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Aging and the Motor Unit

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It has long been known that humans have decreased strength and muscle mass with age, but the mechanisms behind this are still not completely understood. In his review, Degens [1] discusses some potential reasons for this loss in strength with age, concluding that the hypertrophy capability of a muscle fiber does not change as one gets older, but rather that there are fewer muscle fibers. The primary reasoning behind fewer muscle fibers is associated with restructuring and subsequent loss in motor units, as well as a lack of mechanical stimuli from physical activity.

Age-related muscle atrophy occurs with both a decrease in muscle cross-sectional area and a decrease in muscle fiber number. The gradual loss of muscle fibers appears to begin at around 50 years-old, with approximately 50% of the muscle fibers in the limbs lost by the age of 80 [2], resulting in a loss of 30-50% of skeletal muscle mass [3,4]. There appears to be a greater loss in lean body mass in the lower body (15%) than the upper body (10%) in both men and women [5]. This atrophy is linked to a decline in muscular strength and power [6], and an increase in rate of fatigue as shown in animal models [7,8]. The losses in strength and power are associated with a decrease in both the size and number of fast-twitch (type II) muscle fibers. Evidence shows that there is a loss in fast twitch fiber cross-sectional area with age, while slow twitch (type I) fibers appear to maintain their cross-sectional area [4,9]. This loss in fiber size is associated with an age-related decline in growth factors [10], as well as a lack of mechanical stimuli for the fast twitch fiber.

The majority of the literature indicates that muscle fiber loss is due to a loss in motor neurons. There is consistent deinervation and reinervation of the muscle fiber throughout one's lifespan, but in the aged, deinervation appears to outpace reinveration [11,12]. Data indicate that a 60 year-old has approximately 25-50% fewer motor neurons than a 20 year-old [13] with the greatest losses in distal fast twitch motor neurons [4,14,15]. With the loss of the motor neuron, the deinervated fast twitch muscle fibers that were attached to it are either permanently deinervated and undergo apoptosis, or are reinverated with a different motor neuron [4,16], most likely that of a slow twitch neuron, potentially making the fiber take on slow twitch characteristics. This motor unit restructuring is supported by evidence that older men and women have larger motor unit size compared to their younger counterparts [17]. The motor unit number appears to be consistent until the sixth decade of life, but declines by approximately 50% by the eighth decade [18].

The restructuring of the motor unit does not appear to completly convert the former fast twitch fibers to a slow twitch fiber, but rather the classification of the fibers become convoluted. The confusion in muscle fiber typing is seen because several fibers appear to express both myosin heavy chain-I and II isoforms [19,20]. A potential explanation for this is that while the motor neuron loss seen with aging is mostly with fast twitch neurons, the majority of the muscle atrophy associated with lack of physical activity is in slow twitch muscle fibers [20].

The most common solution to muscle atrophy in younger individuals is the stimulus of physical activity. However, even in master athletes who do exercise regularly the loss in muscle fibers is still observed, but at a lower rate [21]. When master weight lifters were compared to untrained controls of the same age, the lifters had greater peak power and peak force production compared to the controls. However, muscle power and isometric strength have been shown to decline at a similar rate for both master lifters and the untrained controls, but because the master lifters had a larger muscle mass than that of the untrained controls, the master lifters then had a twenty year advantage over the untrained controls [21]. Additionally, with the introduction of an exercise stimulus to an elderly individual, the evidence of hypertrophy of slow and fast twitch muscle fibers appears to be equivocal [22,23].

Overall, it is this loss in motor units that appear to drive the loss in muscle fibers [2]. The most commonly utilized reasoning for fewer fibers is based on the principle of reversibility and detraining, or "use or lose it," but this is only a portion of the explanation for the elderly. It appears that despite participation in physical activity, aging individuals still experience a loss in muscle fiber size and number, with the loss in fiber number being driven by a decrease in functional motor neurons. The mechanical stimulus of physical activity does not seem to attenuate this process, but rather provides a better physiological foundation so that trained older individuals have more lean mass than that of their untrained counterparts. The relationship between aging and disuse is complex, but perhaps more answers can be found in the future with a larger focus in studying master athletes.

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