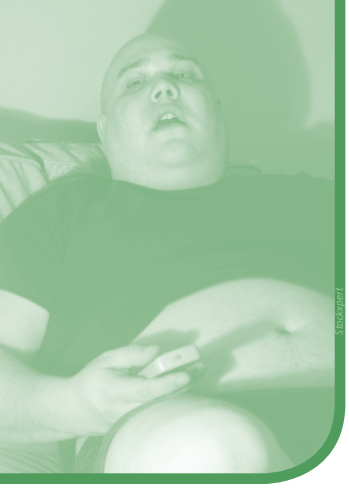


Couch potato or elite athlete? Finding the happy medium

In the year of the Olympics, SGM explores the impact of exercise on our ability to fight infections.

INFECTIONS of the nose, throat, windpipe (trachea) or the two airways that branch from the trachea as it reaches the lungs (bronchi) are common. These upper respiratory tract infections (URTIs) include the common cold, sinusitis and tonsillitis, and most are due to a viral infection. The average adult has two to three URTIs each year. We are constantly exposed to the viruses that cause these infections, but some people seem more susceptible to catching URTIs than others. Every day our immune system protects us from an army of pathogenic microbes that bombard the body. Immune function is influenced by an individual's genetic make-up as well other external factors such as stress, poor nutrition, lack of sleep, the normal aging process, lack of exercise or overtraining. These factors can suppress the immune system making a person more vulnerable to infection.

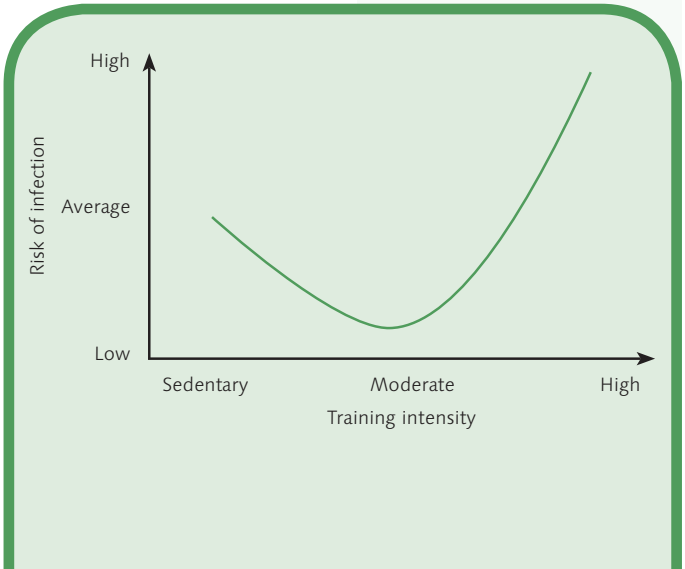
EXERCISE AND ITS EFFECT ON THE IMMUNE SYSTEM

Exercise can have both a positive and negative effect on immune function and can influence an individual's vulnerability to infection. The underlying reasons for this variability are multifactorial and include infectious, neuroendocrine and metabolic factors, with the diet and training regime of the individual also playing a role. For athletes, environmental factors such as travel and accommodation also contribute to the risk of infection.

Researchers have found a link between moderate regular exercise and reduced frequency of URTIs compared with a sedentary state and excessive amounts of exercise and an increased risk of URTIs. An epidemiological study carried out by Matthews *et al.* in 2002 on moderate to vigorous activity and risk of URTI showed that regular moderate exercise per day was associated with a 29% reduction in the risk of getting a URTI compared to individuals that had a sedentary lifestyle. Professor Nieman of Appalachian State University, USA showed that when moderate exercise is repeated on a near daily basis there is a cumulative effect that leads to a long-term improvement in immune response. His research showed that those who walk at 70–75% of their $V_{O_2\,max}$ (volume of oxygen that can be utilized while exercising at maximum capacity for 1 minute) for 40 minutes a day have half as many sick days due to colds or sore throats as those who don't exercise. Conversely, other studies have reported a 100–500% increase in risk in developing an URTI in the weeks following marathons and ultra marathons. Following strenuous exercise, athletes enter a brief period of 'open window' time in which they experience weakened immune resistance and are more susceptible to viral and bacterial infections, in particular of the respiratory tract.

Evidence of URTIs collected for this research is not usually based on detection of the virus in isolates but taken from medical records or via an individual's response to questionnaires, so some of the reported sore throats may not be due to infectious agents but to non-infectious airway inflammation caused by allergies or inhalation of pollutants.

A 'J'-shaped model (see diagram below) has been used to describe the relationship between the amount of physical activity that is undertaken and risk of URTI. There is some evidence that this increased susceptibility to infection is due to a depression in immune system function of the individual. Studies have shown that exercise causes



physiological changes in the immune system.

IMMUNE RESPONSE – NATURAL KILLER (NK) CELLS

NK cells are a type of white blood cell that plays an important role in the host's defence against virally infected cells. NK cells are cytotoxic and recognize and kill host cells that have become infected with virus. NK cells are known as natural killers because they don't need to react to specific antigens, they just need to recognize that a cell is foreign. They form part of the innate immune system. When NK cells come into close contact with an infected cell they release granules of protein called perforin and proteolytic enzymes called granzymes from their cytoplasm. Perforin forms pores in the cell membrane of the infected cell, allowing the granzymes to enter and cause apoptosis. The infected cell breaks up into membrane-bound fragments that are then removed by phagocytes. An advantage of killing infected cells by apoptosis is that the cell's contents, including virus particles are not released as they are during cell lysis, thus preventing their spread into uninfected cells. NK cell activity can be modulated by many different agents. The cytolytic activity of NK cells is enhanced by cytokines such as interferon and interleukin, signalling molecules that are released by the host cell in response to infection by the virus particle. Conversely, prostaglandins and immune complexes downregulate NK cells.

NK cells are highly influenced by physical exercise. The possible important mechanisms behind exercise-induced changes in NK cell function are cytokines and stress hormones.

During moderate activity, NK cell activity is enhanced. Studies show that NK cells are recruited to peripheral blood during exercise and that the cells recruited respond to interleukin. Intense activity experienced by elite athletes involved in training and competing in endurance events such as marathons and ultra-marathons has been shown to downregulate NK cell activity. This immunodepression is thought to be caused in part by prostaglandins.

HORMONES

Adrenaline

Adrenaline, often known as the 'flight or fight' hormone, is produced by the adrenal gland in response to physical activity. It is constantly produced in small amounts to maintain normal blood pressure. During exercise, larger amounts of the hormone are released into the bloodstream where it prepares the body for increased physical activity by speeding up the heart rate, diverting blood flow to the muscles, widening the airways, dilating the pupils and raising the blood sugar level. Increased NK cell activity during exercise may relate to adrenaline levels, since it has been shown that the increase in activity occurs within 15–30 minutes after subcutaneous administration of adrenaline to healthy individuals.

Corticosteroids

Corticosteroids are a class of hormones with a wide range of physiological functions that are produced in the adrenal cortex. They include glucocorticoids – the most important of which in humans is cortisol. Cortisol is known as a stress hormone as it is secreted at higher levels in response to stressful situations. Elite athletes are exposed to the psychological stress of competition (worry/anxiety). During endurance events and over-training, the body is exposed to the physiological stress of prolonged exercise, and taking part in extreme environments – heat, cold and altitude can also put stress on the body. Repeated bouts of intensive exercise can cause the elevation of stress hormones, particularly glucocorticoids, which may suppress the immune system. Corticosteroids have been shown to inhibit NK cell activity *in vitro* and also *in vivo* when measured more than 24 hours after administration of the synthetic corticoid drug methylprednisolone. However, other studies have shown that NK cell activity increases 4 hours after cortisol is given. Whilst it is known that during intense physical exertion stress hormones temporarily lower immunity, further research is needed to determine how such exercise might influence NK cell activity.

GET A MOVE ON ...

The message from current research seems to be that moderate exercise does have a positive effect on the immune system. So to keep colds at bay we should all go out for a brisk, daily walk.

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Thanks are due to Professor Mike Gleeson, University of Loughborough, for reviewing this article.

FURTHER READING

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