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INTESTINAL DYSBIOSIS IN ELITE ATHLETES AND ITS ATTENUATION BY PROBIOTICS WITH PREBIOTICS

[1]Tyler M. Delarosa and Kedar N. Prasad[2]*

[2]Egage Global, Inc. 245 El Faisan Drive, San Rafael, CA 94903.
[1]300 East 77th Street, Suite 24 C, NEW York, NY.

***Corresponding Author: Kedar N. Prasad**
Egage Global, Inc. 245 El Faisan Drive, San Rafael, CA 94903.

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ABSTRACT
Elite athletes such as Football, soccer, and basketball players who undergo sustained intense physical activity during the training and the game, face gastrointestinal problems, immune dysfunction, and risk of respiratory infection due to induction of intestinal dysbiosis (change in the composition of bacteria in favor of harmful bacteria). These adverse health issues can interfere with the ability to perform during the game. The question arises whether daily oral supplementation with probiotics with prebiotics would prevent the development of health problems by reversing the intestinal dysbiosis. Several reviews and studies have shown that supplementation with probiotics and prebiotics individually or in combination has produced inconsistent results on the beneficial health effects in Elite athletes because of variation in the number of probiotics or the amounts of prebiotics, type of athletes, and period of observation. Most studies have used Bifedo or lactobacillus strains of bacteria which are acid sensitive. most of them are killed in acid pH of the stomach and bile acid of the intestine. Therefore, we have proposed that changes in the diet and lifestyle and daily oral administration of probiotics with prebiotics that include acid resistant strains of probiotic to reverse and prevent the development of intestinal dysbiosis after the game. Adoption of such a strategy would prevent muscle and gastrointestinal damage, reduce recovery time, and improve performance during the game.

KEYWORDS: Elite athletes; intestinal dysbiosis; probiotics; Prebiotics; performance.

1. INTRODUCTION

A recent review has revealed that the use of probiotics is growing in the sports. This may be due to the fact that up to 50% athletes suffer from gastrointestinal discomforts and immune dysfunction associated with the increased risk of upper respiratory tract infection after high intensity training or game.[1] Elite athletes such as Football, soccer, and basketball players are involved in sustained intense physical activity during the training and the game. They face a major health risk that can interfere with their time needed to recover as well as performance ability during the game. This health risk is due to the induction of intestinal dysbiosis (changes in the composition of bacterial population in favor of harmful bacteria) which can induce gastrointestinal problems and immune dysfunction that impair rate of recovery and performance ability during game.

In healthy individuals, the gut microbiotas are dominated by beneficial bacteria; however, elite athletes who are involved in sustained intense physical activity in sports such as Football, Soccer, and Basketball can induce transient intestinal dysbiosis which can suppress immune function that can lead to upper respiratory tract infections, enhance intestinal permeability that can allow the entry of infective agents into the blood stream, and gastrointestinal disorders which can cause cramps and diarrhea.[2] These defects can cause interruption in training or competition, delay in recovery time, and may adversely affect performance of these athletes during the game.[3] The question arises how to prevent and reverse the intestinal dysbiosis in Elite athletes involved in prolong sustained intense exercise.

This review briefly describes history, definition, and effectiveness of probiotic or prebiotics on sustained intense exercise-induced delay in the recovery time, immune dysfunction, soreness of muscle, and reduced performance ability during the game. Although the existence of intestinal dysbiosis was demonstrated after the game in Elite athletes, supplementation with probiotic or prebiotics in reducing these adverse health effects has produced inconsistent results. We propose that administration of probiotic with prebiotics for a few days before the training or the game may prevent occurrence of exercise-induced intestinal dysbiosis.

Adoption of the proposed strategy may prevent the development of muscle soreness, reduce time of recovery after the game, and improve the performance during the game by improving immune function, reducing inflammation, gastrointestinal disorders, and infection.

2. History of Probiotics

As early as 2500 years ago, Hippocrates, who is considered father of the medicine, stated that "all human diseases begin in the gut", even though he had no idea about the existence of microbiota in the gut. Today, no one can doubt the existence of numerous microorganisms and their role in maintaining good gut health and overall health. Probiotic, derived from the Greek word meaning "for life" and is defined as a group of beneficial bacteria that improve human health. The International Olympic Committee defined probiotics as live microorganisms that are "associated with a range of potential benefits to gut heath, as well as modulation of immune function.[4] The Food and Agriculture Organization of the United Nations and World Health Organization (WHO) defined probiotics as living organisms that when administered in adequate amounts confer a health benefit on the host.[5] Prebiotics are mixture of soluble and insoluble fibers which are needed for fermentation to produce beneficial products for maintaining good health. Probiotics without prebiotics may not be effective in helping to maintain optimal health.

It is only over a century ago, when a Bulgarian Nobel Prize winner scientist Elie Metchnikoff suggested that regular consumption of fermented dairy products can lead to long and healthy life.[6] Fermented products include yogurt, sauerkraut, cabbage kimchee are rich in probiotics. Now it is established that the gut microbiota includes bacteria, viruses, fungi, and other microorganisms and that bacteria are responsible for fermentation of fibers to produce beneficial substances that play an important role in maintaining good health. Revised estimate of the number of microbiotas in the gut is approximately 38 trillion, whereas number of cells in the human body is 37 trillion.[7]

3. Characteristics of Microbiotas

Gut microbiota consists of 160 species of microbes some of which are beneficial while others are harmful. Beneficial probiotics bacteria include most species of Bifidobacterial and Lactobacillus, whereas harmful bacteria include some species of *Colostridium, Enterococcus, Staphylococcus, Bacteroides, E. coli, Helicobacter pylori*. Imbalance of gut microbiota in favor of pathogenic microbiota is called intestinal dysbiosis and can lead to poor health outcomes.[8] Diet, stress, and prolonged intense physical activity can induce intestinal dysbiosis.[9] To reverse the intestinal dysbiosis, it would be essential to supplement with probiotics together with prebiotics which would restore the composition of gut microbiota in favor of beneficial bacteria. These bacteria produce diverse biological function ranging from fermentation of fibers to produce short chain fatty acids, production of certain B-vitamins, vitamin K, certain neurotransmitters, improv immune fucntion, reduce oxidative stress and inflammation.[9] Supplementation with probiotics together with prebiotics can prevent the development of intestinal dysbiosis among elite athletes after the training or game.

4. Studies on the Effects of Supplementation with Probiotics on the Health of Elite Athletes

Analysis of several reviews and studies revealed that some investigations support the value of supplementation with probiotics in improve athlete performance and reduce recovery time, and stimulate immune function, whereas a few others do not. This inconsistent results could be due to the fact that the number of probiotic bacterial strain used in the study varied from one to multiple strains, some probiotics were used with prebiotics and some probiotics were utilized without prebiotics, different types of athlete population, and observation period varied.[10,11] There were no adverse effects of probiotics supplementation.

Healthy young athletes during off season do not suffer from intestinal dysbiosis; however, increased intense exercise during training or game induces changes in gut microbiota in favor of harmful bacteria which enhance intestinal permeability, levels of intestinal inflammation markers, and enhanced the time to achieve exhaustion. Daily supplementation with probiotics and vitamin D3 for 4 weeks produced increased number of beneficial bacteria which improved intestinal permeability, and decreased intestinal inflammation and time needed to become exhausted in mixed martial Arts athletes. Vitamin D3 alone did not produce these effects.[12]

Another review reported that supplementation with probiotics does not improve sport performance among endurance athletes; however, it indirectly improves immune function, reduces upper respiratory tract infections, and deceases oxidative stress among these athletes.[13] During Football game, players must make decision based on a rapidly changing environment in the field with respect to their teammates, opponents, and the ball. To become successful in their decision, they need to intensely focus their attention on the game which requires an excellent physical and mental health. Stress, anxiety, and depression are often associated with the competitive football game. Daily supplementation with only one probiotic (*lactobacillus casei*) for a period of 4 weeks improved sustained attention and relaxation during the game.[14] Daily administration of probiotics for a period of six weeks was more effective than prebiotics in improving immune function and performance of male university Football players.[15] Immunosuppression occurs after intense exercise during prolong training or match game which can lead to upper respiratory tract infections that interfere with the performance.[16] Administration of Probiotics containing multiple strain of beneficial bacteria for 17 weeks caused reduced muscle pain and heaviness in the legs which correlated

with improvement in sleep and motivation in Rugby athletes.[17] Supplementation with a probiotic containing one train of *Lactobacillus casei* for six weeks improved aerobic capacity by 5.9% and relieved anxiety and stress, but did not enhance the speed, strength, leg power, and agility in badminton athletes.[18] Administration of probiotics containing only one strain *Bacillus subtilis* for 12 weeks had no effect on body composition, performance, hormone status, or gut permeability; however, it reduced circulating tumor necrosis factor-alpha (TNF-alpha) in male college baseball players.[19]

Supplementation with a single probiotic strain *Lactobacillus plantarum*TWK10 at a dose of $3x10^{10}$ CFU /day and $9x10^{10}$ CFU/day for six weeks improved endurance performance compared to placebo group. Higher dose was more effective than the lower dose.[20, 21] In another study, supplementation with *Lactobacillus plantarum* PS128 at a dose of $3x10^{10}$ CFU /day for six weeks reduced circulating markers of oxidative stress and inflammation. In addition, it increased plasma level of branch-chain amino acids which play a role in reducing fatigue and improving muscle energy.[22] Administration of *Lactobacillus casei* Shirota at a daily dose of $4x10^{10}$ CFU for 30 days before Marathon reduced markers of inflammation in upper airway and induced anti-inflammatory response reducing harmful effects on the mucosal inflammation in 42 male Marathon runners.[23]

5. Proposed Plans to Improve Performance of Elite Athletes

5.1. Diet and lifestyle changes: Dietary recommendations include daily consumption of a low fat and high fiber diet with plenty of fruits and vegetables and reduction of sugar intake. Daily intake of adequate amounts of protein and carbohydrate especially essential fatty acids Omega-3 fatty acids is essential.

Lifestyle recommendations include stopping cigarette smoking or vaping (e-cigarette), reducing stress by yoga or meditation, and limiting intake of caffeine because high doses of caffeine may interfere with the repair of DNA damage. Avoid exposure to air pollution containing tiny particles, because it increases the levels of oxidative stress and chronic inflammation.

5.2. Oral administration of probiotics with prebiotics: Daily supplementation with probiotics with prebiotics would prevent and reverse intestinal dysbiosis. Probiotics of *Bifedo* and *Lactobacillus* strains when taken orally are destroyed about 60-70% in acid pH of the stomach and further reduction occurs in bile acid of small intestine; therefore, an effective probiotic must also have acid resistance strains of microorganisms. An effective probiotic also must have adequate amounts of prebiotics for fermentation that produces beneficial substances which may improve performance of the Elite athletes during the game.

6. CONCLUSIONS

The use of probiotics is growing in the sports because up to 50% athletes suffer from gastrointestinal discomforts and immune dysfunction that increases risk of upper respiratory tract infection after high intensity training or game. Elite athletes who are involved in sustained intense physical activity during the training and the game face a major health risks that can interfere with their time of recovery as well as performance during the game. This health risk occurs due to induction of intestinal dysbiosis (changes in the composition of bacterial population in favor of harmful bacteria) which can induce gastrointestinal problems and immune dysfunction that impair rate of recovery and performance ability during game. We propose that changes in the diet and lifestyle, and daily oral administration of probiotics with prebiotics may prevent the development of intestinal dysbiosis, and thereby, decreased the risk of gastrointestinal problems, improve immune function, recovery time, and improve performance during the game.

Declaration

Ethical statement. Since it is a review manuscript, ethical statement is not needed. Any ethical statement related to a review paper has been met.

Conflict: KNP is a retired professor from the University of Colorado School of Medicine, and currently, he is Chief Scientific Officer of the Engage Global of Utah. This company sells nutritional products to consumers. Tyler is a junior in high school and is an Elite athlete. He raised the issue of the health of Athletes and researched references on the role of intestinal dysbiosis. He has read the draft and approved it.

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