



Can Nutritional Interventions Prevent Athletes from Illnesses or Excessive inflammation?

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Introduction

High level athletes are continuously exposed to different stress factors. High intensity and exhausting training programmes, travel, sleep disturbances due to time shift, psycho-social and environmental stress factors influence their organism homeostasis. All these factors are potential immune disruptors sometimes leading to immunodepression and increased likelihood of illness. In order to minimise these disruptive effects and to optimise recovery, nutritional interventions could be considered by athletes as possible countermeasures to the training-related immunodepression.

However among numerous nutrients available, only a few of them have so far shown any positive effects in maintaining athlete immune health.

General recommendations

As long as the diet meets the energy demands and provides sufficient macro- and micro- nutrients to support the immune system, there is probably no need for consumption of “immune boosting” supplements. However, there are specific scenarios where energy, macro- and micronutrient intake may be insufficient and athletes might benefit from nutritional supplements to bolster immunity (Table 1).

In the real world, athletes sometimes either intentionally or non-intentionally experience deficits in energy intake (e.g. weight-loss diets, restricted rations, irregular due to travel schedule) and macronutrient intake (e.g. restricted carbohydrate as during periodised nutrition). There is substantial evidence showing that only a few days on restricted energy intake compromises immunity. There may be other times when athletes experience both a down-turn in host defense and increased exposure to pathogens, e.g. foreign travel for training camps and competitions. As such, there are specific scenarios listed in the Table 1, when these individuals might benefit from nutritional supplements to bolster immunity.



Carbohydrates

Carbohydrates are fuel for the immune cells. As far as immune system functions are concerned, carbohydrates appears to be more effective when ingested during exercise rather than increasing their relative content in the daily diet.

Performing exercise at very low carbohydrate diets (less 10% of energy consumption) is associated with blunted immunological response after exercise. These effects are diminished when exercising following high (more than 70% of energy consumption) carbohydrate diet. 60 g/h could be seen as recommended amount of carbohydrates during exercise as consuming since bigger amounts doesn't seems to give additional benefits. Increasing dietary carbohydrates does not neither appear to exert any additional beneficial effects on immune system functions.

Thus carbohydrate ingestion is a partial countermeasure against exercise-induced immune impairment and is more effective when consumed during exercise than by increasing dietary content of carbohydrate on routine basis.

Minerals

Several minerals are known to exert modulatory effects on immune function, including Zinc (Zn), Magnesium (Mg), Iron (Fe), Selenium (Se), and Manganese (Mn).

Regarding exercise, requirements for some of these minerals are certainly higher in athletes compared with sedentary people. Behind that exercise increase losses of minerals with sweat and urine. There is evidence that regular exercise training of high volume and intensity may be accompanied by deficiencies of certain minerals such as Zn, Mg and Fe. Thus, it is important to check that the athlete's diet contains sufficient quantity of these elements.

However there is no evidence that additional supplementing non-deficient athletes might boost the immune system or prevent exercise-induced immunodepression. Se and Mn cannot be classified as immunonutrients for exercise.

Fatty acids

There is evidence that several saturated fatty acids promote inflammatory processes. n-6 poly-unsaturated fatty acids have shown some immunodepressive effects. This occurs regardless the origin of arachidonic acid: meat, eggs or plants. Some studies with untrained individuals eicosapentaenoic acid and decosahexaenoic acid appears to decrease the exercise-induced inflammation and muscle soreness.

However most of the studies on fatty acids and immune function and inflammation in context of exercise have provided data which is difficult to interpret.

Probiotics

Probiotics are interesting immunonutrients since they demonstrate immunomodulation properties. In non-athletic populations studies demonstrated that probiotic use resulted in a lower incidence of upper



respiratory tract infection (URTI), reduced numbers of illness days, and fewer days of absence from day care/school/work. Despite a lower number of studies, the same benefits seem to exist in athletic populations.

Although a daily dose of $\sim 10^{10}$ live bacteria is widely promoted, there is still some debate about the optimal duration of supplementation and the potential benefits of selecting and mixing specific bacterial strains with or without prebiotics.

Bovine colostrum

Bovine colostrum exhibits antibacterial, anti-inflammatory and anti-viral properties. Several investigations have reported a reduction in self-reported URTI incidence in athletes following a period greater than four weeks of supplementation. However, the effect of bovine colostrum on illness duration is less conclusive.

Vitamin D

A large number of different immune cells and functional are influenced by vitamin D. Optimal circulating 25-hydroxy vitamin D concentration is possibly beyond 75 nmol/l as individuals with such a vitamin D concentration demonstrated a lower incidence of URTI.

Antioxidants

Prolonged, exhaustive exercise and immune system activation are associated with an increased production of reactive oxygen species, leading to a potential increase in oxidative stress.

However there is no data to support links between exercise-induced oxidative stress and immune dysfunction. There is neither any evidence on benefits of dietary antioxidant supplementation in preventing immune dysfunction during exercise or in reducing the risk of respiratory illness in athletes.

Herbal supplements

Although herbal supplements are widely used by athletes either to improve their performance or to boost their immune system, few human *in vivo* studies focusing on specific immune parameters are available and most of the available studies use *ex vivo* or *in vitro* conditions. Results from these studies are conflicting and are often not in full agreement with the purported immunomodulatory claims from the food supplement industry. For example, as therapeutic immunomodulators for athletes, there is some evidence that *Echinacea* may be efficacious whereas the evidence for ginseng is poor. Polyphenols found in tea, coffee, fruits and wine exhibit strong anti-inflammatory, antioxidant, anti-pathogenic, and immuno-regulatory properties *in vitro*. Epidemiological data in general support that polyphenol-rich plant extracts and unique polyphenol-nutrient mixtures have small but significant effects in increasing anti-oxidant capacity, with inconsistent, short-term effects on mitigating exercise-induced oxidative stress, inflammation, and immune dysfunction. Quercetin consumed at high doses (500 to 1,000 mg) has been linked to reduced incidence of self-reported URTI in athletes.



Table 1: possible scenario to bolster immunity in athletes

Scenario	Immune health and performance	Supplement	Supporting evidence and knowledge gaps
Winter season	Common cold and Influenza season; URS decrease training and performance; low ultraviolet B skin exposure decrease vitamin D	Vitamin D ₃	Moderate support for vitamin D in athletes/military; recommend 1,000 IU/day of D ₃ from autumn to spring to maintain sufficiency
		Vitamin C	Moderate support in athletes/military; Cochrane review of 5 studies in heavy exercisers (n=598) shows ~50% decrease in URS taking vitamin C (0.25-1.0 g/day); unclear if antioxidants blunt adaptation in well-trained; further support required
		Probiotics	Moderate support in athletes with daily dose of ~10 ¹⁰ live bacteria; Cochrane review of 12 studies (n=3720) shows ~50% decrease in URS incidence and ~2 d shortening of URS; minor side effects
		Glutamine	Limited support; Glutamine (2 x 5 g), or a Glutamine precursor, decrease self-reported URTI after endurance events; this dose increases but does not maintain blood Glutamine nor alter many aspects of immunity; mechanism for therapeutic effect unclear; further studies required
Suffering URTI	URS decrease training and performance; particularly in illness prone	Zinc lozenges	Moderate support; Cochrane review shows benefit of zinc acetate lozenges (75 mg) to decrease duration of URS; must be taken < 24 h after onset of URS; side effects include bad taste and nausea
		Vitamin C	No support; Cochrane reviews show no benefit of 'initiating' vitamin C supplementation (> 200 mg/day) after onset URS
Foreign travel	Increased URS risk; stress prior to travel may decrease immunity; increased exposure to pathogens; travelers' diarrhea and risk of dehydration	Probiotics	Moderate support; probiotics can reduce risk of travelers' diarrhea; probiotics do not decrease episode duration; minor side effects; further studies required
Energy deficit	Training with energy deficit decreases performance and immunity	Multi-vitamin/mineral; probiotics; bovine colostrum etc.	Limited support for supplements to reduce URS and bolster immunity in these scenarios; multivitamin/mineral supplement may provide insurance; unclear if antioxidants blunt adaptation in well-trained; impact of train low CHO on immune health remains unclear; further studies required
Train low CHO	CHO restriction/periodization may increase adaptation and performance but decrease immunity		
Training camp/military operation	Threats to immunity include: increase in physical exertion; other stressors e.g. psychological, altered sleep, heat and/or altitude; limited food choices; energy deficit		

URS = upper respiratory symptoms; URTI = upper respiratory tract illness; CHO = carbohydrate