synopsis of

Age Related Motor-Unit Remodeling and its Effect on Muscle Performance

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Aging is associated with loss of muscle mass and strength due to numerous, non-pathological changes.

Two common changes: loss of the number of muscle fibers and loss of fiber size.

Progressive destruction of the nervous system due to aging impacts the structure and function of the neuromuscular system, and so performance of muscle.

A Motor Unit (MU) is a lower motor neuron (alpha-motor neuron) and all the muscle fibers innervated by it. Not to be confused with the gamma motor neurons that innervate reflexes in muscle spindles.

Muscular force depends on 3 factors:

a) The number of MUs recruited
b) The size of the MUs recruited, and
c) The frequency of MU recruitment.

With increasing demand for force more MUs may be activated, larger ones activated, and already activated ones done more than once.

Variation in control of force is called "coding."

The "size theory of recruitment" of MUs: the order of MU recruitment is directly related to the size and electrical threshold at which cell bodies can be activated.

The recruitment is "additive." For a specific task, similar-sized MUs are recruited first.

Once force has been added, "sequential recruitment" provides for more force generation.

MUs with a greater number of fibers can generate more force than those with fewer fibers.

But MUs with more fibers have less precision or ability to "grade force."

MU Remodeling is the natural cycle of turnover of connections between motor neurons and muscle fibers.

In advanced years, reinnervation of muscle fibers with motor neurons breaks down. There is a larger number of muscle fibers without neural supply. This results in muscle fiber atrophy and death. The estimate rate is 1% per year start at age 30 and increasing expoentially in later years...25%-50% loss of total MU number.

MUs take on abandoned muscle fibers but there is a limit according to the muscle, the MU type, and the species.

Age-related neural degeneration is present in all MU tpes but preferentially targets Type II (Fast twitch) muscle fibers. These are innervated by larger MUs. Evidence is that the myosin heavy-chain (MHC) that provides the power stroke and contraction speed in Type IIb fast-defagiable fibers to Type IIa fast-fatigue-resistant fibers.

Abandoned Type II fibers are incorporated into slower MUs supplying Type I (Slow twitch) muscle fibers.

MU remodelling results in:
a) Decreased strength,
b) decreased rate of force development, and
c) declining control of force.

The loss of large MUs (Type II) decreases force generation because fewer large MUs are available for recruitment. Type II fibers become remodeled into slow MUs and show those characteristics, incoluding reduced capacity for generating force. This results in a loss of strength.

The rate of force development (RFD) is the amount of force that can be generated per unit time. RFD decreases with age correlated with the declining large/fast MUs and Type II fibers. RFD declines more rapidly than gross strength.

Atrophy may be more significant in Type II fibers resulting in more obvious ability to generate force quickly or generate force maximally.

Loss of large MUs and Type II fibers is concurrent with decline of moto nerve conduction velocity (MNCV). Peak MNCV is attained and maintained from ages 10-50, then declines near-linearly yearly.

Due to decreased MUs, there is greater force per MU but decreased ability to control/grade force.

Sequential recruitment of MUs lead to large size and higher innervation rations. So, decreased ability to control force. With fewer fibers per MU, smaller innervation rations allow for greater precision.