Vol 4, 2007 CEC ARTICLE: Physiological Responses to Dynamic Exercise

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ADAPTATIONS TO DYNAMIC EXERCISE

CARDIOVASCULAR:

In untrained individuals, resting HR is generally 60-100 BPM; it increases directly and proportionally with exercise intensity, and, like oxygen consumption, plateaus at maximal exercise intensities. Maximal HR varies within individuals and declines with age, typical maximal heart rates being 190-200 in young adults and 140-160 in older adults. Because the variance increases significantly as the population ages, however, heart rate is a poor predictor of exercise intensity in the geriatric population.

RESPIRATORY:

At rest, normal respiratory rate is 8-20 breaths per minute. It increases with increasing effort, as does tidal volume, in an effort to maximize ventilation. Like heart rate, pulmonary ventilation increases linearly with oxygen consumption. Again there is a close linkage between central supply of oxygen and peripheral demand.

METABOLIC:

Physical exercise profoundly challenges homeostasis of fuel in normal humans. Whole-body energy expenditure can increase ten to twenty-fold from rest to maximal exercise. Since quantities of high-energy phosphate compounds such as creatine phosphate (CP) and ATP within muscle are relatively limited, metabolic machinery and oxidizable substrate are necessary for sustained muscular activity. Enzimatically-regulated metabolic pathways in human skeletal muscle produce energy by oxidizing carbohydrate (glucose and glycogen), nonesterfied fatty acids, and, to a small extent, amino acids.

It is well known among rehabilitation professionals that training improves fitness and can reverse changes induced by inactivity or immobilization. Improvements in VO2 max vary with initial level of conditioning and intensity of training but range on average between 10% and 30%. Immobility has detrimental effects on VO2 max. In a study using healthy young males, 21 days of complete bed rest decreased VO2 max by 25% and reduced stroke volume, cardiac output, and plasma volume by similar levels. Thirty years later, the same subjects were studied. Interestingly, 21 days of bed rest had a more profound impact on exercise capacity than did three decades of aging.

ADAPTATIONS TO STRENGTH TRAINING

Strength training as an element of physical training/rehabilitation has an impact on not only skeletal muscle, but also neuromotor excitation, cardiovascular function, immunological activity, integrity and viability of connective tissue, and a sense of well-being. Positive benefits of strength training include increasing muscle mass, bone mass, tensile strength of connective tissue, and immunologic, neurologic and cardiovascular well-being.

Basic strengthening programs are based on overload, specificity, cross-training, and reversibility:

OVERLOAD: Muscle tissue must be challenged beyond its current force capability in order to change both structurally and functionally.

SPECIFICITY: Training effects are specific to the mode of exercise stress imposed on the exercising muscle.

CROSS TRAINING: To overcome the limitations of specificity and to maximize the broad range of muscle performance, incorporates all modes of training into your programs, whenever possible.

REVERSIBILITY: The benefits of training are **not** sustained unless muscles remain sufficiently challenged through continuous use of the strength gains.

NEUROMUSCULAR ADAPTATION: In the early stages of exercise, the changes documented by electromyography include increased motor unit recruitment and synchronization of motor unit discharge. These changes reflect more effective activation of anterior horn cells, elicited by improved voluntary motor control. As the efficiency of neural elements improves, hypertrophy of skeletal muscle occurs when the exercise challenge is adequate. Exercise studies of subjects who have been immobilized for long periods of time have reported initial increases in type I fiber cross-sectional area, followed by changes in type II fibers. Based on the size order of recruitment, low-intensity exercise may not challenge the large type II fibers sufficiently to cause hypertrophic changes.

The temporal relationship between neural and muscular changes depends on the interaction of several factors: the intensity, frequency, and duration of the exercise program; the age and health status of the patient; and the specific cause of the muscle weakness. With minimal impairment or in healthy subjects, strength changes during the first 6 to 12 weeks of a training program are primarily due to increased motor unit recruitment and motor learning.

Adaptations to a strength-conditioning program include increased bone mass, alterations in body composition, and improved balance and coordination. Bone mass increases in response to the stresses imposed during strength training. The extent of this effect depends on the magnitude of skeletal loading through weight bearing and on the torque applied to bone during muscular contraction. Strength training increases lean tissue mass and decreases percent fat. These changes have been documented after resistance training athletes, normal healthy individuals and older adults. The demands of active muscle include the utilization of fatty acids, particularly to support oxidative phosphorylation. Improvement in strength can result in improved balance and coordination, gait speed, ability to perform activities of daily living (ADL), and higher-level activity in athletic performance or occupational tasks.

BASIC DEFINITONS IN STRENGTH TRAINING

RESISTANCE EXERCISE: any form of active exercise in which a dynamic or static muscular contraction is resisted by an outside force.

Two Definitions of Resistance Exercise:

A) Manual- resistance is provided by a therapist or other health professional

B) Mechanical- resistance is applied through the use of equipment or mechanical apparatus.

Goals of Resistance Exercise:

A) Increase strength
B) Increases Muscular Endurance
C) Increase Power

BASIC CONCERNS IN STRENGTH TRAINING

PRECAUTIONS (be aware of while training):

1) Cardiovascular precautions- Valsalva Maneuver
2) Fatigue; a) local muscle fatigue
   b) total body fatigue
3) Recovery from exercise
4) Overwork/Over training
5) Substitute Motions
6) Osteoporosis-pathogenic fractures
7) Exercise induced muscle soreness;
   a) acute
   b) DOMS – Delayed Onset of Muscle Soreness

CONTRAINDICATIONS (reasons to delay training):

1) Inflammation
2) Pain

Personally, I utilize the "Any Exercise Drill" as explained in Douglas Brooks' manual, EFFECTIVE STRENGTH TRAINING© for my exercise analysis.

A) What is the goal for the client/exercise
B) What is the joint motion(s)?
C) What muscles are being used to create movement at the joint(s)?
D) What is the proper path of motion?
E) What is a normal range of motion at the joint?
F) What is the active ROM at the joint?
G) Is the overload effective in terms if the amount of resistance?
H) Is the direction of force or resistance in direct opposition (or as close as possible) to the movement pattern?
I) Has the necessary stabilization occurred and been maintained?
J) Do the risks of the exercise outweigh its potential effectiveness?

TYPES OF RESISTANCE EXERCISES

There are 3 types of resistance exercise Isotonic, Isokinetic and Isometric. We must understand what they are in order to be able to use them effectively. We also need to understand the range of motion in an exercise and the importance to functional training of muscle tissue.

•ISOTONIC

1) **Manual or mechanical resistance**
2) **Constant vs. variable resistance**

Dynamic Constant (isotonic)

a. The amount of resistive force encountered determines the amount of muscle force applied. More resistive force requires more muscle force. The water, compared to air, is twelve times more resistant. Adding gloves, hand belles, etc., increases the resistance.

b. The resistive force (water) remains constant throughout the exercise movement. However, the effective muscle force is higher in some positions and lower in other positions due to the mechanics of human movement. Free weights would also provide a dynamic constant resistance.

Dynamic Variable (isotonic)

The dynamic variable is the same as the dynamic constant, in that the amount of resistive force encountered determines the amount of muscle force applied. It is DIFFERENT than dynamic constant, in that the resistive force changes throughout the exercise movement. The use of dyna-bands, tubing, a weight stack machine with levers, cams, or linkage systems and specially designed air pressure equipment provides dynamic variable resistance.

3) **Concentric vs. eccentric exercise**
4) **Open chain vs. closed chain**
    A) open chain: movement that occurs in an open (kinematic) chain, in which the distal segment (foot/hand) moves freely in space, i.e. free weights and most machines.
    B) Closed chain: movement that occurs in a closed (kinematic) chain, where the body moves over a fixed distal segment, i.e. weight bearing exercise using the lower body (squats, stair climbing), and pushups,

•ISOKINETIC

1) The joint is moving at a constant angular velocity, a constant movement speed, and a
   Matching resistive force.
2) The amount of muscle force applied determines the amount of resistive force encountered. More muscle force produces more resistive force. This type of contraction is only possible with isokinetic equipment such as hydraulic resistance machines and electronic resistance machines capable of varying the resistance and maintaining a constant angular velocity.

•ISOMETRIC

Isometric contractions are an important component in training the stabilizing muscles. An isometric contraction occurs when the resistance is an immovable

object such as a wall or weight-training equipment, or the opposing muscle group. No visible movement occurs.

R.O.M. (RANGE OF MOTION) movement of a body segment takes place as muscles or external forces move bodes. Bones move with respect to each other at the connecting joints. The structure of the joints, as well as the integrity and flexibility of the soft tissues that pass over the joints, affects the amount of motion that can occur between two bones. The full motion possible is called ROM. When moving a segment through its ROM, all structures in the region are affected: muscles, nerves.

TYPES OF R.O.M. EXERCISES:

A) Passive: movement within the Unrestricted ROM for a segment that is produced entirely by external force; no voluntary muscle contraction.
B) Active: movement within the Unrestricted ROM for a segment that is produced by an active contraction of the muscles crossing that joint.
C) Active-Assistive: a type of active ROM in which assistance is provided by an outside force, either manually or mechanically, because the prime mover muscles need assistance to complete the motion.

Aerobic Exercise: follow ACSM guidelines, unless directed otherwise
Stretching: follow health professional's and ACSM guidelines.

FUNCTIONS OF THE MUSCULAR SYSTEM

We need to understand the functions of the muscular system in order to train the system effectively or to rehabilitate damaged tissue. The major functions of muscles are:

1. **Body movement.** Most skeletal muscles are attached to bones, are typically under conscious control, and are responsible for most body movements including walking, running, or manipulating objects with the hands.
2. **Maintenance of posture.** Skeletal muscles constantly maintain tone, which keeps us sitting or standing erect.
3. **Respiration.** Muscles of the thorax are responsible for the movements necessary for respiration.
4. **Production of body heat.** When skeletal muscles contract, heat is given off as a by-product. This released heat is critical to the maintenance of body temperature.
5. **Communication.** Skeletal muscles are involved in all aspects of communication, such as speaking, writing, typing, gesturing, and facial expressions.
6. **Constriction of organs and vessels.** The contraction of smooth muscle within the walls of internal organs and vessels causes constriction of those structures. This constriction can help propel and mix food and water in the digestive tract, propel secretions from organs, and regulated blood flow through vessels.
7. **Heartbeat.** The contraction of cardiac muscle causes the heart to beat, propelling blood to all parts of the body.

PROPERTIES OF MUSCLE

Muscle has four major functional properties:

1. **Contractility** is the ability of muscle to shorten forcefully. When muscle contracts, it causes movement of the structures to which it is attached, or it may increase pressure inside hollow organs or vessels. Although muscle shortens forcefully during contraction, it lengthens passively; that is, gravity contraction of an opposing muscle, or the pressure of fluid in a hollow organ or vessel produces a force that acts on the shortened muscle, causing it to lengthen.
2. **Excitability** is the capacity of muscle to respond to a stimulus. Normally skeletal muscle contracts as a result of stimulation by nerves. Smooth muscle and cardiac muscle can contract without outside stimuli, but they also respond to stimulation by nerves and hormones.
3. **Extensibility** means that muscle can be stretched beyond its normal resting length and is still able to contract.
4. **Elasticity** is the ability of muscle to recoil to its original resting length after it has been stretched.

With a better understanding of the function and properties of muscle tissue we can understand the precautions and reasons for the guidelines from the industry on proper training techniques.

CEC ARTICLE QUESTIONS VOL 4, 2007 (2 CEC's)

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1. Why is heart rate a poor predictor of exercise intensity in geriatric populations?

2. What happens to heart rate with cardiovascular exercise?

3. What happens to respiration with cardiovascular exercise?

4. How much energy expenditure can the body produce relative to rest when exercising?

5.How is energy produced in the skeletal muscle?

6. How can extended bed rest and lack of activity affect the body?

7. What is worse on the body extended bed rest/lack of activity or aging 30 years?

8. What are 6 other benefits of strength training?

9. What are the 5 things strength-training programs are based on?

10. In the early stages of exercise of strength training what are the primary reasons for strength changes?

11.List 4 adaptations to strength training that occur.

12. What is resistance exercise?

13. List two definitions of resistance exercise.

14.List 7 precautions when strength training.

15. What are the 2 main contraindications to strength training?

16. What are the 4 variables in isotonic resistance exercise?

17. What are the 3 types of ROM exercises?

18.Whar are the 7 functions of the muscular systems?

19. What are the 4 properties of muscle?