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**Physiology of the Exercise Medicine Prescription**

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s I recall, I had a graduate student several years ago say to me, "Why not just start another research project and let it go?" I said, No I can't do that. It wasn't because I had traveled too far to do so. Simply stated, I felt exercise physiology must be going somewhere!

What compels me to share my thoughts is that I feel academic exercise physiologists must figure out who they are and what they do. We need a profession, not a discipline or a field. We need to press on towards the realization of the American Society of Exercise Physiologists to help the students of exercise physiology.  We need to support our own professional organization.

Why? I believe that it is never too late to think differently, to change, and it is the right thing to do for many reasons. Other professions have evolved and help their members to be recognized as credible healthcare professions. Yet, our academic exercise physiologists are still working the halls of academia as if ASEP does not exist and as if exercise physiology as it presently exists makes sense. The bottom line is that exercise physiologists are a joke when it comes to thinking as professionals. They fail to understand that publishing another research paper does not define exercise physiology as a profession.

From the ASEP perspective, in addition to the emphasis on athletics and sports performance, exercise physiology has its roots in health and wellness as well. But, strangely enough, the latter emphasis is often the last to be discussed. Exercise medicine is important because of the failure of society to address lifestyle factors that have led to the epidemic of chronic diseases in the United States and throughout the world.

Yes, sports are important but life and health are more important than placing all of one's research emphasis on how to run faster and jump higher. Less disability, improvement in quality of life, and lower mortality that result from the adaptive responses to regular exercise are important to preventing disease and improving health.

To help ensure the students of exercise physiology are a critical part of the healthcare landscape when they graduate from college, the academic fingerprint must be upgraded to include courses that teach students how to educate clients and patients as well as the specifics of designing exercise programs. Understanding how and why "education" is critical to a client's change in lifestyle is to promote and optimize the prevention of disease.

Ultimately, this thinking helps to drive ASEP's accreditation agenda and promote Board Certification that should be part of the exercise medicine intervention. Thus, it should be self-evident that educating a client as to how and why the body responds to regular exercise helps in promoting a healthy lifestyle. In short, education is at the heart of the healthcare change process.

Clients do not need to know everything, just enough to keep their mental involvement engaged to help facilitate adapting to their new lifestyle. Indeed, coping and adapting to a new way of living is not an isolated event, but rather a new mental and physical homeostasis. Thus, in addition to the refinement in exercise-induced cardiorespiratory and skeletal muscle responses, the metabolic stress of regular exercise changes the brain and mental responses to stressors.

Mind-body crosstalk is linked to the ASEP's message to educate clients and/ or patients. The emphasis on education is critical to the 21st century view of the Board Certified Exercise Physiologists’ role in healthcare. As an example, given that the recent college graduate doesn’t have the money to purchase expensive metabolic analyzers, several regression equations are presented to facilitate the client’s/patient’s education.

The client’s oxygen consumption (VO2) in mL·min-1 can be calculated from the kilopond meters of workload on a Monark cycle ergometer using Equation 1.

In this case, the client is exercising at 600 kpm·min-1 (or a 100 Watts, given 600 ÷ 6 = 100) that requires a VO2 of 1500 mL·min-1 or 1.5 L·min-1. With just a brief conversation, the client can come to understand the importance of oxygen during exercising by speaking to the VO2 to sustain the workload.

Equation 1:

**VO2 (mL·min-1) = (kpm·min-1 x 2) + 300**
 = (600 x 2) + 300
 = 1500 mL·min-1 (or 1.5 L·min-1)

While it is not important for the client to know the role of the specific steps in the citric acid cycle or the way in which adenosine triphosphate (ATP) sustains muscle contraction, he should have a basic understanding of what is happening in his body. For example, the client should know that at a given VO2, he is expending “x” number of kcal·min-1 (refer to Equation 2).

Equation 2:

**kcal·min-1 = VO2 (L·min-1) x 5**

= 1.5 x 5

 = 7.5 kcal·min-1 (times 20 min of cycling = 150 kcal)

Remember, as a healthcare professional, you are doing what you can to motivate your client to stay with the exercise program.

Given that the client’s estimated exercise VO2 in L·min-1 at 600 kpm·min-1, his cardiac output (Q) can be discussed using Equation 3. The 12.58 L·min-1 is increased 2½ times relative to the resting cardiac output of 5 L·min-1.

Equation 3:

**Q (L·min-1) = (6.12 x VO2 L·min-1) + 3.4**

 = (6.12 x 1.5 L·min-1) + 3.4

 = 12.58 L·min-1

Knowing the client’s exercise VO2 and Q at 600 kpm·min-1 allows for talking about peripheral tissue extraction of oxygen (a-vO2 diff) by the muscles for the continuation of muscle contraction and, therefore, the cycle ergometer exercise itself (refer to Equation 4).

Equation 4:

**a-vO2 diff (mL·dL-1) = [VO2 (L·min-1) ÷ Q (L·min-1)] x 100** = [1.5 L·min-1 ÷ 12.58 L·min-1] x 100
 = 11.92 mL·dL-1

Similarly, with respect to Equation 5, knowing the client’s exercise heart rate (HR), the volume of blood ejected from the heart per beat (stroke volume, SV) can be determined.

Equation 5:

**SV (mL·bt-1) = Q (mL·min-1) ÷ HR (beats·min-1)**

 = 12,580 mL·min-1 ÷ 100 beats·min-1

 = 125.8 mL·bt-1

Also, a brief analysis of the client’s double product at rest (Equation 6) and during exercise will help in understanding the work of the heart, given that DP is correlated with myocardial oxygen consumption (MVO2) (Equation 7).

Equation 6:

**DP = HR (beats·min-1) x SBP (mmHg) x .01** = (70 beats·min-1 x 120 mmHg) x .01
 = 8400 x .01
 = 84 (at rest)

Equation 7:

**MVO2 (mL·100 g LV·min-1) = .14 (HR x SBP x .01) – 6.3**

 = .14 (70 x 120 x .01) – 6.3

 = .14 (84) – 6.3

 = 5.46 mL·100 g LV·min-1 (at rest)

Here, it is important to explain to the client that his commitment to daily exercise has resulted in positive physiological changes in heart rate (HR) and systolic blood pressure (SBP) during exercise (Equation 8).

The changes allow for the heart to do the same amount of work while the heart now requires less oxygen. Thus, a positive effect of his training is that as his heart supplies oxygen to the peripheral tissues via left ventricular contraction, it does so in a more efficient manner

Equation 8:

**MVO2 (mL·100 g LV·min-1) = .14 (HR x SBP x .01) – 6.3** = .14 (140 x 180 x .01) – 6.3
 = 29 mL·100 g LV·min-1 (exercise before training)

**MVO2 (mL·100 g LV·min-1) = .14 (HR x SBP x .01) – 6.3**

 = .14 (120 x 165 x .01) – 6.3

 = 21 mL·100 g LV·min-1 (exercise after training)

The following calculations (Equations 9-12) will help the client understand the relationship between the size of the heart and his or her body weight. The weight of the heart is larger in men vs. women.

Using the data in Equation 9 with respect to HR, SBP, and MVO2 (mL·100 g LV·min-1), we can estimate the clients’ absolute MVO2 (in mL·min-1) via the following equations.

|  |  |
| --- | --- |
| Equation 9:  |  |

**HWmen (g) = (2.54 x kgBW) + 128** = (2.54 x 70 kg) + 128
 = 306 g

Equation 10:

**HWwomen (g) = (2.10 x kgBW) + 126** = (2.10 x 60 kg) + 126
 = 252 g

Equation 11:

**MVO2men (mL·min-1) = MVO2 (mL·100 g LV·min-1) x HWF** = 5.46 mL·100 g LV·min-1 x 3.06 g
 = 16.7 mL·min-1

Equation 12:

**MVO2women (mL·min-1) = MVO2 (mL·100 g LV·min-1) x HWF** = \*7.14 mL·100 g LV·min-1 x 2.52 g
 = 17.99 mL·min-1

**\***Assuming a resting HR of 80 in women (vs. 70 in men) at the same SBP of 120 mmHg, then MVO2 for women would be 7.14 mL·100 g LV·min-1.

But, since 17 and 18 mL·min-1 are essentially the same, the increase in HR to deal with the smaller SV in women means that both men and women consume about equal amounts of oxygen at the heart level.

The client’s left ventricular power output (LVPO) can be calculated using the cardiac output regression formula, Q (L·min-1) = (6.12 x VO2 L·min-1) + 3.4] and measuring the client’s blood pressure.

Equation 13:

**LVPO (kg·m·min-1) = Q (L·min-1) x SBP (mmHg) x 13.6 x .001** = 9.52 L·min-1 x 150 mmHg x 13.6 x .001
 = 19.42 kg·m·min-1 [300 kpm·min-1]

**LVPO (kg·m·min-1) = Q (L·min-1) x SBP (mmHg) x 13.6 x .001** = 12.58 L·min-1 x 175 mmHg x 13.6 x .001
 = 29.94 kg·m·min-1 [600 kpm·min-1]

**LVPO (kg·m·min-1) = Q (L·min-1) x SBP (mmHg) x 13.6 x .001** = 16.25 L·min-1 x 195 mmHg x 13.6 x .001
 = 43.01 kg·m·min-1 [900 kpm·min-1]

Then, one can talk about cardiac power output (CPO), which is LVPO plus the power output of the right ventricle (Equation 14).

Equation 14:

**CPO (kg·m·min-1) = LVPO x 1.2** = 19.42 kg·m·min-1 x 1.2
 = 23.30 kg·m·min-1 [300 kpm·min-1]

**CPO (kg·m·min-1) = LVPO x 1.2** = 29.94 kg·m·min-1 x 1.2
 = 35.92 kg·m·min-1 [600 kpm·min-1]

**CPO (kg·m·min-1) = LVPO x 1.2** = 43.01 kg·m·min-1 x 1.2
 = 51.62 kg·m·min-1 [900 kpm·min-1]

Given that the weight of the average male heart is ~300 g, the mass of the left ventricle is ~180 g (due to the ventricular contraction against a relatively high mean arterial pressure due to ventricular systole that is in part driven by the high systemic vascular resistance) while the mass of the right ventricle is ~60 g (due to less contractile work to send the blood to the lungs via the pulmonary arteries). This leaves ~20 g each for both of the upper chambers.

The mean arterial pressure (MAP) and the systemic vascular resistance (SVR) can be discussed using the following regression formulae. Note that MAP rises with the increase in systolic blood pressure, which is appropriate given the increase in the client’s exercise intensity along with the decrease in the SVR.

Equation 15:

**MAP (mmHg) = DBP + .32 (pulse pressure, i.e., SBP – DBP)**
 = 80 mmHg + .32 (120 mmHg – 80 mmHg)
 = 80 + .32 (40)
 = 93 mmHg [rest]

 = 80 mmHg + .32 (150 mmHg – 80 mmHg)

 = 80 mmHg + .32 (65)
 = 101 mmHg [300 kpm·min-1; 50 Watts]

 = 70 mmHg + .32 (175 mmHg – 70 mmHg)

 = 70 mmHg + .32 (105)
 = 104 mmHg [600 kpm·min-1; 100 Watts]

 = 70 mmHg + .32 (195 mmHg – 70 mmHg)

 = 70 mmHg + .32 (125)
 = 114 mmHg [900 kpm·min-1; 150 Watts]

Equation 16:

**SVR (mmHg·L·min-1) = MAP (mmHg) ÷ Q (L·min-1)** = 93 mmHg ÷ 5 L·min-1
 = 18.6 mmHg·L·min-1 [rest]

**SVR (mmHg·L·min-1) = MAP (mmHg) ÷ Q (L·min-1)** = 101 mmHg ÷ 9.52 L·min-1
 = 10.6 mmHg·L·min-1 [300 kpm·min-1]

**SVR (mmHg·L·min-1) = MAP (mmHg) ÷ Q (L·min-1)** = 104 mmHg ÷ 12.58 L·min-1
 = 8.26 mmHg·L·min-1 [600 kpm·min-1]

**SVR (mmHg·L·min-1) = MAP (mmHg) ÷ Q (L·min-1)** = 114 mmHg ÷ 16.25 L·min-1
 = 7.01 mmHg·L·min-1 [900 kpm·min-1]

While the use of estimates of the client’s physiologic responses to exercising is not as accurate as actual measurements determined through the use of various testing modalities, ASEP Board Certified Exercise Physiologists should use them to educate the client in understanding oxygen consumption and related physiological variables and responses to exercise training.

Please keep in mind that recently graduated exercise physiologists do not generally have access to open circuit spirometry and other expensive laboratory equipment. Thus, the standardized metabolic equations presented can be routinely used to estimate the client’s physiological responses at rest and during the cycle ergometer exercise. In so doing, the client can begin to comprehend the responses and adaptations that occur with regular exercise (as he or she is enjoys a better quality of life).