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When you steal from one author, it is plagiarism; if you steal from many, it is research.

*-- Wilson Mizner
Sayings*

FOR MANY YEARS, exercise physiologists were aware that regular exercise helped people to feel better and live better. They understood that inactivity and prolonged rest resulted in changes in the body and mind that were unhealthy while the medical profession turned a blind eye to both the research and the obvious. Naturally, the lack of medical support didn't help. But, that is no longer the case. The medical profession seems to have gotten the message. Talking about and prescribing exercise as medicine is increasingly the thing to do. It is believed that exercise helps to keep the mind and body healthy and strong. Of interest is the anticipated decrease in ischemic heart disease and the increased integrity of the muscles and bones.

Exercise physiologists are keenly aware of the importance of physical activity, exercise, and fitness. They realize there are differences between physical activity and regular exercise. The latter is helpful in developing and maintaining a healthful lifestyle. Regular exercise helps to improve and/or maintain cardiovascular endurance, muscle strength, endurance, and flexibility. The most common method of determining the influence of regular exercise on the body is by measuring

I like to believe that, despite obvious limitations, my constant efforts to state matters in my own way so that they are clear to me may have helped those who have limitations similar to mine.

*-- Wilhelm R. Frisell, PhD
Acid-Base Chemistry in
Medicine*

maximal oxygen uptake (VO_2). The units for reporting VO_2 max are liters per minute ($\text{L}\cdot\text{min}^{-1}$), milliliters per minute ($\text{mL}\cdot\text{min}^{-1}$), and milliliters per kilogram of body weight per minute ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$).

The lungs are responsible for bringing in oxygen from the atmosphere. The blood in the pulmonary circuit (i.e., between the right ventricle and the left atrium) transports the oxygen in combination with hemoglobin (HbO_2) to the heart where it is pumped from the left ventricle throughout the circulatory system to the metabolizing tissues (e.g., muscles). Oxygen uptake and carbon dioxide output (VCO_2) at the cellular level are measured during gas exchange testing. The O_2 consumed during cellular metabolism is equal to VO_2 . The increased metabolism during exercise is reflective of the increased need for O_2 consumed by the mitochondria to produce adenosine triphosphate (ATP), which is necessary for muscle contraction. Hence, exercise increases the work of the lungs, heart, and muscles that in return helps to ensure that they can function at increasing levels above resting.

CPX Testing

In normal individuals, like Bob next door, maximum VO_2 indicates his maximum aerobic capacity, which is also referred to as maximal aerobic power. In individuals like Linda, who lives several blocks away, heart disease has compromised the function of her heart. The decreased left ventricular function results in a decrease in cardiac output (Q), which is the product of heart rate (HR) x stroke volume (SV). Hence, even though the arterial blood is full of O_2 , the decrease in SV and, therefore, the decrease in Q is primarily the reason for Linda's decrease in VO_2 and physical ability to exercise.

The cardiopulmonary exercise (CPX) test measures the body's capacity for gas exchange. Often, it is carried out in conjunction with an ECG stress test with the subject on either a cycle ergometer or treadmill). By measuring the exercise performance of the respiratory, cardiovascular, and circulatory systems, the CPX test via breath-by-breath measurements of gas exchange provides an excellent indicator of functional power (capacity). In addition to this information being useful to develop the type, duration, and frequency of the subject's exercise prescription, it allows for the assessment of the potential danger of excessive or inappropriate exercise.

Not only is the CPX an excellent beginning point, it allows for a solid assessment of physiological function on cardiovascular morbidity and mortality rates. Therefore, by demonstrating that VO_2 is increased after the exercise prescription (given that $\text{VO}_2 = \text{ATP}$, which = Energy = Muscle Contraction = Life), there should be (statistically speaking) a reduction in cardiovascular mortality (i.e., $\text{VO}_2 = \text{Life}$). This is especially the case when the exercise prescription results in the expenditure of more than $2000 \text{ kcal}\cdot\text{wk}^{-1}$ vs. $500 \text{ kcal}\cdot\text{wk}^{-1}$ (1). While it should not be surprising that regular exercise (a form of physical activity) is inversely related to the risk of developing heart disease and stroke (2), it is still not accepted by the majority of the population in the United States.

For we in this generation and in the United States, are the pampered of our planet....We are the fat of the land: never in history, nowhere else in the world have such numbers of human beings eaten so much, exerted themselves so little, and become and remained so fat. We have come suddenly into the land of milk and honey, and we look it. And we suffer because of it.

-- Jean Mayer

Exercise Medicine

The idea that regular exercise is an important prescriptive treatment for high blood pressure, type 2 diabetes mellitus, obesity, elevated lipids, thrombosis, coronary artery endothelium function, and improved measures of heart rate variability just as certain prescriptive drugs are recognized a treatment means that regular exercise is the equivalent of a powerful drug. Think about it. Regular exercise helps to prevent the development of hypertension (3), increases the sensitivity to insulin while decreasing the production of glucose by the liver (4), promotes weight loss while decreasing total cholesterol and low-density lipoprotein (LDL) cholesterol (5), favorably influences the fibrinolytic system by decreasing platelet aggregation (6), and enhances the activity of the parasympathetic nervous system with a resulting decrease in double product (DP) and myocardial oxygen consumption (MVO_2).

*Who would have imaged the 21st century reality that “**Exercise as cardiovascular therapy = exercise medicine!**”*

Exercise medicine is defined as low to moderate intensity aerobic exercise carried out 3 to 5 times·wk⁻¹ for ~20 to 60 min·d⁻¹. The benefits are enormous, especially the respiratory, cardiovascular, and metabolic responses. Regular exercise increases the efficiency of the respiratory process. For example, at a given physical workload, expired ventilation (V_E) is decreased. This increased efficiency is the product of an increase in tidal volume (V_T) and a decrease in frequency of breaths (F_b). Also, the diaphragm and the external intercostals (i.e., the primary muscles responsible for respiration) become more efficient during the respiratory process. This means they use less O₂, thus allowing for more O₂ to be used elsewhere in the body (particularly the muscles).

The oxygen that diffuses from the alveoli into the pulmonary blood is transported by more hemoglobin (Hb) per 100 mL of blood. In general, the non-exercise trained concentration of Hb is ~15 g·100 mL. With training, it is slightly increased to ~17 g·100 mL. This means that the oxygen carrying capacity of the blood increases from 20.1 mL of O₂ per 100 mL (i.e., 1.34 mL of O₂ x 15 g·100 mL) to ~23 mL·100 mL of blood). Since the development of energy in the form of ATP in the electron transport system (ETS) of the mitochondria requires O₂, then, more O₂ in the blood is helpful in producing more energy for muscle contraction. There is also an increase in the number of capillaries at the respiratory level and at the cellular level. This means that more O₂ can diffuse per unit of time from the lungs into the pulmonary blood that is then transported to the heart and by way of the left ventricle into the arterial system. Hence, it also means that there is more O₂ to dissociate from the HbO₂ combination at the tissue level to diffuse into the muscle cells.

Exercise can be the most effective intervention for CHD, and yet it is the most neglected.

-- Stamatakis and Weiler (8)

As a result of regular exercise, the heart becomes stronger with each contraction that delivers the blood into the circulatory system, and it does so with a decrease in HR at rest and during exercise. This means that the increase in ventricular contractility results in a larger volume of blood ejected per beat (SV), often at a lower HR for a given workload. The decrease in MVO₂ is directly related to the decrease in HR and systolic blood pressure (SBP). The product of both variables is DP. The lower

the DP for a given workload, the less O₂ is needed by the heart during exercise to deliver Q to the muscle fibers.

Regular exercise promotes the activation of more motor units and transmission of nerve impulses for increased muscular strength and muscular endurance. The increased supply of O₂, removal of CO₂, and ATP molecules at the cell level allows for an increase in muscular activity to perform daily physical tasks and recreational activities energetically. Overall, there is an increase in VO₂ max that argues for increased chances of surviving chronic diseases (such as a myocardial infarction, MI). The increased elasticity of the arterial system along with the decrease in LDL cholesterol with an increase high-density lipoprotein (HDL) cholesterol provides increased protection from coronary artery disease (CAD).

Individuals who are unfit and sedentary develop chronic diseases prematurely and die at a younger age.

-- S.N. Blair

Also, it is important to point out that regular exercise improves the ratio of total cholesterol (CHL) to HDL cholesterol. If the CHL:HDL ratio is 6 or greater, it is likely that there is significant CAD (e.g., 180 mg·dL⁻¹ ÷ 30 mg·dL⁻¹). In other words, even though the total cholesterol is less than 200 mg·dL⁻¹ (which is good), the low HDL is associated with a high risk for CAD. Fortunately, regular exercise helps to raise the HDL cholesterol while lowering total CHL as well as having a favorable effect on stress and depression. In short, it is clear that a change in lifestyle that includes a prudent diet and more exercise helps to lower CAD death rate (8).

That which is used develops, and that which is not used wastes away.

-- Hippocrates

The bottom line is simple: Regular exercise helps to decrease cardiac mortality on one hand while improving recovery after a cardiac event on the other (9,10). Regarding the first, regular exercise helps to decrease triglyceride levels in the blood, increase body fat loss, decrease emotional tension, and brings about the regression of atheroma in major arteries that afford important protection against CAD. As to the second, regular exercise improves metabolic capacity and function, such as decreases resting HR, increases the efficiency of

the myocardium (heart), promotes peripheral blood flow and distribution, and lowers blood pressure, platelet stickiness, and glucose intolerance. In sum, exercise not only increases cardiac fitness and muscle strength, it improves psychological health (11,12).

Final Thoughts

In terms of disease management, board certified exercise physiologists play a vital role in defining, prescribing, and encouraging clients and patients to take an active part in regular exercise (13) and healthcare. They are scientifically educated and prepared to provide an ethical approach to explaining the mind and body benefits of regular exercise. The recommended target for exercise medicine is 30 min, 3 to 5 times·wk⁻¹. Of course it is also important to understand the need to teach progressive relaxation techniques and the power of positive thinking, including the role of spirituality in psychosocial health (14,15). Individually and collectively each intervention reduces the stress of work and life while helping to promote positive and relaxing feelings. Spirituality, in particular, can have a very positive influence on the immune, cardiovascular, hormonal, and nervous systems.

Key Point: *Isn't it time that board certified exercise physiologists get involved professionally in the personalized written prescription of exercise medicine for clients with symptoms or diseases where regular exercise is likely to have a positive healthcare benefit?*

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