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The prospective effects of exercise sports on the body's immune functions

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Abstract
Strenuous or intense exercise has severe and continual influences on a person's systemic immunity. When athletes and non-athletes are resting, their respective systems are more alike than dissimilar except the activities of the NK cell which have a tendency to be elevated in the athletes. Many constituents of the immune system display adverse changes after long-drawn-out heavy exertion. These changes occur in several sections of the immune system and the body (like the skin, lungs, blood, muscles and the mucosal tissues of the upper respiratory tract). Although it is still subject to interpretation, most exercise immunologists are of the opinion that it is during the said "open window" of impaired immunity (whereby the duration may vary from 3 to 72 hours, contingent on the immune measure) during which viruses and bacteria may possibly gain a foothold, thereby resulting in a higher risk of subclinical and clinical infection. The risk of infection can become greater than before when the other immune-related factors are present, such as being exposed to novel pathogens when travelling, not having enough sleep, undergoing severe mental stress, suffering from weight loss or malnourished.

Keywords: exercise, training, leukocytosis, antibodies, immunoglobulins, infection

1. Introduction
The methods that can be used to assess the most important functional elements of the immune system are described here. The seriousness of the responses to exercise is dependent upon the intensity and period of the required activity as well as the fitness level of the individual. Moderate endurance exercises do not change or enhance indices such as granulocyte, leucocyte, lymphocyte, monocyte and total T-cell counts, serum immunoglobulin levels, helper-suppressor cell ratio, *in vitro* immunoglobulin production and cell proliferation in response to mitogens. But, very tiring exercises then to produce unfavorable changes in these indices, especially if the physical activity occurs with environmental or competitive stress [1]. Moderate and appropriately graded training decreases the reactions to any of the exercise with an absolute intensity. When undergoing a training regimen that is more demanding, it is vital for the person doing the exercise to optimize his immune responses. If the preparation for the athletic performance is worked at till it becomes stale and results in muscle injury, it may have extensive negative implications for several aspects of the immune functions and it includes resistance to acute infections, cancer, ageing, HIV infections as well as any other conditions that are influenced by the immune system [2].

2. The Methods for Assessing the Responses of the Immune Functions to Exercise
Exercise and its overall effect on the immune system can be observed by plotting a subject's responses to inoculations or general susceptibility to infections. The separate elements of the system can be assessed by carrying out differential blood counts, analyzing lytic activity, quantifying the degree of cell proliferation or immunoglobulin production in reaction to cytokines or external mitogens, and assessing cytokine or cytokine receptor densities [3].

2.1 Susceptibility to Infections
Susceptibility to infections can be assessed by inoculating subjects with a standard amount of a comparatively harmless virus like that of the common cold. But, rapid mutation of the virus can give rise to problems and result in a loss of immunity. Another possible method is to

examine antibody production after the injection of anti-tetanus toxoid or Merieux Multitest [4].

Epidemiologists have established a link between incidences of specific infections with heavy training sessions or strenuous competition. But, do not forget that exercise can change the risk of infection through mechanisms apart from a change of immune function. Examples of the earlier assertion includes activities that may result in exposure to contaminated water or air, cold or polluted air when inspired may depress the function of the tracheal cilia, or a change of lifestyle by the subject may vary his chances of falling sick [5].

2.2 The Differential Blood Counts

The population of white blood cells includes polymorphs (basophils, eosinophils and neutrophils) and mononuclear cells (lymphocytes, monocytes and plasmocytes, a progeny of B lymphocytes). The various sub-populations in the blood can be ascetained through the use of monoclonal antibodies. The total and differential white cell counts provide some clues of the functional condition of the immune system, but many other factors may alter the reading during bouts of vigorous exercise [6].

An incomplete list of extraneous influences that can alter peripheral leucocyte counts during strenuous activity includes: (1) a reduction of blood volume; (2) higher cardiac output resulting in the demargination of hitherto sequestered cells; (3) the activation of adrenoreceptors that decreases the number of leucocytes that are attached to the endothelium depending on the level of circulating catecholamines; (4) autonomic nerve activity that results in the release of catecholamines and co-transmitters; and (5) the secreting of cortisol that stimulates the release of granulocytes from the bone marrow [7]. The analysis is complicated because a big portion of the total leucocyte count is ordinarily not circulated. The amount and whereabouts of the non-circulating leucocytes can be traced by injecting radiolabelled autologous cells into the body [8]. The non-circulating neutrophils are generally located in the liver, lungs and spleen, but the non-circulating lymphocytes are predominantly located in the liver and spleen. During long exhaustive runs, the number of immature neutrophils in the blood circulation system increases by 17 times, and this indicates that the non-circulating cells have been carried into the general circulation system. In human beings, exercise has minimal influence on the dimensions of the spleen and splenectomy also has minimal influence on the exercise-induced leukocytosis. The changes in the total leucocyte or lymphocyte counts indicate the mobilization of cells from the liver and the 2A lymphocytes is mainly responsible for the cell-mediated immune function [9]. The lymphocytes are divided into T cells (coded in the thymus in response to both specific allergens and nonspecific mitogens), B cells (it undergoes the maturing process in the bone marrow) and null cells. The T cells were initially distinguished due to their tendency to form “rosettes” with sheep [10].

2.3 Cell Proliferation

When lymphocytes are incubated with tritiated thymidine, the radioactive molecules are integrated with the DNA of the newly formed cells. From the radioactivity of the newly formed cells it is possible to study how the spontaneous proliferation rate is transformed by exercise, training and non-specific activators like hormones, antigens, cytokines and neuropeptides [11]. Most of the time, the cell proliferation rate is assessed *in vitro* and whole blood or the mononuclear cells from washed peripheral blood are incubated with non-specific mitogens like plant lectins, concanavalin A (Con A) or phyto-haemagglutinin (PHA). When the procedure is carried out using whole blood samples, the responsed to PHA are known to be resistant to oral cortisone, but the responses to Con A are depressed by cortisone The mitogens derived from plants act on receptor sites that are different from the receptors for specific antigens. The lectins stimulate a non-specific reproduction of all the subsets of T cells which can be employed to test the effect of exercise and training on the particular kind of lymphocyte [12]. The major actual problem with this assay is that the responses varies enormously depending on the concentration of the mitogen. Therefore, the tests have to be replicated by using different concentrations of mitogen so as to find the optimal dose. A 12 hour fast by the subject will enhance the chance of getting the same response from a given subject [13].

2.4 Immunoglobulin Synthesis

The changes in the concentration of immunoglobulins of the plasma or saliva do not mean that there are corresponding changes in the immunoglobulin synthesis [14]. The body fluids concentration are affected by receptor binding, blood concentration, catabolism as well as the movement of protein involving the blood and other fluid compartments. The salivary concentrations are also affect by the amount of saliva that is secreted. The most common type of immunoglobulin is IgG, but it also includes anti-toxic, anti-bacterial and anti-viral antibodies as well as potent opsonins which can enhance phagocytosis. Macroglobulins (IgM) are found in cytoplasm as well as on the surface of B cells during the early stages of their maturation. The first group of antibodies is produced by the plasma cells that are developed from the activated B cells and it include cold agglutinins, haemaglutinins, IgA, IgD and IgE.[15] The capability of the plasmocytes to manufacture immunoglobulin can be evaluated *in vitro* by using antihuman IgM and IgA after the peripheral blood mononuclear cells have been incubated with a non-specific mitogen like pokeweed, that can activate T and B cells [16].

3. The Reaction of the Immune Functions to Acute Bouts of Exercise

Even though exercise can induced noticeably severe responses in some components of the immune system, the said responses are normally transitory, and there have been queries about the extent such changes can affect the body’s defense system in the presence of bacteria, viruses and neoplastic cells. If blood samples are taken more than 30 minutes after the exercise, the results of the analysis may be affected by the rebound phenomenon and the measurement of the various immune functions may even exceed that of the pre-exercise levels [17]. Unfortunately, the responses are fairly variable and changes from one day to another as well as one person to another thus making it difficult to generalize. The factors that can modify the reactions of the immune system consist of the amount of effort that is put in relative to the person’s state of training, the amount of time spent doing the exercise as well as associate competitive and environmental stresses. With regards to the duration of the exercise, it has been noted that short-term activities will mobilize the sequestrated cells while longer duration of activities will result in them escaping into the tissues. The results that have been obtained show that it is dependent upon the methods that were used during the assessment of the immune function [18].

3.1 Leukocytosis of the Blood and Lymphocytosis

Previously, the studies merely report on the total white cell or lymphocyte counts. Acute exercise brings about a higher peripheral venous leucocyte count that is approximately proportional to the severity and period of activity. However, prolonged activity may reduce total leucocyte counts caused by the migration of monocytes and NK cells into the injured muscles. Strenuous exercise may result in a delayed leukocytosis about 30 minutes to 3 hours after the exercise and this is due to the release of white cells, stimulated by cortisol, from the bone marrow. After a marathon, the late leukocytosis may persevere for a few hours, but if the exercise is moderate, it is more often than not complete with 6 hours [19]. However, the granulocytes and especially neutrophils causes most of the late increment in the white cell count. The response is most obvious in persons that have a high capacity for physical work whereby the eosinophil count drops whereas the basophil count remains relatively unchanged. How significant these responses has on body functions is still in doubt, but non-specific immunity may be improved [20].

The is a substantial increase in the monocyte count during or as soon as the exercise is completed, and at this stage the lymphocyte count also shows some increase. Some studies have put forward the idea that the response is dependent on the kind of exercise performed by the subject, for example, cycle ergometry gives rise to a larger lymphocytosis than treadmill exercise [21]. Other inter-trial differences point to the time blood samples were taken relative to when the exercise was performed and this is due to the use of non-automated cell-counting methods in the early days which resulted in relatively smaller number of blood samples and the immune function recovery was often already completed within 30 minutes after the exercise. Not less than two groups of hormones play a part to the changes in cell counts, At the beginning stages of the exercise, catecholamine secretion invigorates the discharge of lymphocytes from the endothelia of the venules, through the process of "demargination". Further into the exercise, the cortisol that is secreted induces and overall leukocytosis which in turn stimulate the discharge of granulocytes from the bone marrow. However, it also impedes the entry and expedites the exit of lymphocytes from the circulation. Perhaps, some of the lymphocytes enter the muscle tissues together with the monocytes and NK, thereby expediting the repair processes. The remainder migrate to the lymphoid tissues, where they have a bigger probability of encountering macrophages as well as other antigen-loaded cells [22].

3.2 Lymphocyte Subsets

Outdated or archaic studies using non-specific markers indicated that exercise increases the proportion of B cells. But, the early investigators were not able to differentiate B cells from natural killer cells. It is an important source of blunder when stating B cell counts because exercise is known to have increased the NK counts significantly and therefore there is a need to cast doubts on the accuracy of such reports [23].

Nevertheless, current monoclonal antibody methods indicate that the absolute numbers of T and B cells rises after a 15 to 30 minute-round of submaximal exercise. However, the relative percentage change of the T and B cells varies from one study to another depending on the methodology, intensity of effort and the subject's fitness. On the whole, immediately after a half-hour of energetic submaximal treadmill exercise the proportion of B cells shows a small decrease [24].

The helper-suppressor cell ratio has a significant influence upon susceptibility to infection. Berk *et al.* [25] reported that immediately after the maximal treadmill exercise the overall percentage of T cells remained unchanged. However, the helper-suppressor ratio experienced a transitory drop from 1.94 to 1.36, an unsatisfactory level. Keast *et al*. reported findings that are essentially similar, and remarked that strenuous exercise heightened the sensitivity of T cell P-adrenoreceptors, i.e., by 121% and 80% on the helper T cells and suppressor T cells respectively [26]. Some researchers have, in general, found an increase while others a reduction in the percentage of T cells when the subject is exercising, but most of them have corroborated the early reduction of the helper-suppressor cell ratio [27]. Exercise apparently increases the number of cytotoxic T cells and at the later phases of recovery up to 24 hours after the exercise, the helper-suppressor cell ratio is higher largely due to a cortisol-induced reduction of suppressor cell numbers and this may possibly compensate for the snuffing out of natural killer cell activity [28].

The number of inter-cell differences of the P-adrenoreceptors is directly linked to the sensitivity to exercise-induced secretion of catecholamines and may lead to the lymphocyte subset changes for the duration of and after the exercise. B cells have about thrice the number of such receptors as T cells whereas the number of receptors T helper cells have is quadruple that of T suppressor cells. In addition to that, there is further a potential for up- or down-regulation of the system because the lymphocyte f3-receptors is controlled by normal levels of catecholamines and cortisol in the blood, and training [29].

3.3 The Natural killer Cell Numbers and Activity

Edwards *et al*. reported that 5 minutes of stair-running resulted in an instantaneous four- to five-fold rise in natural killer cell numbers as well as an upsurge of overall NK activity (based on the amount of chromium that was released from the labelled myeloid tumor cells). Other researchers have also document the early increase in the number and/or percentage of NK cells during moderate bouts of exercise [30]. A catecholamine-mediated reduction of cell margination may also contribute the increase in NK cell count. However, the intensity and duration of exercise that can create such effects has yet to be defined. Exercise can also activate and bring about an instantaneous higher proportion of killer cells. Berk, L. S., *et al* found that, immediately and within 24 hours after a 12.8 kilometer run, there was an enhancement of the cytotoxic activity of NK cells [31]. Similarly, Brahmi, Zacharie, *et al*. noted that NK activity increased by 40% 1 hour after the exercise. Unfortunately, strenuous exercise appears to have a less favorable long-term impact upon the natural killer cells. Berk *et al*. noted that there was a 31% drop in NK cell activity 90 minutes after a 3-hour marathon as well as a 50% drop in the number cells carrying the NK specific CD16 antigen, but there were no changes in the number of cells carrying the CD56 antigen that is common to cytotoxic T and NK cells. Shek & associates as well as Shinkai *et al*. have also reported a lengthened suppression of NK cell activity after a sustained round of exercise. Shek *et al*. discovered that there was a substantial drop of NK count and activity, and it persisted for not less than 7 days after one round of exercise that lasted between 90 to 120 minutes at 65% maximal oxygen intake [32]. However, their important findings have not been replicated by other laboratories or researchers [33]. The initial increase in of

cell activity is restrained by naloxone, an endorphin inhibitor, implying that endogenous opioids could probably be mediating the preliminary stimulation of the natural killer cells. If that is so, the round of exercise probably ought to be fairly vigorous because moderate activity does not have much influence upon the secretion of endorphin. Exercise-induced fluctuations in the concentration of interleukins and interferons can also modify the surface properties of the NK cells, including their lytic activity. The NK activity is negatively correlated with the serum cortisol levels and a large gush of cortisol secretion will probably cause the late suppression of NK activity. Prostaglandins released by the monocytes may also cause the persistent late reduction of NK cell activity. If that is the case, the negative impact of sustained or repeated rounds of heavy exercise can possibly be neutralized by the administration of indomethacin [34].

3.4 Immunoglobulin Synthesis

Hanson and Flaherty noted that the serum immunoglobulin levels did not change 10 minutes following a 13 kilometer submaximal run, however the concentrations in serum, saliva and in the nasal, saliva and serum secretions generally dropped after extended exhausting activity and sometimes it take as long as 4 days to recover [35]. Most researchers have deduced that there is a corresponding inhibition of immunoglobulin production. Zoher, *et al*. detected a half an hour after finishing a marathon run the *in vitro* production of tetanus antibodies was normal [36]. However, Hedfors *et al*. stated that just 15 minutes of submaximal exercise was enough to slow down the pokeweed-stimulated production of IgG as well as IgM. Quite recently, it was observed that properly trained long distance runners who, after finishing a 30-minute round of submaximal treadmill exercise, showed higher pokeweed-stimulated *in vitro* production of IgG 5 minutes after the exercise. The discrepancies is due to the following differences: (1) the amount of exercise performed; (2) the timing of the sampling; and (3) the subject's level of training. In addition to that, Hedfors *et al*. adopted the whole-blood culture method in their studies [37].

4. The Case of the Immune Function after Endurance Training

The use of cross-sectional comparisons between animals that have been trained and those that have not or endurance sports persons and sedentary subjects is advantageous because of the prolonged training as well as there being sufficient opportunity for the individuals to get use to the physical demands of the strenuous activities [38]. During the process of making the said comparisons of immune responses between the endurance sports persons and sedentary subjects, it is crucial to distinguish the relative strength of any workout that is performed so as to be able to take into account the stresses of concurrent competition as well as the heavy travel plans, and to make sure that there is sufficient recovery from the recent training sessions [39].

If there is no "overtraining", the immune status of athletes at rest is generally normal, even though some researchers have noticed granulocytosis, lymphocytosis, higher antibody-dependent cytotoxic and NK cell activity as well as plasma IL-1 and IL-2 activity [40]. At any given absolute work-rate, athletes will have less leukocytosis than sedentary persons, however if the two groups are stressed to the maximum or at a comparable fraction of maximum effort, the leukocytosis appears to be comparable in the two groups. There are essentially no dissimilarities in the overall T cell or trained and untrained persons' subset responses to exercise. In any case, the test results on mitogen responsiveness is conflicting [41].

Athletes that are undergoing active training may have poorer phagocytic activity. Simpson *et al*. remarked that compared to healthy men without training, athletes who are taking part in basic controlled intensity training have lower total lymphocyte, NK, T and T helper cell counts and the CD4-CD8 ratio was also lower in their resting blood samples [42]. Oshida *et al*. have also observed that while exercise unvaryingly lowered the percentage of T and T helper lymphocytes cells, in trained athletes the percentage of T suppressor cells showed distinct increases. However, they noted that there was an increase the NK count and the preceding finding was recently duplicated by Rhind *et al*. The higher NK count in athletes also appears to be linked to an upsurge in the number of cells bearing markers of the 70-75kDa P-receptor for IL-2 (but, it does not have the p55IL-2 oa-receptor) [43].

Pedersen *et al*. reported that the resting salivary IgA levels were lower in elite cross-country skiers when compared with the controls, although it was probably due to incomplete recovery from the previous exercise. The levels decreased further after 3 to 3 hours of exhaustive skiing, although the analysis of the data was complicated by the changes in the volume of saliva that was secreted [44]. A few other researchers have also observed that elite performers have low serum immunoglobulin levels, but most researchers have discovered there were either no changes or even the immunoglobulin readings were higher in response to more moderate training, especially if due care was taken to allow for the expansion of plasma volume induced by training [45].

Tomasi *et al*. noted that complement levels, both during and after exercise were found to be lower in marathon runners than in age-matched controls [46]. They conjectured that the demands of repetitive distance running may have overworked the liver's ability to synthesize, although the blood volume was altered, the catabolism of amino acids like glutamine in response to depressed levels of glycogen and urgent repair reactions in damaged muscles may also have contributed to this finding. The serum levels of C-reactive protein in athletes are also lower than those in the control group and this may be caused by the chain of events that were induced by muscle injury [47].

4.1 Longitudinal Training Studies

The response to planned training is dependent on the intensity, frequency and period of the applied regimen, as well as on the preliminary condition of the individual. Several researches involving training whereby the sports persons almost reached the point of overtraining, indicated that after training the T cells can account for a larger proportion of the total lymphocytes, but the helper-suppressor cell ratio is decreased. If the training was strenuous, the NK cell count may also drop and it is caused by the migration to injured tissues or they were converted into T cells. But, Woods *et al*. discovered that NK cell activity was increased in an elderly population upon the completion of a light training program [48].

Training tends to increase resting mitogen-induced lymphocyte proliferation, but the recovery period after the final round of exercise must be sufficient for the response to be present. Thus, Koch *et al*. noted that there was a decreased response to mitogens immediately after the cessation of a training program, but after 72 hours of recovery the response was higher [49]. Training typically weakens the overall

lymphocytosis of a sedentary person when he participate in an exhausting exercise. Rhind *et al*. observed that 12 weeks of moderate exercise weakened the exercise-induced lower *in vitro* IL-2 production and augmented the expression of IL-2 p-receptors. But, exhausting training has a calmative effect on animals and humans. In rats and mouse, the mass of the thymus is reduced and the lymphocytes of the spleen become less responsive to mitogen stimulation, and it may be because the proportion of T cells in relation to B cells have been altered and it may also be due to T suppressor cell actions or macrophage-secreted prostaglandin E2. Similarly, data from studies in humans indicate that after a round of submaximal exercise the lymphocyte response to mitogen usually decreases even though the proliferation may be increased in athletes who abuse the usage of anabolic steroids [50].

Moderate exercise seemingly increases resting plasma IgA levels whilst on the other hand, heavy exercise lowers the IgG and IgM resting levels, and mitogen-stimulated IgG synthesis. Immediately before and during major competitions, the levels of IgG, IgA and IgM are also low [51].

4.2 Interaction with Other Stressors

If an athlete's diet is insufficient to meet the demands of exercise, an absence or deficiency of amino acids like glutamine can have an adverse effect on the growth of immune cells. Athletic competition by itself can be perceives as stressful or it may be caused by environmental and psychological stress. The stress-induced secretion of cortisol may repress some aspects of the immune function. Finally, extended exercise by itself may stimulate the release of cortisol, even though it is a normal metabolic control mechanism there are parallel implications for the immune function [52].

Systemic infections can change the immune responses to training and can also directly cause a deterioration of physical performance and it can be a source of stress for an athlete. Even though an exercise may not be stressful to a healthy person, it can become physically and psychologically stressful if the person has a developing infection. During the assessment of supposed training-induced responses, consideration must be given to the superimposed stresses including how the factors change as the subjects become familiar or get used to any given laboratory or competitive environment [53].

5. The Clinical Embodiments

In conclusion, several clinical embodiments of the exercise-induced changes of the body's immune function will be briefly discussed.

5.1 Detection of overtraining

There were hopes that the changes of the resting immune parameters or a disturbed immune response to training might give an early warning that an athlete's conditioning program was too intensive and was becoming over-trained. It is difficult to conduct such type of experiments because it is ethically incorrect to make athletes train until the reach the level of injury. Richardson *et al*. observed that when a group of long distance athletes undergoing intensive training intentionally, over a period of three weeks, increase their average training intensity by a whopping 38%, the resting mitogen-stimulated lymphocyte proliferation have a propensity to increase [54].

The helper-suppressor cell ratio decreased (perhaps, the athletes did not reach the overtraining threshold but the ratio was above the important level of 1.5) and the pokeweed mitogen-induced synthesis of immunoglobulins was less than normal. Furthermore, a 30 minute round of submaximal exercise (which formerly did not modify cell proliferation) has now induced an 18% suppression of lymphocyte proliferation and the immunoglobulin synthesis, stimulated by exercise, did not happen. Nonetheless, the changes that occurred were small and varied. As such, the researchers concluded that simple psychological tests may perhaps offer a simpler and more effective method to detect staleness in an athlete [55].

5.2 The Risk of Infection

Viral infections is a serious threat to international sports persons. Experiments and clinical studies of animals have linked too much physical activity to any increased risk of viral infections and viral myocarditis. Verde *et al*. opined that two out of ten long distance runners contracted acute upper respiratory tract infection (URTI) in response to a 3-week training schedule that was deliberately intensified and they have linked this outcome to evidence of immunosuppression [56]. Similarly, Peters discovered that the chances of developing URTI were doubled in runners who ran more than 97 kilometers per week during training as compared to those who ran less than 32 kilometers per week. When a runner takes part in a major marathon, the chances of infection is 6 times more than other runners who did not take part. On the other hand, moderate exercise evidently increase the human volunteers resistance to some diseases [57].

5.3 The Risk of Cancer

The role of the NK cells is to destroy tumor cells, but excessive exercise is believed to increase an athlete's risk of developing some form of cancer. A few early experiments carried out on animals indicated that moderate exercise make the animals more resistant to experimental tumors. Studies done with humans indicate that moderate, occupational or leisure activity offers protection against some types of cancer. In colon cancer, the mechanism probably involves an alteration of the colon's transit time instead of an exercise-induced modification of the immune function. Reproductive cancers in active women may also undergo small alterations, but the change appears to be linked to lowered body fat and lower estrogen levels, instead of enhanced immune function. Experiments to treat certain type of cancers with IL-2 were carried out recently. Excessive doses of interleukins gave rise to major complications and a training program can probably play an important role in the development of IL-2 receptors, thereby resulting in a lower dosage of cytokine to treat the patient [58].

5.4 Ageing

Ageing is linked to the progressive deterioration of the immune function as well as the development of various autoimmune disorders. Therefore, probably moderate exercise may offer some protection whereas excessive exercise may hasten the problems. Currently, there is not much evidence to show that habitual exercise delays the ageing process, however studies on animals indicate that animals with physical inactivity and a restricted diet has a slower inherent rate of ageing [59].

6. Conclusion

The evidence reviewed in this brief article indicates that a moderate dose of endurance exercise has beneficial effects

upon a person's immune responses, but more intense and stressful exercise may have a persistent adverse effect. Most of the changes that were acquired from one round of moderate exercise were fairly short-lived, but a prolonged round of exercise or training for an event like a marathon race can caused a prolonged suppression of NK activity, exposing the athlete to an immediate risk of viral infections as well as potential adverse changes in other more long-term manifestations of impaired immune function. The probability that any given round of exercise may have an adverse effect on immune function is dependent on the relative intensity of the effort that is demanded. Regular training can move the threshold for adverse reactions higher. Nevertheless, given the importance of the immune system in the many aspects of health, this writer is of the view that there is a need to have more information as to the dose of exercise that will optimize a person's responses and to avoid the long-term negative consequences.

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