The Physiology of Circuit Training and Aging

The science of endurance training requires multiple adaptations occurring in the cardiovascular, muscular, metabolic and neuromuscular systems and requires manipulation of an activity's volume, intensity and movement complexity.

Recent research indicates that the adaptability of one's neuromuscular system determines and affects improvements in endurance and reductions in muscle fatigue. Consider that the accumulation of hydrogen during exercise interferes with calcium diffusion. Calcium must be able to pass through cell membranes because it is essential in muscle contraction, relaxation and nerve impulse transmissions. Also consider increased lactic acidosis when cells do not receive sufficient oxygen during exercise. This most-often occurs during vigorous exercise, but in older adults and/or deconditioned individuals, the activity does not need to be vigorous to induce acidosis. The condition causes a gradual buildup of lactate in the bloodstream and interferes with the body's ability to convert ATP into energy, thus affecting endurance.

Combined thresholds of hydrogen and lactate define maximal levels of exercise intensity and occur when the production and removal of these by-products are equal. The efficiency of this process is the single most important indicator of the exercise intensity an individual can sustain over time. (Kravitz, 2010)

Developed in England in 1953, the original circuit format included ten to twelve "stations" for resistance training combined with aerobic training performed in a non-stop, continuous format. The formats and techniques have evolved over the years because the combination of concurrently alternating aerobic and resistance training has numerous physiological benefits:

- Decreased age-related degeneration of fast-twitch muscle fibers. This mitigates sarcopenia, or the loss of muscle mass, strength and function.
- Increased insulin sensitivity and blood glucose tolerance.
- Increased calcium diffusion aids actin/myosin protein coupling, which acts as a trigger for ATP (adenosine triphosphate) molecules within the myosin protein to break down and cause muscle contraction.

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- Increased ability to remove accumulated hydrogen and lactate from working muscles, facilitating muscle endurance improvements over time.
- Increased blood circulation through greater capillary density and volume.
- Increased numbers of red blood cells and oxygen-carrying hemoglobin.
- Increased neuromuscular pathways that improve muscle contractions. The central nervous system has to increase the number of motor units recruited to maintain the endurance circuit training requires.
- Increased VO2 max. (i.e., the maximum volume of oxygen muscles can consume per minute)
- Increased tolerance for intense exercise and percentage of VO2 max, thus making a previously anaerobic activity, aerobic. Greatest gains occur when exercising at the hydrogen/lactate threshold level.

Studies and research also point to benefits for specific chronic disease conditions:

- According to the American Journal of Respiratory and Critical Care Medicine, a combined strength and endurance training program significantly **improved breathlessness scores and dyspnea (labored respiration) dimension** in COPD patients.
- For those with heart disease, circuit training **may lower diastolic blood pressure** in borderline-hypertensive patients (Harris and Holly) and demonstrates significant strength and endurance improvements in the absence of cardiac or orthopedic complications. (Stewart, Mason & Kelemen).
- Though many studies have proved the benefits of exercise for diabetics, the **best type of exercise for Type II diabetics is a combination of aerobic and resistance training**, according to Ron Sigal, MD, associate professor of medicine at the University of Calgary.
- In a 2007 study of 250 adults with Type II diabetes, one group participated in a "combination" exercise program while the second group participated in either a resistance- or aerobic-only training program. The "combination group" demonstrated the best results - a 1% drop in hemoglobin A1C or average blood glucose. (An A1C score is the average amount of sugar that has been in the blood over a period of three months.) The second group lowered their hemoglobin A1C levels by only .5%.

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In addition to physiological, metabolic and neuromuscular benefits, instructors should consider the circuit format's practical benefits and innumerable options to guarantee safety and effectiveness:

- **Variable and self-directed choices with resistance tools** allow participants to select hand-held weights and color-coded elastic tubing with handles according to their skills, abilities and health conditions.
- **Variable and self-directed choices in aerobic choreography** maximizes comfort and safety. By manipulating speed, use of space and simultaneous upper and lower body movement, the circuit format allows participants individual options within a group setting to select the appropriate volume of work, as well as intensity and complexity options.
- **Less risk of injury for weight bearing joints.** A circuit format allows for periods of recovery for the working muscles and joints when the format alternates between the upper and lower body. If exercising for more than an hour, check blood glucose at regular intervals. Also, encourage participants to check blood glucose levels after class, as post-exercise hypoglycemia can last for up to 30 hours. (Feeney and Hyatt, Exercise and Diabetes, 2009).

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