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A Review on exercise and blood cells

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Abstract

Exercise is generally known to be beneficial to the body. However if the intensity and duration of the exercise is increased it can lead to tissue damage, release of stress hormones and alteration in the levels of circulating immune cells which can be also seen in cases like burns, surgery, and physical trauma.Leucocytes according to many authors increase significantly within the few minutes of exercise.Rohde and wacholder were the first to observe that leukocyte counts increases within the first few minutes of exercise. Trained athletes, especially those that engage in endurance sports such as marathon races and other long distance races, have a decreased hematocrit, which is sometimes called sports induced anaemia. This is not anaemia in a clinical sense, because these athletes in fact have an increased total mass of red blood cells and haemoglobin in circulation relative to sedentary individuals.The slight decrease in hematocrit by training is brought about by an increased plasma volume (PV).During exercise, blood circulation through the body is faster than normal and as the blood moves white blood cells, oxygen and nutrients pass through the walls of capillaries into the interstitial fluid or tissue fluid whereas cell waste flows in the opposite direction into the circulation for excretion.The paper reviewed exercise and blood cells.

Keywords

Exercise,
Red blood cells,
Platelets,
white cells.

Introduction

Exercise is generally known to be beneficial to the body. Exercising regularly boosts the immune system, prevents or reduces the risks of developing cardiovascular diseases, Type 2 diabetes mellitus and obesity (*Stamfer et al., 2001*).Exercise also promotes positive self esteem, prevents depression and improves the mental health generally.Stamina can be improved with constant exercise and with time reduces the amount of time required for the same exercise.

However if the intensity and duration of the exercise is increased it can lead to tissue damage, release of stress hormones and alteration in the levels of circulating immune cells which can be also seen in cases like burns, surgery, and physical trauma.

Interleukin-10(IL-10) level (anti-inflammatory cytokine) is known to increase when the duration of the exercise is increased, and this increase is related to the extent of tissue damage (*Nieman et al., 2006*).Creatinine kinase also increases when the intensity of the exercise is increased (*Brancaccio et al., 2007*).

Leucocytes according to many authors increase significantly within the few minutes of exercise.Rohde and wacholder were the first to observe that leukocyte counts increases within the first few minutes of exercise. Other researches that were carried out supported this idea that acute bouts of exercise increases the total white blood cell count especially the monocyte, neutrophil and lymphocyte counts but little is known about the effect of prolonged exercise among sportsmen (Footballers) who engage in the same form of exercise over a long period of time.

Platelets are blood cells that are essential for blood clotting, and also help in the immune function.Exercise is believed to have effect on the platelet count among sedentary individuals but little is known about how exercise affects trained sportsmen.

Exercise and the immune system

Exercise has both positive and negative effects on the immune system function and susceptibility to infections. It has been reported that regular performance of 2hour moderate exercise everyday is associated with 29% decrease in susceptibility to upper respiratory tract infection when compared with sedentary individuals (*Freedson et al., 2002).*

There is substantial increase in the number of circulating white blood cells particularly lymphocytes and neutrophils and the rate at which it increases depends on the intensity and duration of exercise.

Studies have shown that various immune cell functions are temporarily impaired after acute bouts of prolonged continuous heavy exercise (*Pederson et al., 2012).*

During or after exercise, there is an increase in the plasma concentrations of substances such as C-reactive protein, anti inflammatory cytokines (interleukin-6, interleukin-10, and interleukin-1-receptor antagonist), tumour necrosis factor-alpha and macrophage protein-1. Interleukin-6 is released from contracting muscle cells and the increase that is observed during exercise is as a result of release of this cytokine from the contracting muscle cells (*Steensberg et al., 2001*).

Hormonal changes also occur in response to exercise, including increases in the plasma concentration of several hormones like epinephrine (adrenaline), cortisol, growth hormone, and prolactin which are all known to have immune-modulatory effects. Muscle-derived IL-6 appears to be at least partly responsible for the elevated secretion of cortisol during prolonged exercise. Infusion of recombinant human IL- 6 into resting humans to mimic the exercise-induced plasma levels of IL-6 increases plasma cortisol in a similar manner (Steensberg *et al.,* 2003).

Recent researches have shown that relatively small increases in plasma levels of IL-6 induce the two anti-inflammatory cytokines IL-1ra and IL-10, together with c reactive proteins and as exercise ensues, the increase in IL-6 precedes the increase in these two cytokines, arguing circumstantially for muscle-derived IL-6 to be the initiator of this response (*Steensberg et al., 2003*).Whether humoral or cell-mediated immunity will dominate depends largely on the type of cytokines that are released by the activated T helper cells. T lymphocytes can be classed as type 1 or type 2 cells, depending on which cytokines they predominantly produce. Type 1 T cells produce mainly Interferon-γ and tumor necrosis factor, and their actions activate macrophages and induce killer mechanisms, including T-cytotoxic cells, thereby driving the immune system toward cell-mediated immune responses, which primarily provide protection against viruses. Type 2 cells mainly produce IL-4, IL-5, IL-10, and IL-13, which are necessary for promotion of humoral immunity, IgE-mediated allergic reactions, and activation of potentially tissue-damaging eosinophils. IL-4 and IL-13 are responsible for B-cell differentiation that results in antibody production, while IL-5 stimulates and primes eosinophils. Together with IL-4, IL-10 (which is also produced by monocytes and B cells) can inhibit type 1 T-cell cytokine production. Interestingly, it appears that exercise can influence the type 1/type 2 cytokine balance.

Strenuous exercises or prolonged bouts of moderate intensity exercise inhibits the production of Interleukin-6 (*Starkie el al., 2001*), and also inhibits the Interleukin-2 and Interferon-gamma by the T-lymphocytes (*Halson, 2004).*

Effect of exercise on the brain function

Consistent aerobic exercise over a period of several months induces an increase in increased gray matter volume in multiple brain regions, particularly those which give rise to cognitive control.The brain structures that show the greatest improvements in gray matter volume in response to aerobic exercise are the prefrontal cortex and hippocampus (Erickson *et al.,* 2014).

Neurobiological effects

The wide range of neurological effects that exercise has on the body could be long term and short term. Some examples of these exercises include jogging, brisk walking, cycling and swimming. Several researches that have been carried out have shown that consistent aerobic exercise (example walking for 30 minutes daily) induces persistent beneficial and neural plasticity as well as healthy alterations in gene expression.Neural plasticity is the ability to adapt overtime in response to stimuli (*Malenka el al., 2009*).

Long term effects of exercise are increased neurogenesis, increased neurological activity (c-Fos and BDNF signalling), improved stress coping, enhanced cognitive behavioural control, and structural and functional improvements in brain structures & pathways associated with control and memory.Exercise improves neurogenesis by increasing the production of neurotrophic factors (compounds that promotes survival and growth of neurons) that includes brain derived neurotrophic factor (BDNF), insulin- like growth factor (IGF), and vascular endothelial growth factor (*Szuhany et al., 2014*).

Another long term effect of exercise is that it helps in fighting depression. Depression is a mood disorder that is characterised by severe feeling of dejection and in most cases those that suffer from depression end up committing suicide. A number of medical reviews have shown that exercise has a significant and persistent antidepressant effect in humans (*Cooney et al., 2013*). The antidepressant effect of exercise is believed to be mediated through increased brain derived neurotrophic factor (BDNF) signalling in the brain.In 2013, Cochrane collaboration review on physical exercise noted that exercise is more effective in control intervention and comparable with psychological or antidepressant drug therapy.

The major short term effect of exercise is euphoria, which is colloquially known as “runner’s high” in distance running or “rower’s high” in crew (*Raichlen et al., 2012).* Recent researches and medical reviews have shown that endogenous euphoriants such as beta-phenylamide (stimulant), beta-endorphin (an opiod), and anandamide are responsible for producing exercise related euphoria.

Beta-phenylamide also known as phenylethylamine is a potent endogenous trace amine neuromodulator that has the same bimolecular target as amphetamine and as a result they interact with monoamine neurons in the central nervous system in the same manner.Thirty (30) minutes of moderate to high intensity exercise has been shown to induce a significant increase in beta-phenylacetic acid.

Beta-endorphin is an endogenous opiod neuropeptide that binds to opiod receptors to produce pain relief and euphoria. Moderate intensity exercise produces the greatest increase in secretion of beta-endorphin synthesis whereas higher or lower intensity exercises are associated with smaller increases in beta-endorphin synthesis.

Anandamide is an endogenous cannabinoid neurotransmitter that binds to cannabinoid receptors (*Tantimonaco et al., 2014*). Aerobic exercise causes an increase in the plasma anandamide level and it has been observed that moderate intensity exercise causes the greatest increase in plasma anandamide concentration. Increased plasma anandamide concentration is associated with psychoactive effects because it can cross the blood-brain barrier to act on the central nervous system (*Tantimonaco et al., 2014*).

Other effects of exercise on brain function

Exercise can reduce the risk of developing dementia, and in the Caerphilly heart disease study which over the course of 30 years observed 30 male subjects to determine the association between exercise and dementia. It was shown that male subjects who exercise regularly showed a 59% reduction in dementia when compared with sedentary individuals (*Elwood et al., 2013*).

Some other effects of exercise on brain function are increased supply of blood and oxygen to the brain, as well as increase in chemicals such as dopamine, nor-epinephrine, serotonin and glutamate which are known to promote cognition.

Effect of exercise on sleep

A review of published scientific research showed that exercise helps in sleep disorders like insomnia. It was observed that exercise induced effects on sleep was obtained when exercise was done 4-8 hours before bedtime, whereas heavy exercises before bed time was detrimental (*Buman, 2010*).

Anti-cancer effects of exercise

Physical activity (exercise) has been shown to have a relationship with reduced cancer mortality, especially in breast cancer and colon cancer mortality (*Friedenreich et al., 2012*).

Hyper-methylation of CACNA2D3 and L3MBTL genes is associated with development of gastric cancer and breast cancer, brain tumors respectively (*Yuasa et al.., 2009; Zeng et al, 2012*). Physical activity or exercise results in low methylation of these genes thereby leading to a decrease in mortality.

Cancer cachexia is a multi-organ syndrome characterised by inflammation, weight loss, muscle and adipose tissue wasting in cancer patients(Evans *et al.*,2008) and exercise is widely accepted as a non-pharmacological intervention for the prevention or attenuation of cancer cachexia in cancer patients (*Lira et al., 2014).*

Exercise and type 2 diabetes mellitus

Physical inactivity and muscle disuse results in accumulation of visceral adipose tissues and loss of muscle mass consequently leading to activation of a network of inflammatory pathways that promote insulin resistance or impair the function of insulin.

It was discovered that active muscle cells produce myokines whereas physical inactivity or muscle disuse leads to an impaired myokine response or resistance to the effects of myokines, thereby explaining the reason why lack of exercise increase the risk of developing diseases such as Type 2 diabetes mellitus and other cardiovascular diseases (*Pederson, 2012*).

Effect of exercise on the blood cells

Red blood cells

The main function of red blood cells in exercise is the transport of O_2 from the lungs to the tissues and the delivery of metabolically produced CO_2 to the lungs for expiration. Haemoglobin also contributes to the blood's buffering capacity, and ATP and NO released from red blood cells helps to vasodilation and improved blood flow to working muscle and these functions require adequate amounts of red blood cells in circulation.

Trained athletes, especially those that engage in endurance sports such as marathon races and other long distance races, have a decreased hematocrit, which is sometimes called "sports induced anaemia." This is not anaemia in a clinical sense, because these athletes in fact have an increased total mass of red blood cells and haemoglobin in circulation relative to sedentary individuals. The slight decrease in hematocrit by training is brought about by an increased plasma volume (PV).

Even though exercise stimulates erythropoiesis, it can decrease the red blood cell mass by intravascular haemolysis of senescent red blood cells, due to mechanical rupture of red blood cells as they pass through capillaries in contracting muscles, and by compression of red cells e.g., in foot soles during running or in hand palms in weightlifters. These adjustments cause a decrease in the average age of the population of circulating red blood cells in trained athletes and production of newer red cells. These younger red cells are characterized by improved oxygen release and deformability, both of which also improve tissue oxygen supply during exercise (*Mairbaurl, 2013*).

White blood cells

During exercise, blood circulation through the body is faster than normal and as the blood moves white blood cells, oxygen and nutrients pass through the walls of capillaries into the interstitial fluid or tissue fluid whereas cell waste flows in the opposite direction into the circulation for excretion.

Moderate increase in the number of lymphocytes (lymphocytosis) is observed after a few minutes of acute bouts of exercise which may often lead to an increase in the total white blood cell count (*Bhatti, 2003*).

However some forms of exercise that require the same amount of movement over a period of time focuses on specific muscles and results in improper circulation of blood to other organs and tissues in the body. These areas then become deficient in white blood cells, oxygen and nutrients. Low or moderate intensity exercise that requires the same type of movement over a long duration of time can cause improper circulation and lower white blood cell counts. Examples of such exercises are jogging, swimming, running.

Platelets

Exercise is believed to increase the platelet levels in sedentary and trained individuals but counts above 400 million per ml(severe thrombocytosis) induced by exercise returns to normal after 30 minutes of the exercise.

Trained sportsmen and sedentary individuals respond differently to the same form or intensity of exercise and these differences in their response is probably related to their platelet reactivity and antioxidant capacity.

Strenuous exercise increases the platelet levels and the increase could be as a result of the release of platelets from the spleenic pool.

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Conclusion

Exercise is generally known to be beneficial to the body. Exercising regularly boosts the immune system, prevents or reduces the risks of developing cardiovascular diseases, Type 2 diabetes mellitus and obesity. However if the intensity and duration of the exercise is increased it can lead to tissue damage, release of stress hormones and alteration in the levels of circulating immune cells which can be also seen in cases like burns, surgery, and physical trauma.

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