Understanding the Relationship between Immune Health, Exercise and Nutrition

The immune system plays a major role in training adaptations, but is poorly understood by most exercise professionals. Part of the reason is medical science has yet to unravel all of the functions, reactions and interactions of this system. For example, various autoimmune disorders and diseases remain untreatable such as multiple sclerosis, rheumatoid arthritis, celiac disease and type I diabetes. The immune system is remarkably complex and regulates homeostasis in a synergistic fashion with other intricate components such as the endocrine system; leaving many unknowns even among the scientific elite. As it relates to health professionals, the immune system is involved in tissue recovery and repair following strenuous exercise as well as protecting against potentially-damaging pathogens such as bacteria or viruses (e.g., the flu). The system is designed to quickly recognize and systematically attack foreign materials in the body; in the case of autoimmune disorders, it mistakenly recognizes healthy bodily organs or tissues as internal invaders. Immunological processes are facilitated via two subsystems with specific functions:

**Innate Immunity System:**
- Activated when an infectious agent attempts to enter the body; first line of defense
- Comprised of general mechanisms such as skin and mucus (e.g., nose, throat) as well as cellular defenders such as phagocytes, natural killer (NK) cells, and cytokines

**Adaptive Immunity System:**
- Activated when the innate system fails and an infection has begun; directly aids recovery by releasing lymphocytes from lymph nodes to attack the infectious molecules
- Has the ability to create an immunological “memory” response following an encounter with an infectious agent; this allows for an augmented defensive response the next time the body is infected by the same pathogen

Immune responses vary based on the demand. In some cases it must attack a certain type of infectious agent, in others it must cope with environmental conditions associated with distress due to intense
exercise, lack of sleep, and/or poor nutrition. In any case, a systemic inflammatory response will be initiated to increase blood flow and capillary permeability in the area(s) of infection to allow white blood cells (WBCs) and other components to enter and potentially resolve the issue.

**Immune Responses to Exercise and the Reducing the Risk for Infection during Intense Training Periods**

For reasons that are not fully understood, the incidence and prevalence of autoimmune disorders in the US is rising. It is estimated that they currently effect between 14.7-23.5 million people, or up to 8% of the total population. This makes many potential clients at risk for negative immune responses or suppression when exercise is inappropriately applied. It is equally important to recognize the relationship between exercise and immune health for correct programming. In any case, prolonged intense exertion is associated with hormonal and biochemical changes which challenge the immune system and lead to overreaching. Without adequate recovery the immune system weakens and contributes to overtraining syndrome.

In fact, an acute bout of exercise results in responses which are similar to those seen during an infection:

- There is an acute increase in WBC, cytokine, NK cell and stress hormone (e.g., cortisol, adrenaline) activity; with a subsequent drop during the recovery period following the session
- Circulating glutamine levels tend to drop by around 20% and can remain depressed for hours
- Inflammation from muscle damage and temporary reductions in immune function after the session provide an open window for infection

These reactions and the risk for infection can be accelerated due to a number of physical, environmental, psychological and nutritional factors. For example, clients who engage in high-mileage endurance training are at a higher risk for upper respiratory tract infections (URTIs). Prolonged training in the heat can actually increase intestinal leakage which allows bacteria to enter circulation; this is one of the reasons nearly 70% of all lymph nodes in the body surround the gut. Anxiety and high levels of distress can impact stress hormone dynamics; while nutritional deficiencies (or excess) can impair various immune functions directly (e.g., low carbohydrate intake). A common behavioral error is exercising without adequate carbohydrate and fluid sufficiency. Exercising intensely in this state causes significant muscle damage when hypoxic conditions are prolonged.

Exercise professionals can use the following practical recommendations to educate their clients on how to reduce the risk for infection from flu viruses and/or severe immune suppression. They have application following an exercise bout as well as during training phases characterized by higher levels of physiological strain.

- Avoid immediate contact after training sessions with others who are sick, large crowds or school-age children when possible
- Immediately wash your hands upon leaving the gym with antibacterial soap or wipes and do not share towels
- Avoid touching your eyes, inner nose or mouth after working out until you have taken a shower
- Maintain good oral hygiene, use antiseptic mouthwash and never share bottles or cutlery
- Use properly treated water for swimming or recovery after training; consider avoiding shared saunas or showers directly after a training session
- Keep other life, social and psychological stresses to a minimum if possible
- Get regular and adequate sleep; >6 hours is recommended for most people, teenagers need >8
- Following each training session, make sure to consume a healthy meal including carbohydrates as soon as possible
- Rehydrate during and immediately after each session; dry mouth increases the risk for a URTI
- Avoid large quantities of alcohol
- Eat a well-balanced diet to obtain all the necessary vitamins and minerals; if the diet is lacking or fresh foods are not readily available a multivitamin supplement may be useful
- Ensure adequate daily energy, carbohydrate and protein intake (low-carbohydrate diets can be associated with immuno-depression)
- Drink carbohydrate sports beverages before, during and after prolonged endurance training
- Allow sufficient time between training sessions for recovery; more training is not always better
- Avoid extremely long training sessions, restrict activity to less than 2 hours per session
- Provide variations in training loads; follow a hard training day with a less intense day
- Do not eliminate recovery days even when attempting to increase training volume
- When recovering from an illness, begin with very light training and build back up gradually
- Monitor and record mood, feelings of fatigue, and muscle soreness during training; decrease training intensities or load when sessions feel harder than normal

**Nutrition and Immune Function**

Inadequate nutrient (energy) availability has a significant impact on the immune system. Likewise, excess intake of specific micronutrients such as iron or zinc can have detrimental effects. Nutritional deficiencies can have direct or indirect effects on immune function. When it has an impact on the lymphoid system it is categorized as direct; when it impacts all cells or related organs it is categorized as indirect.

Low carbohydrate availability can directly impact immune function by reducing WBC function as well as indirectly through its influence on circulating stress hormones such as catecholamines and cortisol. In fact, carbohydrate intake has one of the most significant impacts on immune function. Adequate blood glucose is necessary to fuel the very high metabolic rates of most immune cells that attack invading pathogens. Exercising in a carbohydrate-depleted state causes larger increases in circulating stress hormones, reduces glutamine availability and reduces the effectiveness of several immunological defense mechanisms. To limit the risk for these effects among clients who perform high-volume training (e.g., >2 hours every day), 8-10 g/kg of body weight should be consumed on a daily basis.
Healthy fats also exert effects on the immune system by altering cellular membrane activity to increase nutrient absorption as well as serving as precursors for eicosanoids. Eicosanoids are hormone-like compounds produced from essential fatty acids that help regulate a number of functions such as blood pressure, inflammation, cellular metabolism and blood clotting. Omega-3 and Omega-6 polyunsaturated fatty acids can also promote direct changes in the immune system. Some studies have even shown them to improve the condition of individuals suffering from an overactive immune system (e.g., rheumatoid arthritis). However, the contributions of dietary fatty acids to the acute regulation of immune function following exercise in not clearly understood. Protein deficiency on the other hand can have significant impacts on acute and chronic immune function. Glutamine is utilized at extremely high rates by WBCs. Daily intake of about 1.6-2.0 g/kg of body weight is necessary for many clients who engage in high-volume and intense weightlifting.

Several vitamins also play an important role in immune activity and are essential for normal function including vitamin A (antioxidant), vitamin C (WBC production), and various B-complex vitamins (metabolism, immune cell function). All micronutrients that function as antioxidants help reduce the distressing impact of free radicals on the immune system. Unregulated free radical activity can inhibit the activity of antibodies, lymphocytes, and NK cells. Nevertheless, mega-doses of antioxidants are not recommended; they should be obtained through natural sources such as fruits and vegetables as supplemental antioxidants can suppress inflammatory signaling. Major minerals to consider include zinc, iron, selenium, copper, magnesium, manganese and cobalt. Zinc deficiency directly causes lymphoid atrophy and increases the risk for infections. Iron deficiency greatly depresses macrophage production and the capacity of lymphocytes to attack invading pathogens. Selenium, copper, magnesium and manganese all serve as antioxidants while cobalt promotes the development of red and WBC in bone marrow. Many other non-essential nutrients outside of the essential maco- and micro-varieties can influence immune function. High consumption of alcohol can directly suppress a wide range of immune responses, while moderate intake may actually be beneficial (polyphenol content). Caffeine seems to exert positive effects when consumed in appropriate quantities. Likewise, Echinacea, probiotics, beta-glucans, quercetin, curcumin and various dietary supplements have all been shown to possess immunomodulatory potential.

**Conclusion**

Science currently understands that alterations in immune function depend upon the parameters set during exercise such as frequency, intensity and total volume. These training factors cause cascades of cellular signaling which lead to complex processes of DNA translation, protein synthesis and/or cell proliferation (adaptations). Moderate exercise has been shown to bolster certain components of the immune system and possibly decrease the incidence of some infections and perhaps even cancer (e.g., colon). High-intensity, long-duration exercise on the other hand can have adverse effects and promote a marked decline in the functioning of all major cells within the immune system. In addition, overtraining may reduce the response of lymphocytes to infection, decrease antibody synthesis and impair macrophage phagocytosis. The reduced plasma glutamine levels that occur with high-intensity exercise or excessive training are postulated to contribute to these adverse effects on the immune system. Proper balance of nutritional intake is just as important with various micronutrients as well as carbohydrates and protein having a major impact on immune health.