**Exploring the Mysteries of Exercise**

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Although the benefits of exercise are espoused daily in classes, newspapers, journals and on TV, less information has been dispersed regarding the underlying mechanisms causing these physiological changes. The responsibility of fitness instructors and personal trainers to their clients has grown vastly in the last few years. Being able to explain why and how certain physiological phenomena occur, from the regular participation in exercise, has become more of a daily necessity. This article will examine and explain some of the mechanisms how exercise may influence several bodily processes.

The Effect of Exercise on Resting Heart Rate

Regular participation in aerobic exercise often results in a decrease in resting heart rate by 5 to 25 beats per minute, although the explanation of this well-established phenomenon has not been conclusively elucidated. A complex network and interaction of nerves and chemicals regulate the speed of the heart as well as the openings in blood vessels to accommodate the distribution of blood throughout the body. The resting heart rate is under the influence of the autonomic nervous systems' sympathetic (accelerator) and parasympathetic (depressor) nerves. The lowered resting heart rate from exercise training is proposed to be due primarily to an increase in the parasympathetic activity with a minor decrease in sympathetic discharge (Katona, McLean, Dighton, & Guz, 1982; Smith, Hudson, Graitzer, & Raven, 1989).

An adaptation to the lowering of the resting heart rate, from aerobic training, is the heart's ventricles (specifically the left ventricle which pumps blood throughout the body) are able to accommodate a greater volume of blood. As the resting heart rate decreases there is then more time for filling the ventricles with blood, and more time for the delivery of oxygen and nutrients to the body and the heart muscle, making the heart more efficient in meeting circulatory challenges at rest.

The Effect of Exercise on Blood Pressure

High blood pressure is one of the most important risk factors for cerebrovascular diseases (NIH, 1993) . As many as 50 million Americans have elevated blood pressure [systolic blood pressure (SBP) of 140 mm Hg or greater and/or diastolic blood pressure of 90 mm Hg or greater] (NIH, 1993) . Regular moderate intensity physical activity (40% to 60% of maximum aerobic consumption) may be beneficial for both the prevention and treatment of hypertension, lowering SBP by approximately 10 mm Hg. The evidence is not as supportive on the effectiveness of resistance training in lowering blood pressure.

The mechanisms by which aerobic exercise may lower blood pressure partly involve the effects of two hormones, epinephrine and norepinephrine, on blood flow in the arteries. Both of these hormones are vasoconstrictors, which means that they decrease the diameter of the smallest arteries, referred to as arterioles. It has been shown that aerobic exercise can reduce the blood level of norepinephrine (Duncan et al., 1985), which limits the vasoconstriction of the arterioles, allowing for less peripheral resistance to blood pressure. In addition, there is a slight reduction in sympathetic neural activity that may help to mediate this decrease in blood pressure from aerobic exercise (Duncan et al., 1985).

The Effect of Exercise on Fat Utilization

It has been demonstrated that a result of regular endurance training is that the body uses fats more efficiently for the same submaximal task (Henriksson, 1977) . This increased ability of the aerobic energy system to produce energy using both carbohydrates and fats is probably related to an increased mitochondrial activity in the trained muscles. As more ATP is produced aerobically, there is a lesser need for involvement of the anaerobic pathways and thus less lactic acid will be produced. Lactic acid can have an inhibiting effect on the release of fatty acids from fat depots (because it blocks the action of epinephrine, a fat mobilizing hormone). Therefore, the result is more fatty acids are delivered to the muscle for energy utilization. In addition, evidence suggests that the hormone-sensitive lipase enzymes of the fat cells become more sensitive to epinephrine and norepinephrine after aerobic training (Lamb, 1984) . Thus a smaller production of these two hormones will still be able to positively stimulate the release of fatty acids for utilization.

The Effect of Exercise on Reducing Infection

Regular exercisers claim that they have fewer infections and colds then their sedentary counterparts. While some studies show that physically active people have fewer colds and infections, it may not just be the result of exercise. It has been hypothesized that exercise may boost the immune system, or that active people take better care of themselves, or there may be a natural buildup of antibodies as we age.

Support for the boost in the immune system function seems to be growing. Moderate exercise has shown increases of circulating levels of interleukin-1, which stimulates the immune system by increasing the activity of the lymphocytes, the primary cells involved in the immune response. Moderate aerobic exercise also increases the production of some of the interferons, a group of naturally occurring proteins with antiviral properties. However, this increase only lasts for up to two hours after exercise and thus is suspect with regard to its potential long-term antiviral effect.

It should be noted that regular, strenuous exercise has also been shown to have an opposite effect on the body's immure system. Persistent high intensity exercise may actually increase the likelihood of respiratory infection by suppressing some components of the immune system immediately after the exercise session. This adds more support for an exercise prescription directed towards regular, moderate levels of exercise participation.

The Effect of Exercise on Bone Mineral Density

Not only is bone density higher in physically active people, but evidence suggests that increased physical activity is associated with a lower rate of age-related bone loss (Snow-Harter & Marcus, 1991) . Maintaining a higher bone mineral density throughout life may help to prevent many fractures associated with low bone density, which is a growing public health concern. The underlying mechanisms by which bone responds to physical activity are not well-known. Bone, like muscle will adapt to the imposed stresses, or lack of them, by forming more or less tissue. This process occurs via a remodeling cycle involving bone-forming osteoblasts and bone-reabsorbing osteoclasts. When stress is applied to the bone with weight-bearing activities or with the muscles via resistance training, the osteoblastic activity exceeds the osteoclastic activity, which leads to a gain in bone tissue. If the stress decreases, i.e., the person stops exercising, this process will be reversed. With regard to the importance of weight-bearing on the skeleton, recent studies suggest loads other than those generated by gravity, such as muscular pull, can actively stimulate bone deposition (Snow-Harter & Marcus, 1991) . Although swimming is considered a nonweight-bearing activity, the positive contributions to bone mineral density may occur through loads created from the muscular activity. More research is needed in this area. It should be noted that the effect of exercise on bone mass is not an ongoing process. A point will be reached at which, even with an increase of training, increased bone mass will be negligible. Also, many experts feel that even with the positive effect of exercise on increased bone mass, it is inappropriate to consider exercise as a replacement for hormone therapy as a deterrent to bone loss, particularly during the first 5 years of menopause (Snow-Harter & Marcus, 1991).

The Effect of Exercise on Reducing Stress and Improving Mental Health

The research is convincingly clear that physical activity can help to bring about both short and long term reductions in stress, enhancement of coping mechanisms, reduction in anxiety, depression and hostility, and increased general well-being and self-concept (Morgan & Goldston, 1987) . Currently there are several theories which try to explain how exercising the body can affect the mind. One theory states that physical training gives people a sense of mastery or control over self and their environment. This control becomes associated with a sense of well-being that enhances the self-concept, self-efficacy, reduces anxiety, and positively affects other personality variables (Greist et al., 1978) . Morgan (1980) hypothesizes that physical exercise provides a distraction or diversion for anxiety provoking cognitions. A similar hypotheses is that exercise is a form of meditation which precipitates an altered state of consciousness that may relieve depression and anxiety (Van Andel, 1986) . Folkins and Sime (1981) hypothesize that fitness training enhances a person's ability to adapt and cope with the environment. Increases in fitness reduces the excitation of emotion-provoking stimuli by slowing autonomic responses (i.e. heart rate, blood pressure) thus decreasing somatic (pertaining to the body) "turmoil."

Although no cause and effect relationship has been found, there is a growing body of research that describes biochemical induced changes to mood following exercise. Regular physical exercise stimulates the central nervous system which increases the transport of oxygen to the brain as well as cerebral metabolic activity of various neurotransmitters including dopamine, serotonin, norepinephrine, and acetylcholine. Endurance running has also been shown to produce immediate increases in beta endorphins in the blood after training. However, chronic exercise training may actually decrease beta endorphin levels (Lobstein, Ismail, & Rasmussen, 1989) . It is important to interject that the contents of our blood do not directly reflect what is happening in brain tissue. It is still not clear whether beta endorphin levels outside of the brain rise and fall in a parallel manner with those in the brain. At present, the hypothesis that exercise-produced endorphins result in mood alteration remains plausible, but not satisfactorily demonstrated in the literature. Allen's (1983) "detoxification" theory is another credible explanation. With this theory, it is hypothesized that exercise "detoxifies," or gets rid of the stress-related hormones quickly. This could be a result of the increased metabolism from exercise or possible unknown hormones involved in this complex occurrence.

The efficacy of exercise to reduce stress and improve mental well-being is well-founded and supported even though the underlying mechanisms to these changes is speculative. Yet there is plenty of reason to be optimistic that this mystery will unfold. A great deal of interest exists in the research community involving this phenomenon which will surely lead to a better understanding, development and application of theories underlying the relationship between physical activity and mental health.

The Effect of Exercise on Cardiac Risk

It is important to emphasize that only individuals with underlying heart disease are at risk of a cardiac event (i.e., heart attack) during exercise (Franklin, Blair, Haskell, Thompson, & Van Camp, 1994) . No evidence suggests that people with healthy cardiovascular systems are at risk of sudden cardiac death from exercise. It is the cardiovascular pathology, not the exercise, that establishes the likelihood of a cardiac event (Franklin et al., 1994) , and the exercise may only be the precursor to it. The importance of the aerobic warm-up and cool-down cannot be minimized, as this is the time when cardiovascular events may occur. For instance, one theory regarding the risk of a cardiac event upon abrupt cessation of exercise involves the relation between blood pressure and the hormones, epinephrine and norepinephrine. During exercise, epinephrine and norepinephrine stimulate the heart to beat faster. When exercise stops abruptly, the blood pressure begins to drop rapidly, but the hormone response continues to stay up, causing the heart to continue its fast pumping. The venous blood return to the heart also slows creating an imbalance in the body's circulatory system (the heart is rapidly pumping with an inadequate blood supply). This anomaly may mediate an irregular heart response. This is why exercisers need to be continually reminded of the importance of a progressive aerobic cool-down to their workout.

The Effect of Exercise on Body Composition

It is increasingly clear that people who maintain a physically active lifestyle or become involved in endurance programs may successfully maintain a desirable level of body composition (McArdle, Katch, & Katch, 1991) . There is an increase in caloric output through endurance-type exercise that provides a significant and desirable option for unbalancing the energy balance equation (i.e., energy input vs. energy output) to facilitate weight loss and a desirable modification in body composition (McArdle & Toner, 1988) . The alterations in body composition most often attributed to aerobic exercise are a decrease in fat weight and a maintenance or slight increase in fat-free mass indicating the importance of aerobic exercise to burning calories and losing body fat (Hoeger, 1989) .

Although resistance training does not usually create the caloric deficit that rhythmic aerobic activities do, it can increase the body's resting metabolic rate (the amount of energy used by the body during rest) due to the increase in muscle tissue. Metabolic rate is directly proportional to lean body mass: The more muscle mass, the higher the metabolic rate (Fahey, Insel, & Roth, 1994) . Muscles expend calories much more than fat. For instance, a pound of muscle may burn as much as 40 to 50 more calories a day than a pound of fat (Rosato, 1994) . Therefore, an exercise program combining aerobic activities with resistance training appears to be the best combined approach of using exercise in weight management programs.

Summary

Understanding some of the underlying physiological mechanisms of how physical activity can affect bodily processes can help you better explain to your clients and students the overall value of a complete health and fitness program. As fitness educators, our continued efforts will then be focused on developing various strategies to increase the commitment and motivation of our students towards lifetime enjoyment of physical activity.