Physiology of Aging

What can be done to slow or stop the loss of muscle mass? Or impairment of muscle function?

Aging defies easy definition, at least in biological terms. Aging is not just the passage of time, but rather an accumulation of biological events that occur over a span of time. If we define aging as the loss of one's ability to adapt to a changing environment, then biological or functional age becomes a measure of one's success for adaptation.

At the turn of the twentieth century, approximately 4% of the United States population was over age 65; today, it has climbed to 13%. Life expectancy at birth in the U.S. has increased to about 76 years today, and is expected to reach 83 years by 2050. The absolute number of older persons, currently about 36 million, has increased 11-fold, compared to only triple in the entire U.S. population. As individuals age, especially past 85 years, there is a growing need for assistance with everyday activities; half that group needs some assistance. Thus, as individuals live longer, we must determine the extent and mechanisms by which exercise and physical activity can improve health, functional capacity, quality of life, and functional independence.

The most often reported consequence of normal aging is the loss of skeletal muscle mass or sarcopenia. Most researchers agree that sarcopenia cannot be explained by a single factor but is due to a complex interaction of muscle (myopathic) and nerve (neuropathic) alterations and a declining stimulus to these two physiological systems from decreased physical activity. Possible reasons for the decrease in muscle mass with increased age involve changes in both muscle fiber area and fiber number. Some studies report that Type I (slow twitch, aerobic) muscle fibers are resistant to age-associated atrophy, at least until the ages of 60 to 70 years, while the relative area of Type II (fast-twitch, anaerobic) muscle fibers appear to decline with increased age. The loss of muscle fibers has been reported for both male and females and corresponds to the critical age period of around 50 years when muscle atrophy becomes most noticeable.

One of the most obvious manifestations of a decrease in muscle mass is the decreased ability to produce force. This decrease in the force-producing capacity of skeletal muscle is not universal, but depends on the type of contraction being performed and the muscle group being examined. Research that examined isometric force production characteristics during the aging process reported that the earliest declines in strength occurred for the forearm extensors and the muscles of the lower leg (dorsiflexors and plantar flexors), around age 40, while the greatest overall loss of strength occurred for the two lower limb muscles (dorsiflexors and plantar flexors).

Perhaps more important than the production of maximal strength is the ability to maintain muscular endurance in the elderly. This literature is somewhat more equivocal. Some researchers have noted that older subjects are able to maintain voluntary isometric and dynamic muscular contractions for up to 60 seconds when compared to younger individuals, as long as the contractions are performed at the same relative percentage of their strength. Others, however, have reported that older subjects had a significantly greater loss of force production over a 30-second period when the potential confounding factor of motivation was removed by using electrical stimulation. Studies have shown that the decrease in the ability to maintain force production is not so much a function of age as it is related to muscle group location; the muscles of the lower extremity are better able to maintain force output when compared to the muscles of the upper extremity.

To summarize the factors associated with age-related muscle atrophy, it should be remembered that changes vary greatly from person to person and between different muscle groups. One should also consider the fact that some changes observed in elderly skeletal muscle may be secondary to other external factors such as nutritional deficiencies, changes in endocrine status, and the lack of regular physical activity.

If increased age results in the decline of muscle mass and function, can the appropriate resistance-training program provide some benefit for the older individual? Recent studies all seem to agree that elderly skeletal muscle is able to adapt to short term (12 weeks) training programs by increasing strength through muscle hypertrophy of both types of fibers and improved functional performance.

A recently completed 26-week weight training study with early post-menopausal women showed that the women, generally in their early 50's, had significant increases in strength for the upper and lower body muscle groups with a concomitant increase in muscle cross sectional areas.
It is also important to note whether the ultimate degree of muscle hypertrophy following training is age dependent. Some studies have reported that young (22 to 31 year old) males and females had significantly greater increases in muscle cross sectional areas after three months of training when compared to older 62 to 72 year olds, however, they concluded that even though there is some age effect on the responsiveness to exercise, this phenomena could not be generalized to all muscle groups.

Still, there is very little information available regarding the adaptability of elderly skeletal muscle to prolonged training periods. One such study involved a two-year randomized control trial of weight training in 113 male and female subjects aged 60 to 80 years. The training program consisted of two sessions per week for a period of 42 weeks, followed by ten weeks of testing and vacation time, and then another 42 weeks of training. Each session consisted of three sets of the exercises with 10-12 reps/set at 80% of 1RM. It was determined that in both muscle groups, males were significantly stronger than females, and the 60 to 70 year olds were significantly stronger than the 70 to 80 year olds. In addition, strength increased continually for each group over the entire two-year period with no prolonged plateau.

To summarize, current research indicates that elderly muscle can adapt positively, just like young muscle, to resistance exercise. Significant improvements in strength occurring from muscle hypertrophy may be the result of an increased sensitivity of androgen receptors and increased levels of circulating factors responsible for muscle growth, such as testosterone, IGF-I, and growth hormone.

The American College of Sports Medicine (ACSM) has published position stands on exercise for healthy adults as well as one for older adults. They state that age should not be a limiting factor for beginning an exercise program (but that medical approval should be obtained), and that the exercises should be progressive in nature, individualized, and involve all the major muscle groups. They should be done two to three times per week with at least one set of eight to 15 repetitions. Multiple sets could provide more benefits, and exercises that help with balance and posture should be practiced.

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