compromise the intestinal barrier by increasing gut wall permeability, thereby facilitating the translocation of bacteria and toxins into the bloodstream. As a result, this may lead to energy deficits and low-grade inflammation [17].

Another mechanism of NSAID action is the inhibition of cyclooxygenase (COX) enzymes, which directly contributes to increased susceptibility to gastrointestinal ulcers, as well as long-term consequences such as bleeding or protein loss. The underlying cause of this phenomenon is reduced prostaglandin production. Prostaglandins play a crucial role in protecting the intestinal mucosa by enhancing blood flow, promoting mucus production, and inhibiting gastric acid secretion [18].

Some commercially available sports drinks may exert negative effects on the gastrointestinal tract of athletes due to their composition. This is primarily related to the presence of artificial sweeteners, colorants, and emulsifiers. As a result, these ingredients can compromise intestinal integrity and trigger inflammatory responses. Sucralose, a commonly used artificial sweetener in such beverages, has been shown to alter gut microbiota composition and its development. Long-term consumption of sucralose may also induce pro-inflammatory responses in the liver and disrupt intestinal motility [19].

Carrageenan is an emulsifier that can also be added to sports drinks. Although the exact mechanism by which it induces inflammation is not fully understood, it has been shown to trigger inflammatory responses and exacerbate existing inflammation in the gut. Research has revealed that this substance reduces the number of epithelial glycoproteins in the colon, increases the secretion of TNF-α, and inhibits interactions between lymphocytes and macrophages [20].

3. The effect of probiotic supplementation in athletes

Chronic inflammation resulting from insufficient recovery can lead to a decline in athletic performance. Therefore, it is crucial to support the body by strengthening the immune system. In this regard, the role of antioxidant and anti-inflammatory defense systems is particularly important. It has been demonstrated that intense physical exertion leads to oxidative stress. In this context, the effects of probiotic supplementation with L. rhamnosus and L. paracasei strains have been studied. These probiotics were found to significantly increase antioxidant levels in plasma, which is essential for reducing damage caused by reactive oxygen species [21].

The use of various types of supplementation is quite common among athletes; however, the existing evidence regarding their effects seems to be insufficient. The International Olympic Committee has defined caffeine, creatine, nitrate, beta-alanine, and sodium bicarbonate as performance-enhancing supplements supported by evidence [22].

Probiotic supplementation, by modifying the composition of the gut microbiota, may have a beneficial effect on physical performance, supported by credible underlying mechanisms [23]. Probiotics can include various types of bacteria, with Lactobacillus and Bifidobacterium being the most commonly mentioned in the context of athletes. Preclinical studies have demonstrated improvements in the intestinal barrier [24], enhanced antioxidant properties [25], as well as anti-inflammatory effects in rodents following intense physical exertion [26].

Previous analyses of the effects of probiotics on the body have focused on various groups of physically active individuals and athletes, testing a range of bacterial strains. Despite the growing interest in this topic, the number of reliable clinical studies remains limited, with most of them based on small sample sizes and differing training protocols. As a result, interpreting the findings requires caution. Additionally, the level of training and the athletic background of participants can significantly modify the body's response to exercise and supplementation [27]. Professional athletes, compared to recreationally active individuals, exhibit different physiological responses to exercise, and as such, the results of studies may seem controversial [27].

Based on the long-term benefits of probiotic supplementation over various periods of time, numerous studies have been conducted evaluating physical performance, recovery after exercise, and cognitive effects. In a group of elite athletes from sports such as cycling, triathlon, badminton, and tennis, a significant increase in subjective feelings of vigor was observed after supplementation with L. helveticus strains for a period of 14 weeks. In another study conducted on marathon runners, supplementation with L. casei bacteria for 30 days significantly reduced TNF-α levels after the marathon compared to the control group [28]. Among a group of female swimmers, a significant improvement in VO2max was demonstrated after consuming 400 ml of probiotic yogurt daily for 8 weeks, as assessed by their performance in the 400-meter freestyle swim [29].

In the context of better recovery after intense physical exertion, current studies demonstrate that probiotic supplementation can have a beneficial impact. This is indicated by, among other factors, a reduction in the inflammatory response and an improvement in sleep quality. However, more research is needed to determine the precise dosages and probiotic strains to optimize results and standardize existing evidence, so that probiotic supplementation can be used as a tool for recovery after demanding training [35].

As is well known, an optimal gut microbiome composition is essential for maintaining proper metabolism and the absorption of nutrients, including minerals, amino acids, and vitamins. Among the mechanisms associated with its modulation to improve athletic performance is the increased bioavailability of key components such as BCAAs, which are crucial for muscle recovery and proper muscle function [30]. A study conducted on triathletes showed a 24-60% increase in BCAAs after 8 weeks of probiotic supplementation, along with an improvement in performance [31]. In another randomized study, the combination of probiotics with whey protein increased protein absorption and circulating BCAA levels (isoleucine, leucine), which translated into increased strength and vertical jump performance [32]. Additionally, in cyclists, a 4-week probiotic supplementation resulted in improved glucose oxidation during exercise [33]. Preliminary data also suggest that probiotics may support iron absorption in athletes with anemia [34]. In conclusion, probiotic supplementation, especially in combination with macronutrients, can enhance the bioavailability of proteins, carbohydrates, and micronutrients, supporting endurance, recovery, and training adaptation.

Gastrointestinal symptoms such as nausea, diarrhea, and bloating are common among endurance athletes, with even 27% of recreational runners reporting moderate or severe discomfort during competitions. The primary mechanism is reduced blood flow to the intestines during exercise, which disrupts the intestinal barrier and can trigger an immune response [36]. Excessive carbohydrate intake is also a risk factor, particularly with impaired absorption [37]. Probiotics, known for alleviating symptoms of irritable bowel syndrome, may also reduce gastrointestinal discomfort in athletes. Studies show that their supplementation decreases the frequency

and severity of symptoms both at rest and during intense training, and may also reduce perceived effort while supporting performance maintenance. Furthermore, they could provide tangible ergogenic support, especially in endurance sports, where gastrointestinal issues are a significant limitation [38].

Intense physical exertion can lead to symptoms of mental fatigue, mood decline, and reduced feelings of vigor, all of which negatively impact athletic performance. Probiotics show potential in supporting mental health by improving well-being and alleviating symptoms of anxiety and depression. In a study involving elite athletes, supplementation with Lactobacillus helveticus for 14 weeks resulted in an increase in subjective feelings of vigor compared to the placebo group, although no differences were observed in the overall mood profile [39]. Similar effects were observed in studies using inactivated Lactobacillus gasseri strains, where a reduction in stress levels and physical fatigue was noted [40].

Probiotic supplementation may also have a positive effect on the cognitive abilities of athletes. In a study involving elite female swimmers who took Bifidobacterium longum for six weeks, improvements in cognitive performance and better recovery markers were observed compared to the placebo group [41]. Importantly, a beneficial impact on cognitive functions was also confirmed in older adults undergoing resistance training, where multispecies probiotic supplementation led to a reduction in self-reported symptoms of depression and anxiety [42].

Probiotics may influence the mental and cognitive health of athletes through mechanisms related to the gut-brain axis. Gut bacteria can affect the nervous system via cytokines, neurotransmitters, hormones, bacterial metabolites, or through the vagus nerve [43]. Intervention studies have also shown a reduction in chromogranin A levels, a biomarker of stress, in groups receiving inactivated probiotics, further supporting their potential stress-alleviating effects [44].

4. Summary

The gut microbiota plays a crucial role in the health of athletes, influencing protection against pathogens, carbohydrate fermentation, vitamin synthesis, and lipid metabolism. Its composition can be modulated by diet, antibiotics, stress, and the type of physical activity. The gut microbiota can improve metabolic and immune functions, reducing mental fatigue and enhancing athletic performance. Probiotic supplementation can increase endurance, aerobic capacity, and recovery after exercise, as well as reduce gastrointestinal symptoms. Probiotics can also positively influence the mental and cognitive health of athletes through mechanisms related to the gut-brain axis. Supporting the gut microbiota through proper diet and supplementation may be key to improving performance, recovery, and mental health in athletes. Additionally, probiotic supplementation may enhance the bioavailability of key nutrients such as branched-chain amino acids (BCAA), which supports muscle recovery and function. However, further research is needed to determine optimal doses and probiotic strains, as current evidence, while promising, is still limited and not fully verified.

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