Probiotics Supplementation on Infections in Athletes

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It is well established that physical activity (PA) can have beneficial effects on the whole human body and strength its immune defenses. In fact, scientific evidence has established that regular PA is effective in the prevention of various chronic diseases, such as cardiovascular diseases, diabetes, cancer, hypertension, obesity, depression, osteoporosis, and premature death. However, the effects of PA can be different depending on its intensity and duration. In fact, during heavy training and competitions, a higher incidence of gastrointestinal (GI) disorders, such as diarrhea and heartburn, and upper respiratory tract infections (URTIs) can occur. This is due to acute post-exercise immune breakdowns and chronic suppression of immune factors, dependent on frequent strenuous exercise. Therefore, reducing these symptoms in athletes becomes a top priority. Evidence shows that probiotics could be useful in reducing the risk of development or the severity of GI or URT infections, but firther research in this field is still needed.

athletes probiotic diet supplementation gastrointestinal disorders

1. Introduction

Nowadays, it is well established that physical activity (PA) can have beneficial effects on the whole human body and strength its immune defenses. In fact, scientific evidence has established that regular PA is effective in the prevention of various chronic diseases, such as cardiovascular diseases, diabetes, cancer, hypertension, obesity, depression, osteoporosis, and premature death [1][2]. However, the effects of PA can be different depending on its intensity and duration.

In particular, high-intensity PA and strenuous exercise seem to increase intestinal permeability and diminish gut mucus thickness, potentially enabling pathogens/toxins to enter the bloodstream, and have been associated with immunosuppression by decreasing immune cell function, which enhances susceptibility to infections [3][4][5][6][7][8][9].

In fact, during heavy training and competitions, a higher incidence of gastrointestinal (GI) disorders, such as diarrhea and heartburn [7][8], and upper respiratory tract infections (URTIs) can occur [9][10][11]. This is due to acute post-exercise immune breakdowns and chronic suppression of immune factors, dependent on frequent strenuous exercise [12][13]. Therefore, reducing these symptoms in athletes becomes a top priority. Nowadays, probiotic supplement use is promoted in this perspective. The term “probiotic” refers to those microorganisms, which, once ingested in adequate quantities, are able to exercise beneficial functions for the body [14].

Indeed, there is increasing evidence to support the efficacy of probiotic supplementation, alone or in combination with prebiotics, in reducing the number, duration, and severity of acute infectious diarrhea and URTI cases in the general population [15][16][17]. The interest in athletes' diet supplementation arises from this evidence. Essentially, probiotics would act by moderating the negative effects of acute and chronic intense exercise on the immune system, thus reducing susceptibility to the aforementioned pathologies [15][16][17].

2. Single-Strain Probiotics Supplementation

Prevention of Respiratory Infections

Eight studies investigated the effects of single bacterial strain probiotic supplementation on the prevention, occurrence, duration, and severity of respiratory tract infections. Cox et al. conducted a trial on a group of healthy elite male distance runners for a duration of 28 days. The supplementation of a probiotic composed of *Lactobacillus fermentum* VRI-003 resulted in a reduction in the number of days of respiratory infection and a tendency to a lesser extent of the disease [18]. Gill et al. evaluated the effects of a short-term (7 days) supplementation of *L. casei* on a group of healthy endurance-trained male runners. They deduced that this kind of supplementation does not provide further immune protection at the level of the respiratory oral mucosa [19]. Gleeson et al. conducted two studies in which they used two different bacterial strains for 16 weeks. In the first study, they administered a probiotic based on *L. casei shirota* to a group of healthy subjects who were engaged in regular sports training (various sports); in this case, there was a reduction in the frequency of respiratory infections correlated with a better maintenance of salivary immunoglobulin A (IgA) levels [20]. In the second study, they conducted the experimentation on a group of endurance athletes by administering them a probiotic based on *L. salivaris*. In this case, there was no reduction in the frequency of respiratory infections, nor did the supplementation affect lymphocyte counts or antimicrobial protein levels [21]. In a further study, Gleeson et al. evaluated the effects of long-term (5 months) supplementation of a probiotic based on *L. casei Shirota* on a group of endurance athletes. This kind of supplementation did not reduce the episodes of respiratory infections, however, it resulted in a reduction in antibodies towards cytomegalovirus and Epstein–Barr virus in people with these infections [22]. Komano et al. found a reduction in cumulative days of respiratory infection symptoms following the short-term (13 days) administration of a probiotic based on *Lactococcus lactis* to a group of healthy male athletes [23]. Marinckovic et al. found only a trend towards a reduction in the severity of respiratory infections, the duration of episodes, and the number of symptoms (*L. helveticus Lafti* L10) [24]. However, West et al. obtained uncertain results following the administration of *L. fermentum* VRI-003 PCC for 11 weeks in a group of agonist cyclists. The burden (duration × severity) of lower respiratory disease symptoms was lower only in males, while it increased in females [25].

Prevention of Gastrointestinal Infections

Regarding the possible effects of probiotic supplementation on the prevention of and reduction in the incidence of infections affecting the gastrointestinal tract, two studies have investigated this. Kekkonen et al. found a reduction in the duration of episodes of GI infections following the supplementation of *L. rhamnosus* for a period of 3 months

to a group of marathon runners [26]. West et al. found a decrease in the severity of GI disease by administering a probiotic based on *L. fermentum* VRI-002 PCC to a group of agonist cyclists for a period of 11 weeks [25].

3. Multispecies Probiotics Supplementation

Prevention of Respiratory Infections

Five studies have investigated the possible effects of multispecies probiotics on respiratory infections. Only Batatinha et al. found no results on the role of probiotics in the prevention of these diseases (*Bifidobacterium animalis* subsp. *Lactis* and *L. acidophilus* for 30 days) [27]. The other studies show encouraging results. Haywood et al. found no episodes of respiratory infections in elite male rugby union players, following the administration of probiotics for 4 weeks [28]. Pumpa et al. reported a lower incidence of infections in a group of rugby players after a 27-week integration period [29]. Strasser et al., after 3 months of supplementation of *Bifidobacterium bifidum* W23, *Bifidobacterium lactis* W51, *Enterococcus faecium* W54, *L. acidophilus* W22, *L. brevis* W63, and *Lactococcus lactis* W58, noted a limited rate of tryptophan degradation directly related to a lower incidence of respiratory infections in trained athletes [30]. Tavares et al. found a mitigating effect on the incidence of respiratory infections in a group of male marathon runners, deriving from the 30 days administration of *L. acidophilus* LB-G80, *L. paracasei* LPc-G110, *L.* subp. *Lactis* LLL-G25, *B. animalis* subp. *Lactis* BL-G101, and *B. bifidum* BB-G90 [31].

Prevention of Gastrointestinal Infections

Four studies investigated the GI tract and all of them showed a beneficial effect of probiotics. Haywood et al. found no episodes of disease [28]. Pugh et al. observed a reduction in the incidence and severity of symptoms associated with GI diseases in a group of marathon runners, after 28 days of administration of *L. acidophilus* (CUL60 and CUL21), *B. bifidum* (CUL20), and *B. animalis* subsp. *Lactis* (CUL34) [32]. Pumpa et al. found a reduction in the onset of GI infections [29]. Schreiber et al., after 90 days of supplementation, noted a reduction in symptoms associated with GI infections in a group of male cyclists supplemented with *L. helveticus Lafti* L10, *B. animalis* ssp. *lactis Lafti* B94, *E. faecium* R0026, *B. longum* R0175, and *Bacillus subtilis* R0179 [33].

4. Effects of Probiotics Supplementation

The studies concern experiments conducted from 2006 to 2021 examining the effects of probiotics on athletes in the context of various sports disciplines. In particular, these studies aimed to investigate how the use of probiotics can prevent or alleviate the main infections related to high-intensity exercise.

With regard to disorders affecting the GI tract, the results suggest that both the integration of single-strain probiotics, based mainly on *Lactobacillus* spp., and that of multispecies probiotics produce protective effects against these pathologies, after a long-term administration ranging from a minimum of 4 weeks to a maximum of 27 weeks. With regard to the integration of single-strain probiotics, minimal dosages, compared to the higher ones experienced in the administration of multispecies probiotics, but taken on a long-term basis, are already able to

help in reducing the duration of GI infections. However, the use of probiotics based on multispecies probiotics at even lower dosages and fewer times can provide more effective protection. In particular, the association of Bifidobacteria, Lactobacilli, and *E. faecium* is able to reduce the incidence of nausea, belching, and vomiting and of GI symptoms due to intense physical exercise.S

Comparing the effects of single bacterial strains with that of multispecies probiotics, it can be deduced that while the former can reduce the duration of episodes of disease/disorders and the severity of infections, the latter actually have a predominantly preventive action, managing to intervene in intestinal permeability and reducing the incidence, as well as the severity, of symptoms affecting the GI tract.

As for respiratory diseases, the results are encouraging in the case of both single-strain and multispecies probiotics consumption. In particular, the administration of *L. casei Shirota* has been shown to be effective in reducing the frequency of respiratory infections. Short-term administration of *L. lactis* at high doses also resulted in a reduction in cumulative days of respiratory symptoms. *L. fermentum* VRI-003 led to a reduction in the number of days of illness and a tendency to a reduction in the severity of the disease (administration for 28 days, 2 billion), and a reduced symptom burden (given for 11 weeks, 1 billion). On the other hand, no results have been obtained from the administration of *L. salivarius*, albeit in high doses and for a long period, of *L. casei* after a short-term administration (7 days), and of *L. casei Shirota* in another study, which, however, found a low incidence of infections.

With regard to the effects of multispecies probiotics, the combination of various strains of Lactobacilli and Bifidobacteria has determined excellent results in terms of reduction in incidence, further underlining the power of multispecies integration. Only one study did not show any results, which is probably attributable to the poor variety of species administered in the 30 days before the competition. In fact, in another considered study, which provided a lower dose of probiotics (5 billion) and a richer variety of species for an equal time, a mitigation of the incidence of infections was found. So, contrarily to the theory that the use of each bacterium separately can produce results while their combination can be less effective or not at all effective [34], in this case it is precisely the heterogeneity of the probiotics that gave a greater effectiveness.

As regards the type of physical exercise, the most represented one is endurance sports [18][19][21][22][25][26][27][31][32][33] in which the supplementation of probiotics has determined, in most cases, positive effects in terms of mitigation of the symptoms associated with respiratory and gastrointestinal tract infections and, in one study, in terms of reducing the incidence of respiratory [31] infections. In this case, the supplementation concerned multispecies probiotics, further underlining the importance of the association of multiple bacterial species.

While there are only two studies [28][29] involving rugby players, they offer interesting results. In both studies, supplementation included the use of multispecies probiotics following which a reduction in the incidence of gastrointestinal and respiratory infections was recorded.

As for the studies conducted on subjects who performed various types of physical exercise [20][23][24][30], the supplementation with a probiotic based on *L. casei Shirota* produced a reduction in the frequency of URTIs in one study [20]. Furthermore, the supplementation of multispecies probiotics in this case also determined beneficial effects in terms of reducing the incidence of URTI.

As for the formulations used for the administration of probiotics, in most of the studies including probiotics these were administered in capsules including maltodextrin as an additive. Maltodextrin is a polysaccharide, used as a food additive and commonly added as a stabilizer, coating material, or bulking agent. Scientific studies conducted in recent years have concerned the potential effects of the consumption of maltodextrin, not only in animals, but also in humans. In particular, it was shown that in humans the use of maltodextrin represents a stressor for the endoplasmic reticulum of intestinal epithelial cells with a consequent reduction in mucus production downstream, thus determining an increase in susceptibility to colitis [35]. In the case of athletic subjects, intense physical activity causes an increase in intestinal permeability, which makes the intestinal barrier more susceptible to the entry of substances such as toxins and pathogens. So, it should be clarified whether the maltodextrin used in probiotic supplements can somehow negatively affect the beneficial effects of the probiotic itself. All this must also be contextualized with respect to the type of diet followed and, therefore, the overall quantity of maltodextrin taken in the diet.

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