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Skeletal Muscles Structure and Aging: A review

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ABSTRACT
The average adult loses muscle mass as they age; the quantity lost varies gender and amount of muscular exercise are both factors to consider. At the molecular level, we age, our muscles lose cross-sectional area and fiber counts, with type II muscular fibers being the most adversely affected. Age-related variations in skeletal muscle performance can be predicted, fibers may be denervated to some extent,in elderly persons, the combination of these factors results in a higher percentage of type I fibers, the glycolytic enzymes appear to be unaffected by aging on a metabolic level, but the aerobic enzymes appear to deteriorate with age,The mechanical properties of aging skeletal muscle tend to "slow" and produce less force than younger muscle.

INTRODUCTION

One of the extreme plastic and dynamic tissue in the body of human is Skeletal muscle. Skeletal muscle, which accounts for about 40% of total body weight and includes 50% to 75% of total body protein, also accounts for 30% to 50% of all-body protein turnover. Protein (20 percent), water (75 percent), and other components, such as inorganic salts, minerals, fat, and carbohydrates, make up the bulk of muscle mass (5%). Generally, Protein synthesis and degradation play an important role in determining muscle mass, which is controlled by a variety of factors, including food, hormones, physical activity, injuries, and diseases including diabetes and cancer(Landon, 1992;Capliceand Deb, 2004;JanqueiraandCarniero, 2005). Because of their importance in mobility, exercise capacity, functioning, and health, the distinct protein compartments (structural, contractile, and regulatory) have gotten a lot of research interest. Skeletal muscles help to double bodily functions in a substantial way. When chemical energy is converted to mechanical energy by skeletal muscle fibers, it allows for the generation of force, the maintenance of body posture, and the generation of movement necessary for daily activities, involvement in work or social contexts, health maintenance, or self-reliance.As part of the body's basic energy metabolism, skeletal muscle stores key substrates like carbohydrates and amino acids and produces heat to maintain the body's core temperature. It also consumes a significant amount of fuel and oxygen during physical activity and exercise(JanqueiraandCarniero, 2005;Wolfe, 2006).

Physiologic capacity is unavoidably reduced as a result of biologic aging,weakness, weariness, and slowness of movement are hallmarks of aging due to a deterioration in all major systems (for example, cardiovascular, metabolic, respiratory, and neuromuscular).The global population is aging, with the number of people aged 60 and up more than doubling since 1980, in 2050, the elderly population will have expanded to about 2 billion people, with 22 percent of the overall population over 60 years old and 5% of the population over 80 years old.Physical performance restrictions will increase as society ages; in Western civilization, up to 42 percent of those over 60 have difficulty accomplishing daily chores (e.g. Standing up from a chair or walking at a fast speed), 15–30 percent can't lift or carry 10 pounds (4.5 kg), and >30 percent have a physical limitation(Louie and Ward, 2010; United Nations, 2012).

Co-morbidity, falls, and institutionalization, and early death are all increased because of the physical constraints, furthermore, the increased prevalence of physical disability as people get older (i.e. bodily function or structural impairments, activity limits, and participation constraints) Physical handicap prevention and treatment are so vital for public health and good aging. A loss in skeletal muscle function is unquestionably the most important factor contributing to physical limitations as people get older. Sarcopenia is the term used to describe a loss in skeletal muscle mass, is one of the defining alterations of aging that is connected to losses in muscle performance (Baumgartner, 1998; Janssen et al., 2002)

Muscle fiber types in the skeletal system

The color of fibers of the skeletal muscle varies based on the amount of myoglobin they contain (red, white, or intermediate) (Myoglobin is

a protein that stores oxygen until it is required by the mitochondria), their capacity to divide adenosine triphosphate is based on this, skeletal muscle fibers contract at varying rates (ATP)Furthermore, skeletal muscle fibers differ in terms of the metabolic pathways they employ to create ATP In addition, the beginning is different of weariness.It is possible to classify skeletal muscle fibers into three categoriesbased on structural and functional characteristicsType I, Type II B, and Type II A fibers are the three types of fibers (Janqueiraand Carniero, 2005;Schiaffino, 2010).

In Type I fibers, they also go by the names slow-twitch and slow-oxidizing, there is a high volume of myoglobin, many mitochondria, and many small blood capillaries These fibers are red and have a slow rate of ATP split and contraction velocity, but they may produce large amounts of ATP through metabolic oxidation and have a strong resilience to fatigue.The postural muscles of the neck include a considerable number of these fibers. Type II-A fibers, known fast-oxidizing fibers, or "fast-twitch" fibers, contain substantial volumes of myoglobin, numerous mitochondria, and several blood capillaries (Staron, 1997; Coen et al.,2010;Schiaffinoand Reggiani,2011).Type II-A fibers are red, fatigue-resistant, and have a strong ability to create ATP through oxidative metabolic processes, as well as a quick contraction rate. Humans don't have many of these fibers. Fibers of type II-B, sometimes referred to as fast-twitch or fast-glycolytic, have a low concentration of myoglobin but a high concentration of glycogen and a low number of mitochondria and blood capillaries. It is difficult to provide skeletal muscle fibers with sufficient ATP on an ongoing basis for Type II-B fibers, which are white in color and readily exhausted. They divide ATP quickly and have a fast contraction rate. A large number of these fibers may be found in the muscles of the arms(Costillet al.,2004; Huang, 2006).

Ultrastructure of skeletal muscle fibers

Cross-striations appear frequently due to the relatively ordered organization of contractile proteins within each myofibril. Only electron microscopy can reveal this. Furthermore, the parallel myofibrils are ordered in the register with their cross-striations, resulting in the regular striations visible in longitudinal sections of skeletal muscle under light microscopy (Zierath and Hawley, 2004).

Anisotropic with polarized light, the dark bands are known as A bands, whilst the brilliant bands are known as I bands (isotropic with polarized light). Narrow zones of differing intensity split the A and I bands. The bright I band is bisected by a dense line known as the Z line, also known as the Z disc. The black band A is also divided into a lighter or less intense zone known as the H band.In addition, the M line, there is a short and densely packed line that separates the bright band H.Electron micrographs are the greatest way to view the M line, while it can be seen in the light microscope in excellent H&E preparations(Sellers and Goodson, 1995;Allen et al.,2008; Ross and powlina, 2011).

The long axis of myofibrils is paralleled by a symmetrical arrangement of thin and thick myofilaments, the dense filaments that make up the A band in the sarcomere's core are 1.6m long and 15 nm wide.The Z line is attached to one end of the thin filaments, which run between and parallel to the larger filaments. 1 m long, thin filaments with an outside diameter of eight nanometers A-bands are made up of thick filaments and interlacing parts of thin filaments, However, the thin filaments in the I-band don't cover any of the thicker ones, resulting in a lighter staining. The H zone, which represents an area consisting solely of the rod-like parts with no thin filaments, is seen in A band. In order to supply ATP for muscular contraction, Phosphate groups are converted from phosphocreatine (a type of high-energy phosphates) to ADP by creatine kinase, adenosine diphosphate (adenosine triphosphate), are two main proteins found in the M lineage, which cuts through the H zone and forms lateral connections between adjacent thick (Allen et al., 2008;Nahirney and Ovalle, 2011).

In band A, thick and thin filaments overlap for a short distance. Thus, the region of filament overlap is encompassed by six thin filaments in the shape of a hexagon around each large one, there are three primary components of thin filaments: a globular complex of three subunits, myosin, and tropomyosin, which also forms an extremely long and fine polymer; and troponin, which also makes an extremely long and fine polymer. Actin and myosin constitute up 55% of striated muscle's total protein content. Two strands of G-actin (F-actin) monomers are wrapped around each other in a double helix orientation to form long filamentous polymers. G-actin molecules are asymmetric, and when they polymerize, they form a polar filament. Myosin has a binding site on each monomer of G-actin, the actin-binding protein -actinin anchors actin filaments perpendicularly on the Z line, resulting in opposing polarity on both sides of the line (Allen et al.,2008;Janqueira and Carneiro,2005;Junqueira and Carneiro,2010)

Muscle Proteins

Protein (contractile, regulatory, cytoskeletal) and sarcoplasm make about 80% of the mass of a single muscle fiber (8%). Because of recent advances in proteome analysis tools, the study of muscle proteins is once again being reviewed in the scientific community(Hoppeler, 1973; Greising, 2012).

More than one billion myofilaments are estimated to be included in each muscle fiber. When the myofilaments are arranged in a very systematic and characteristic way, sarcomeres, the fundamental contractile units of skeletal muscle, are created. Myofilaments such as actin and myosin are common (proteins), accounting for roughly 70–80 percent of a single fiber's total protein composition, myosin is the principal molecular motor in animals, there are 11 sarcomeric myofibril genes and their related proteins (some of which aren't likely to be expressed in humans), two of these genes are found in cardiac muscle as well. It's not just the cytoskeleton that plays a role in sarcomere and sarcoplasm structure, but also the coupling of contraction and excitation, energy release, and force and power creation(Ottenheijm and Granzier, 2010).

Regulatory proteins associated with the actin filament, such as the calcium-dependent troponin complex (containing troponins C, I, and T), and tropomyosin, are particularly crucial in the activation process that leads to myofilament sliding and force generation. Titin and nebulin are two more proteins that contribute to the mechanical and physiological aspects of muscle(Monroy et al., 2012).

Titin is a big, elastin-like protein that connects to the sarcomere's Z disk and myosin, assisting in the stabilization and alignment of the thick filament. In the thin filaments containing actin, nebulin is integrated with other proteins that contribute to the integrity of the sarcomere, alter passive tension and stiffness properties of single cells, and may be relevant to myofibril construction and cell signaling.Furthermore, in vitro tests suggest that titin may play a role in the creation of force during muscular activities. The sarcomere's Z disk includes numerous proteins, including actinin, and serves as an attachment point for the actin myofilament. As previously mentioned, other proteins connect the Z disk to the sarcolemma and extracellular matrix, and may be defective in several myopathies (Ottenheijm and Granzier,2010;Monroy et al., 2012).

Innervation of skeletal muscle

At least two distinct kinds of nerve fibers are sent to every skeletal muscle: sensory and motor.The sensory fibers are transferred to the muscle spindles, while the motor nerve stimulates contraction.Aside from that, autonomic fibers supply skeletal muscle with vascular components.The innervated muscle function is the motor innervation specialization. Motor neurons can control up to 1000 skeletal muscle fibers in one muscle, while a single motor neuron can control 5-10 skeletal muscle fibers in the eye. Each motor neuron is controlled by a motor unit, which generates muscle fibers in response. The all-or-nothing rule of muscular contraction governs the contraction of muscle fibers in a motor unit(Gartner and Hiatt, 2007).

Inside the peripheral connective tissue, myelinated motor nerves branch out, with each nerve creating numerous terminal branches.Because of this, at the point of innervation, an axon is stripped of its myelin sheath and grows a growing tip on the surface of muscle cells.The myoneural junction, also known as the motor endplate, is a structure found in the brain.only the axon of the Schwann cell is covered by this thin visceral extension.the axon terminal contains many synaptic vesicles and mitochondria, the first of which contains the neurotransmitter acetylcholine.The synaptic cleft is a gap between the axon and muscle fibers that contains an amorphous basal lamina matrix made up of muscle fibers.At the junction, the sarcolemma is folded into multiple deep junction folds, resulting in a greater surface area.Many nuclei, mitochondria, glycogen granules, and ribosomes are found beneath the folds of the sarcoplasm. (Junqueira and Carneiro, 2010).

Encapsulated proprioceptors (L. proprius, one's own, + capio, to take) are sensory receptors found in myotendinous junctions and striated muscles.

The fascicles of muscles include stretch sensors known as muscle spindles, which have a connective tissue capsule around a fluid-filled area containing a few thin, nonstriated muscle fibers densely packed with nuclei known as intrafusal fibers, sensory nerve axons pass through each muscle spindle and form an intricate pattern around the many intrafusal fibers,

sensory nerves detect changes in the length of striated (extrafusal) fibers induced by body movements, and muscle spindles send this information to the spinal cord.Maintain posture and regulate the activity of opposing muscle groups contributing to motor tasks such as walking by

mediating complicated reactions by many types of internal and sensory fibers. (Junqueira and Carneiro, 2010).

Large collagen bundles of the myotendinous junction in tendons are encased in a connective tissue sheath at the points where muscle fibers are inserted.

Sensory nerves pass through this capsule and form (Golgi) tendon organs, which are another type of sensory receptor. Motor nerve activity is halted when the tension in the tendons is too great, which is sensed by the tendon organs. As a result of these sensory receptors detecting changes in tension, they help regulate the effort required to perform tasks that require varied degrees of muscular force(Junqueira and Carneiro, 2010).

Aging and its effect on skeletal muscle

Muscle weakening and atrophy are two of the most distinguishing characteristics of aging, To characterize the progressive decrease in muscle mass and strength in older persons, the word "sarcopenia" was first coined in the 19th century. The European Working Group on Sarcopenia in Older People has recently expanded the definition and proposed diagnostic criteria, adding the presence of reduced muscle mass (as evaluated by bioelectrical impedance or DEXA), muscular weakness, and/or poorer function (slow walking speed) (Rosenberg, 1997 ; Cruz-Jentoftet al., 2010). There is a wide range in the prevalence and severity of muscle loss in older adults. Men lose more muscle mass and strength than women, and the lower limbs lose more muscle mass and strength than the upper limbs. When longitudinal studies are compared to cross-sectional observations, the prevalence of sarcopenia in the elderly population ranges from 4% to 27% depending on the study, gender and country(Frontera et al., 2000; Yamada et al., 2014).It is important to note that muscle loss with age is not a universal phenomenon, and some individuals have maintained muscular strength after 10 years of follow-up. Sarcopenia is linked to a decrease in muscle power (force 9 velocity), which is particularly common in elderly adults with mobility issues, power is highly correlated with function, and its loss is a good predictor of mobility issues and falls. This selective retention of muscle strength could be linked to the study population's daily level of physical activity(Hughes et al.,2001; Reid et al., 2014). In older men, interleukin-6 (IL-6) has been linked to a decrease in the number of satellite cells in muscle fibers, particularly those associated with fibers expressing type II (fast) myosin heavy chain. This is significant because type II motor units and fibers are lost in advanced adulthood, and satellite cell activation in response to muscle injury is reduced, a mechanism mediated by IL-6) (Verdijket al., 2007; McKay et al., 2013).Alterations in various components of the muscle cell describe aging muscle,changes in the structure of the sarcoplasmic reticulum, for example, result in segregated calcium stores, which reduce the efficacy of the EC coupling, the loss of mitochondria is another example of age-related changes in cell organelles (Broskeyet al., 2014). Aging is linked to a reduction in mitochondrial content and function, which is impacted by physical activity and can be partially reversed with exercise training, The loss of muscle mass is one cause of sarcopenia, but it is by no means the only (or even the most important) one. Several researchers have discovered changes in muscle fiber quality as a result of aging, and a recent study examined the impact of age-related changes at the myofilament level on muscle fiber quality(Frontera et al., 2000; Miller and Toth, 2013).According to the majority of research, older men and women had lower single fiber peak force in both types I and type II fibers, even after accounting for the diversity in fiber size.A reduction in myosin protein content has been postulated as one molecular mechanism to explain this dysfunction, which may be especially true in immobilized muscle(D'Antonaet al.,2003).

Role of Physiological systems in the elderly skeletal muscle performance loss

The nervous system controls and connects the body's more than 500 skeletal muscles, which connect and support the skeletal system, muscle fibers are made up of tiny units known as "sarcomeres," which control the muscle's contraction and relaxation through a series of complex actions. Sarcomeres are the muscle' smallest recurring functional units, which control the body's ability to perform a wide range of motions from fast and strong movements to small and precise movements(Reid and Fielding, 2012; Jones et al., 2013).Because muscles are the major site of insulin-stimulated glucose absorption from the circulatory system, they also serve as a place for fat metabolism and glycogen synthesis, among other metabolic activities. Different tissues such as bones, pancreas, liver, and adipose tissue, which all rely on myokines for metabolic activity, reveal that muscles are essential for good health throughout life. Myokines are released by muscles and have autocrine, paracrine and endocrine effects on other organs(Otto Buczkowskaand Dworzecki, 2003;

Stump et al., 2006; Schnyder and Handschin, 2015).

Elderly Skeletal Muscles performance and lifestyle

As we get older, our appetites and food intake decrease, which can lead to anorexia. Anorexia of old age affects approximately 21% of elderly people, and it is more common in frail and institutionalized elderly people. Anorexia and weight loss have been linked to negative health consequences, such as falls, immobility and sarcopenia (Doniniet al.,2011;Morley, 2012).According to recent epidemiological data, anorexic seniors have an 88% higher risk of sarcopenia than their non-anorexic counterparts. Because of this, anorexia is often accompanied by malnutrition, which is common in elderly hospital patients; prevalence rates in geriatric wards have reached 35%. Because of this, maintaining skeletal muscle mass is directly linked to anorexia(Landiet al.,2013 ;Kruizengaet al.,2016).Several studies have found that the elderly consume between 0.8 and 1.1 g/kg/bw/day on average of protein, with the lowest intakes found in institutionalized and hospitalized aged adults, in order to maximize the postprandial muscle protein synthesis response and muscle mass accumulation in the elderly. According to current consensus declarations, protein intakes of 1.2 to 1.5 g/kg-bw/day may be necessary to prevent or reverse sarcopenia in the elderly in 35 percent of institutionalized and hospitalized persons. This is less than the estimated average protein demand of 0.7 g/kg-bw/day(Tielandet al., 2012; Deutz et al., 2014).Elderly people who ate 0.8 g/kg-bw of protein per day lost 40% more muscle mass than those who ate 1.2 g/kg-bw of protein per day. Even fragile and community-dwelling older persons may benefit from a protein-rich diet to avoid muscle mass loss and skeletal muscle function, according to the findings of this study.Supplementing with omega-3 fatty acids may also help elderly people gain muscle mass by enhancing muscle protein synthesis. In spite of the fact that omega-3 fatty acid supplementation stimulates muscle protein synthesis, there is no conclusive evidence in the scientific literature associating insufficient omega-3 fatty acid consumption to lower muscle mass or muscular function(Houston et al., 2008; Candowet al.,2012; Di Girolamo et al., 2014).Muscle mass and physical performance decline in the elderly have been related to a lack in vitamin D intake. One theory is that the active form of 25hydroxyvitamin D, 1,25-dihydroxyvitamin D, modulates muscle calcium concentrations through influencing SR and sarcolemma calcium pump function, which may affect force output in muscle(Ceglia, 2008; Ceglia, 2009 ; Veronese et al.,2014).

Role of other agents in the elderly skeletal muscle performance loss

Older skeletal muscle function may be affected by other biological factors, such as hormones, inflammation, and insulin resistance.

For example, twin research looking at the influence of genes on senior women's physical performance (>75 years old) found that age-related genetic variables account for roughly 33–50 percent of the variance in senior women's physical performance(Christensen et al.,2000).There are many examples of age-related gene modulations that are linked to muscle mass and athletic performance, such as reduced vitamin D expression, two-fold higher levels of the protein and mRNA myostatin in elderly people, and myostatin inhibition as a treatment for sarcopenia, which has been linked to myostatin, a protein that works as a negative regulator of muscle growth(Bischoff-Ferrari et al., 2004; McKay et al., 2012; White and LeBrasseur,2014). There may be a correlation between an elderly person's muscle mass reduction and other biological characteristics, such as gender and physical hardiness (the capacity to withstand sickness or other stresses) (Fulopet al., 2010).

Concluding Statement

People's ability to exercise decreases as they become older due to a combination of inactivity, age-related changes in skeletal muscle and neuromotor control, and the catabolic consequences of chronic systemic illness (e.g. heart failure, COPD, and cancer). Scientists stand to gain a great deal by studying the various factors that influence the function of aging skeletal muscles, physicians, and health care providers working on therapeutic interventions to improve and/or avoid mobility and physical limits, therefore supporting healthy aging.

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