Immunology, Nutrition, and the Athlete, Part I

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With the ever-increasing popularity of endurance-type sporting events (marathons, triathlons, and “ultra” versions of these and other combined sports), the study of immunology in the athlete continues to grow as a burgeoning field. More practically, preventative and natural medicine-oriented physicians continue to provide a role in serving this sector of the population as research continues to explore the role of nutraceutical and botanical medicines and their role in athletic performance and immunologic function. The ever-increasing number of such grueling competitions that challenge the limits of human endurance continues to push the boundaries of current dietary recommendations for these athletes. The selection of diet is dependent on factors such as the type and duration of the event, recovery time, and total energy expended.

Another interesting new challenge involves exploring the effects of endurance exercise on the athlete’s immune system. Well-established in the literature, moderate, near daily exercise leads to positive changes in the immune system that correlates with *less frequent* upper respiratory tract infections. Therefore, a commonly held belief is that moderate (near-daily physical activity of 30 minutes or more) exercise benefits the immune system. An example of this was detailed in a study during which a group of people that walked briskly on a near-daily basis were compared to another group of completely sedentary individuals; the walkers experienced a greater than 50% decrease in sick days over a period of 3-4 months; these changes were noted without observed immune function changes.[1] It is hypothesized that the improvement in host protection and immunosurveillance that is concordant with moderate exercise is related to an additive effect from the acute positive immunologic changes that occur with individual exercise sessions. Additionally, the benefits of moderate exercise may be applied to numerous disease processes as both a preventative and treatment therapy. Over time the most notable benefit of a regular, moderate exercise program equates to less sick days with the common cold or other upper respiratory tract infections.[2] This is not to negate the other far-reaching effects of exercise on several disease processes; epidemiologic studies demonstrate a beneficial effect from exercise at decreasing risk from heart disease, stroke, hypertension, diabetes mellitus (type 2), osteoporosis, falls and fractures in the elderly, dementia, anxiety, and depression. In addition, this research shows a link, albeit weaker, between sedentary lifestyles and higher risks of colon, breast, and lung cancers.[3] Exercise is without a doubt perhaps the single greatest contributor to one’s state of health; nearly every person can benefit from some form of physical activity.

On the other hand, intensive, prolonged exercise causes several changes in immune function that are a reflection of the physiologic stress and suppression endured in such circumstances; training of this type leads to an increased predisposition to upper respiratory tract infections (URTIs) and excessive physical exertion that extends beyond roughly 90 minutes is correlated with adverse immune system changes in several areas including the skin, upper respiratory tract mucosa, blood, lung tissue, and muscle.[2]

The risk of exercise-related infection seems to follow a J-shaped curve, with non-exercisers experiencing more infections in comparison to regular, moderate exercisers while those that exercise regularly at a strenuous level have the highest risk. This risk of infection continues to grow when factors such as travel (exposure to new pathogens), inadequate sleep, weight loss, excessive mental stress and inadequate nutrition are added to an aggressive exercise regimen. Following strenuous exercise, athletes enter a period of time in which they experience impaired immune resistance in which they are more susceptible to URTIs. However a definitive causal relationship has not yet been clearly defined.[4] According to Neiman, anecdotal, survey, and epidemiologic data all correlate with an increased risk of URTI among endurance athletes both during and following (perhaps up to 1-2 weeks) periods of intensive training.[5] The period of time in which the athlete is more susceptible to infection is referred to as the open window; the time appears to vary from as little as three hours to seventy-two hours.[6]

In a review of the literature focusing on the effects of chronic exercise training on human immune function, it was revealed that although immune cell numbers remain at normal levels during the training episodes, other evidence shows slight impairment in immune parameters such as neutrophil function, serum and mucosal immunoglobulin levels, plasma glutamine concentration, and cytotoxicity of natural killer cells.[7]
Whether an athlete is clinically immunosuppressed or not, the possibility exists that the combined effects of these small changes in immune function may contribute to a compromised resistance to minor illnesses thereby having a detrimental effect on performance and by preventing the athlete from competing at their maximal level.

Exercise and Immune Function

In an attempt to better understand the mechanisms by which heavy exercise training influences infection resistance, several recent studies have attempted to identify these effects.[8] Among these findings are altered numbers of circulating leukocytes and their subsets, plasma cytokine concentrations, natural killer cell activity, rate of secretory immunoglobulin A secretion, as well as neutrophil and macrophage phagocyte activity. This research also indicates that these perturbations may persist for several hours to days following the exercise while some athletes have shown decreased resting/post exercise values of non-specific immune parameters such as complement, acute phase proteins, and neutrophil activation. Additionally, chronically intensive exercisers displayed progressive decreases in neutrophil function and certain unspecified subclasses of serum and secretory immunoglobulins.

Other studies indicate the role of T lymphocytes in exercise and immune function; decreased T-lymphocyte function has been observed following intensive exercise, and this is suspected to be a part of the causality of increased URTI among certain athletes.[9] Intense exercise may also suppress mucosa-related immune parameters as well; one recent study noted a decrease in salivary IgA and IgM concentrations following intense periods of exercise and that the degree of immune suppression and rate of recovery following exercise were associated with exercise intensity and duration.[10]

Decreased levels of salivary IgA and IgM are associated with an increased risk of respiratory illness in athletes; however the mechanisms for this mucosal immune cell suppression are not known at this time. These data represent only a small fraction of the research in this area; it does suggest that highly trained athletes suffer from immune suppression that is clinically relevant. In addition, it is important to note that the psychological stress associated with training and competing at an elite level may also be a factor in the effects of intense exercise on the immune system.

While at first glance the increased risk of viral URTIs in endurance athletes seems to be trivial, for the competitive athlete such illnesses can be the deciding factor in whether an athlete can remain competitive or not. Additionally, the prevalence of such infections appears to be quite high in this group, both statistically and on a clinical basis. Although actual numbers are not available, the prevalence of athletes one may encounter with persistent URI-type illnesses is quite high and is a popular topic. One often-quoted example is a study based on participants in a marathon event. Those who trained at 97 kilometers or more per week experienced twice the URIs compared to those who trained at 32 kilometers per week, while the faster runners in the marathon had a 6-fold increase in URI in the week following the race.[11] Infections of minor severity can lead to missed workouts or competition, while actual physical performance decreases performance generally. Surprisingly, the exact mechanism of performance degradation has been debated, with one source weighing decreased motivation against the actual effects of the disease![12] Performance following a URTI generally rebounds quite vigorously once the major symptoms have subsided, however some athletes may be saddled additionally by postviral fatigue syndrome.[13]
In general, URTIs may be treated by a moderation of training and other medicines. However, once systemic, the severity of illness can become worse; signs of systemic viral infections include fever, myalgia, cough, vomiting, diarrhea, fatigue and lymphadenopathy. Those with symptoms such as this should temporarily discontinue exercise altogether, until symptoms are gone.

Preserving Immune Function

Many factors are suspect in exercise-related immune depression; researchers continue to explore nutritional influences that can alter this phenomenon. Of the many possible causes for immune dysfunction in athletes, inadequate and or inappropriate nutritional intake seems to take precedence as evidenced by the literature. In general, insufficient dietary intake of protein and certain micronutrients have long been known to adversely affect immune function, regardless of fitness caliber. Fats and carbohydrates play a role as well, and in some instances, competitive athletes may adopt unusual diets in order to enhance performance thereby predisposing them to immunologic challenges.

Fat intake (and large increase in body fat, although unlikely in endurance athletes), in excessive amounts is detrimental to immune function, while insufficient fat intake and concomitant reduction in body mass can impair immune function in an already lean athlete. Likewise, moderate intake of polyunsaturated fatty acids (PUFAs) has many positive health effects for the athlete. PUFAs (namely omega-3-type) exert beneficial effects on immune function[14] and play a major role in altering inflammatory processes, making them useful for injury recovery as well.

Carbohydrates in particular have been shown to have impressive effects on the immune function of athletes engaged in long-term fitness events. Athletes that perform in a carbohydrate-depleted state have greater increases in circulating “stress” hormones and wider negative variations in immune functions while those that consume 30 to 60 grams of carbohydrate during sustained, intense exercise appears to decrease the rise in stress hormones and limits the degree of immune suppression as well.[15] Among the effects of carbohydrate ingestion during competition include higher plasma glucose, decreased cortisol and growth hormone, stabilization of leukocyte counts, lower granulocyte and monocyte phagocytosis and oxidative burst activity, as well as decreased pro and anti-inflammatory cytokine release. Investigators have not concluded, however, that carbohydrate ingestion during competition decreases the amount of infections following intensive exercise.

The majority of athletes demonstrate only minimal deficiencies in essential nutrients (and are therefore far from maintaining *optimal* nutrient levels). Among the most common micronutrients that are deficient in athletes and which have the greatest impact on immune function are the vitamins A, E, B-6, B-12, folate, essential fatty acids, the amino acids glutamine, arginine, and L-carnitine, as well as trace elements.[16,17]

Psychological Influences

The link between the hypothalamus and immune function allows for neurologic perceptions to modulate the impact of physical activity on physiologic systems, including immune cells. Psychological stress and intense physical activity appear to have similar effects; both induce similar neurohormonal responses including secretion of cortisol, growth hormone, epinephrine and norepinephrine. Undoubtedly, athletes participating in competition experience more intense psychological challenges in comparison to athletes working at similar intensity in a laboratory setting thereby predisposing them to greater potential immune dysfunction. One study demonstrated an increased propensity for those who restricted social contacts and/or spent excessive amounts of time in goal-oriented activities to suffer from a greater number of upper respiratory infections;[18] these particular lifestyle patterns are similar to those of athletes pursuing intensive athletic competitive goals. Stress modulation is an important tool (perhaps as important as nutrition) when considering treatment options for prevention of exercise-induced immunosuppression.

Maintaining nutritional health in athletes is a strongly debated and controversial topic. Practitioners must assess the individual’s nutritional needs and at the minimum ensure that the basic requirements for nutrition are met. Adequate energy intake must be met with a correctly balanced ratio of macronutrients; this ratio differs from person to person and is also heavily dependent on the fitness activity of choice. An essential point is that the application of nutritional therapies to endurance athletes cannot necessarily be applied using a one-fits-all, cookbook approach to diet and nutrition. The use of immuneboosting supplements must be applied in much the same way; the field of natural medicine is quite full of numerous products that alter immune function in a variety of ways; selection of the correct therapy for the athlete becomes a more complex issue when taking the entire person, as an individual, into account. The next article in this series will address individual nutrients and botanicals and their application to the immune system in exercise-induced immunosuppression.

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