Can elderly increase muscular strength with training?
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Introduction
Individuals 65 years of age and older make up the elderly population. Aging is a dynamic process accompanied by a decline in skeletal muscle strength, mass, and power. Functional capacity decreases and an activity such as rising from a chair that represents submaximal effort in young people becomes a maximal effort activity in the elderly [3].

There are multiple factors contributing to the age-related atrophy and loss of strength. These factors include alterations in muscle and muscle fiber quality and size, decreased muscle cross-sectional area, changes or declines in the neuromuscular system, alterations in muscle architecture, an increased amount of non-contractile material, decreased agonist activity and increased antagonist activity.

Even with these changes, research demonstrates that the skeletal muscle of elderly men and women retains the capacity for training-induced hypertrophy and explosive force production, improvement in function and static/dynamic muscle strength, provided the volume, intensity, and duration of training is sufficient [5]. Weaker members of the elderly population show greatest potential for improvement.

Biomechanics
The aging process causes reduced muscle cross-sectional area. Muscle fiber type distribution changes with age. Type II fibers reduce in size, number, and maximum force. Studies show a direct correlation between percentage values of the type II fibers and maximal concentric 1RM strength. Evidence shows training-induced hypertrophy in both type I and type II fibers of elderly subjects.

There is a decrease in contractile material of muscle in elderly. The muscle is comprised of a greater amount of non-contractile material such as fat, connective tissue, and blood vessels, and less muscle fibers. There is also a decrease in contractile proteins actin and myosin and abnormalities in troponin and tropomyosin. In response to strength training, however, there is an increase in the synthesis of contractile proteins [3].

The elderly have decreased proprioception and an increased reliance on vision. Alterations in the motor system take place during aging leading to a decreased number of motor units. Collateral innervation of muscle fibers takes place to compensate for this loss. The re-innervation process results in larger portions of the muscle under the control of one motor unit. The lower firing rates in the elderly leads to a greater number of remodeled motor units recruited at a lower torque. Eventually the motor units decline in function causing a substantial loss of muscle fiber resulting in a decrease in muscle mass and strength. In some cases there is also incomplete compensatory reinnervation of the muscle fibers.

Motor units are progressively lost throughout aging but a significant decline in muscle mass, function, and strength is not detected until a critical threshold is reached. For example, studies estimate the threshold to be approximately 40-60% of motor units in young healthy men for the tibialis anterior [8]. Before this point collateral innervation is able to delay any significant loss of excitable mass.

Strength training programs have been shown to increase the magnitude of electromyographical (EMG) activity. This is the result of an increased number of motor units, increased activation, and an increase in firing frequency of the trained muscle. An increase in explosive force production in elderly subjects is largely due to training-induced increases in the rapid neural activation of the motor units. Increases in the net excitation of motor neurons results from increased excitatory input and reduced inhibitory input [5].

The largest increase in EMG is observed during the initial months of training, prior to any increase in muscle size, but increasing intensity throughout a progressive training program results in a continued increase in motor unit function.

Elderly subjects exhibit an increased antagonist muscle coactivation. Eccentric strength is necessary to control gravity and movement and therefore is maintained during the aging process, while concentric strength declines. Strength training programs improve concentric strength but do not decrease the level of coactivation. However, if the concentric strength increases the result will be more force generated by the muscle/movement.

Elderly subjects also demonstrate alterations in muscle architecture. Fasicle length
is decreased, affecting peak muscle torque. Training leads to an increase in the number of in-series sarcomeres, resulting in increased fiber shortening velocity allowing greater torque to be generated and therefore more power. This is important for muscle function because peak muscle torque corresponds to fascicle length.

The mechanical properties of tendons also affect muscle strength and power since tendons are in series with the muscle. The tendon is the series elastic component of the muscle and is responsible for the storage and release of energy. Strength training results in a greater elastic energy recovery from the tendon.

Alterations in the formation of myosin-actin cross bridges are seen in elderly subjects. The space between myofilaments is increased resulting in a reduced amount of force. There is also a loss of myofilaments as a result of deconditioning typically seen in this population. The rate of myosin synthesis decreases with age. This is due to a decrease in gene transcription, an accumulation of dysfunctional myosin molecules, and modifications of the myosin protein [3]. When the basic properties of myosin are changed it cannot form adequate cross bridges with actin. This results in a reduction of force at each cross bridge, ultimately reducing force throughout the muscle fiber and consequently the entire muscle. Altered myosin properties also decrease the shortening velocity. Strength training increases the fiber shortening velocity and power and improves the quality of myosin synthesized.

**Application**

To reverse or slow the decline in muscle quality, elderly should perform strength training exercises on a continuous basis. Studies show that with adequate levels of strength training individuals will benefit from as few as 2 sessions per week. Training intensity should be progressively increased to provide sufficient loading to muscles as they strengthen and adapt. Heavy resistance training should be combined with low resistance explosive-type exercises to induce both hypertrophy and changes in muscle architecture.

The ability to generate power is crucial in everyday locomotor tasks, such as walking, lifting, and rising from a chair. Practical functional training is important in the elderly in order to improve quality of life and promote independence. Some specifics goals of a strength training program in this population are to increase function of the tibialis anterior thereby reducing the risk of falls, and to decrease strength loss of the upper extremities to protect against injury if falls do occur.

**Factors Affecting Muscles with Aging:**

**Summary**

Aging is a process that begins early in life and gradually progresses. Changes in the motor system and muscle architecture and the age-related decline in physical activity contribute to decreased muscle function, strength, and power.

Strength training can negate or slow the aging process of muscle by inducing cellular changes that biomechanically equate to more power generation, larger cross-sectional area, and improved motor system function.
References


