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Exercise and the immune system

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The immune system is a system for self-recognition and maintaining homeostasis. It is an extremely complex network that extends throughout the body, and it can recognize and defend the organism against a theoretical infinity of challenges. The participants in innate immune mechanisms are macrophages and neutrophils, along with natural killer (NK) cells, complement and defensins, and they constitute the first line of defence. All its constituents need a basic capacity to distinguish between self and foreign, and danger or non-danger signals with the involvement of Toll-like receptors (TLR). By engulfing, processing and presenting antigens, macrophages form the critical link to the specific branch of the immune system that mainly comprises the various subpopulations of lymphocytes and their products. While regular moderate exercise is very likely to be associated with decreased susceptibility to infection, excessive exhaustive exercise has been associated with symptoms of transient immunosuppression, leading to increased susceptibility to infection. This outcome is particularly the case for athletes in a competitive setting, who are frequently subjected to physical, psychological and environmental stress as well as to inadequate nutrition that may cause immunosuppression.

However, recently there has been excessive generalization of the notion that moderate exercise is beneficial and intense exercise is harmful for the immune system. The latest studies, however, have revealed that this general finding cannot be extended to phagocytosis. Some stages of the phagocytic process, in particular chemotaxis and phagocytosis, are stimulated by both moderate and intense exercise, which may counter some of the pronounced suppressive effects of intense exercise on lymphocytes and NK responses.

Exercise-induced changes in the immune system are mediated by the stress hormones, mainly glucocorticoids and catecholamines. Exercise-induced stress also results in the release of the 72 kDa heat-shock protein (Hsp72), which also has marked effects on immunity. Stress hormones and proteins may also be considered as 'stress mediators' in the exercise-induced stimulation of phagocytes and as 'danger signals' for the immune system during intense exercise. Stimulation of chemotaxis and phagocytosis of neutrophils and macrophages by glucocorticoids and noradrenaline at physiological exercise-induced concentrations has been reported[1]. Post-exercise Hsp72 concentrations also stimulate neutrophil phagocytosis and chemotaxis through TLR-2 together with its cofactor CD14.

Chemotaxis and phagocytosis of neutrophils and macrophages are two important functions in the inflammatory response. However, while inflammation plays an important role in host defence, uncontrolled inflammatory reactions are responsible for the initiation and progression of autoimmune and inflammatory diseases. In this context, it has also been found that intense exercise also alters the pro-inflammatory–anti-inflammatory cytokine balance, which is critical for inflammatory and autoimmune diseases; mainly in women, who are more susceptible to these types of pathologies. It has been reported that glucocorticoids, noradrenaline and Hsp72 modulate the release of pro-inflammatory cytokines by phagocytes and other immune cells[2,3]. In addition pro-inflammatory cytokines, such as IL-1, IL-6, IL-8, interferon-γ and TNFα can inhibit food intake. IL-1, together with catecholamines and glucocorticoids, may regulate glucose homeostasis during an immune response; probably, as recently reported, serving to divert glucose to inflamed tissues to satisfy the high energy cost of the immune response[4]. During exercise muscle-derived IL-6 has been also shown to affect metabolic responses, such as increase glucose metabolism, lipid oxidation and lipolysis[5].

Thus, it is necessary to bear in mind that the immune system is a homeostatic regulatory system that operates in situations of high energy costs such as exercise-induced stress, and, moreover, it is involved in disease situations that also need high energy contributions.

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