A decline in cardiopulmonary fitness begins to accelerate after 45 years of age more so in people who are disproportionately large, sedentary, and/or smokers. The elderly shy away from exercise, often because they are misinformed and fail to understand that a life without the benefit of strength training leaves the aging individual weak, dependent, and at increased risk for chronic disease. Seniors may also be dealing with balance and stability issues. When balance is a problem, elderly people may not be stable enough on their feet to generate force; strength training will help.

In a study funded by the National Institutes of Health from 1974 to 2006, involving 20,318 men and women across 32 years, it was shown that strength decline was influenced by lifestyle and associated with risk of diseases and dependent living [7]. No surprises there across all those years! But let’s peel the onion and look at what aggressive, ongoing scientific investigation has revealed about the restorative impact of strength training on collapsing alveoli, mitochondrial dysfunction, loss of bone density and muscle mass, aging blood vessels and the muscles they feed.

**Muscle Mass Loss**

Muscle mass loss begins by age 45, its accumulation having peaked in the mid-20s. Strength loss along with fiber and motor units appear at about the same time – 50 years of age. Both muscle mass loss and strength loss can partially be reversed with exercise, but it is not likely that fiber and motor units can be reclaimed. An interesting fact is that muscle mass can remain unchanged even if strength decreases [2].

Lexell and Taylor [10] did cross sections of whole vastus lateralis muscles from 20 men, age 19 to 84. Within the muscle belly cross-section, they found that the muscle fibers from the elderly men had a mean cross-sectional area that was 35% smaller than fibers from the young men. Type I fibers were a little over 6% smaller. There was also a reduction in the number of muscle fibers, resulting in sarcopenia and reduced force production and endurance. Strength-trained elderly individuals average 30-50% stronger than sedentary elderly and have more muscle mass [2].

When it comes to sports and life-tasks that require the strength of well-developed muscles, it’s not always strength alone that gets it done safely. Although mountain climbers peak physically in their mid-20s, they are known to be better climbers in their mid-30s because of the benefits of added experience.
Muscle Types

Skeletal muscle has three general types of fibers and makes up about 40% of total body mass in the young and healthy. Type I fibers are known as “slow twitch” and, although smaller and the least forceful, they contain the most mitochondria, accounting for their resistance to fatigue. Type II fibers (IIa or IIx) are larger, generate more force, contain fewer mitochondria, and fatigue more easily. As researchers learn more about mitochondria and muscle fiber changes in the elderly, they envision an expansion of this simple type I and type II classification to reflect the hybrid fiber types that increase in elderly muscle and are thought to co-express more than one myosin heavy chain isoform, so that fiber type classification in the aged is more complex [2].

Aging Mitochondria and Strength Training

Mitochondria are microscopic energy units (organelles) located within all of our cells and perform multiple diverse functions. Besides controlling the intricate process of supplying energy to muscle cells, they also regulate age-related cellular remodeling, molecular changes impacting muscle integrity and function, including sequestration of calcium. Both age and physical activity determine their structure, function and numbers.

The decline. Advanced age brings with it an acceleration of the decline in mitochondrial content and function. Damage from that decline can be partially restored over the long term with a consistent strength training program. Only partial restoration of the mitochondria is thought to implicate something in the training stimulus, be it duration, frequency or intensity. Duration appears to be particularly suspect in that there is evidence that, with time, it is possible for the mitochondrial adaptations to training to be similar to that of youth. Another consideration is that, not surprisingly, during acute exercise, aging muscle lacks youth’s robust increase in kinase cellular signaling. This blunted signaling may be implicated in the partial nature of mitochondrial adaptation to training [2].

Current estimates. Studies show that the content of mitochondria organelles begins to decline at age 25 at about 0.6% per year and mitochondrial respiration, providing energy to fuel cellular activity, begins its decline at 20 to 25 years of age with a decrease of 0.3-1.4% per year. Exercise can partially reverse these declines.

Similarly, fibers with electron transport chain abnormalities begin to increase at age 25 by 0.5% per year and the percentage by weight of mutant mitochondrial DNA also begins its increase at age 25 at 0.05% per year. Reversal of the pathological increase of electron transport chain abnormalities and mutant mitochondrial DNA with exercise is controversial [2].

PGC-1a and aging. Complicit in the loss of functioning mitochondrial DNA with age is the loss of an important co-activator responsible for numerous transcription factors in gene expression. PGC-1a is a family of co-activators that interact with and activate transcription factors for gene expression. “Elevated levels of PGC-1a prevent atrophy, preserve muscle fiber integrity, retain mitochondrial content and function, increase antioxidant capabilities, and subdue markers of cell death.” When PGC-1a is reduced with age, so is mitochondrial function. Ongoing studies regarding the mechanism of PGC-1a reduction with age are important because of its function in stimulating the beneficial effects of exercise on mitochondrial content during the aging process [2].
Pathfinders. With many studies ongoing using electron micrographs to define mitochondrial morphologies and dynamics in aging skeletal muscle, it has been Carter, Chen and Hood who have reviewed the significant literature and discussed it brilliantly and completely in one document [2].

Mismatch of O₂ Delivery and O₂ Consumption in Elderly Skeletal Muscles

In addition to the loss of energy from mitochondrial dysfunction and cell death, the aged are also dealing with problems delivering oxygen to the muscles in need. The increased resistance of aging blood vessels and the significant depression of nitric oxide levels for vasomotor control of oxygen-consuming skeletal muscles during exercise leaves target muscles without enough oxygen to perform well [3].

In view of the fact that during exercise blood flow to the elderly skeletal muscles is reduced for the high-oxidative red muscles (type I) and elevated to the low-oxidative white muscles (type II), Behnke et al in 2012 [1] tested the hypothesis that exercise training would ameliorate this debilitating age-related difference. In young exercise-trained rats, the need for oxygen in the working skeletal muscles resulted in the formation of more arteries to feed the muscle. In old exercise-trained rats, that same stress did not result in more arteries, but rather an increase in cross-sectional diameter of the vessels feeding the arteries that penetrated the working muscle. This apparently allows for a bigger channel carrying more blood to needy muscles, and an increased exercise capacity.

In 2009 Hirai et al [4] noted the impact of aging on contraction and the reduction in the partial pressure of oxygen in the micro-vasculature, resulting in changes in the speed of contraction and relaxation of aging skeletal muscle. Contraction is faster and relaxation slower than in young skeletal muscle where the reverse is true – slower contraction, faster recovery. This may have functional implications for the decline in strength with age.

Warm-up. Because it is exercise that triggers the expansion of the cross-sectional diameter of aged blood vessels, it seems expedient for the elderly to move immediately into their program-targeted workout after warm-up in order to have the oxygen-laden blood vessels already at work and prepared for the demands on their skeletal muscles. The physiology of the exercised elderly body appears to accommodate skeletal muscle oxygen requirements with intrinsic changes in the structural and functional vascular endothelium, but only when initiated by exercise, permitting more precise oxygen delivery to working skeletal muscles.

It’s All About the O₂

Although systemic oxygen uptake is slower in the older adult as opposed to the young, causing early fatigue, one can actually adjust somewhat for this age difference by 1) diaphragmatic breathing to add circulating oxygen, 2) a consistent, well-programmed strength training regimen, in addition to the well-targeted warm-up already mentioned.

Fading alveoli. The elderly work harder at breathing during exercise because, among other physical changes, the exchange of CO₂ for O₂ across the alveolar membrane is compromised by fewer alveoli. The loss of alveoli reduces surface area for O₂ and CO₂ exchange and is not necessarily age-related –
consistently shallow “chest” breathing at any age reduces alveolar membrane surface for the exchange of CO₂ for O₂. It is a self-inflicted condition that limits one’s exercise capacity and ushers in further age-related decline.

Recovery

It is predominantly during the first 24 hours [6] of the recovery phase following acute exercise that intricate and unique intracellular muscle-building signaling events occur. This is also the time when increased energy capacity is created and continues to function. For it is this increased capacity for energy production that, through a negative feedback loop, “attenuates the initial signaling events brought about by acute contractile activity.” [5]

Recovery capability and the baseline fitness level of trainees are important to coaches and trainers whose clients may include elderly trainees. A huge number of scientific studies are focused on the results of strength training for the aged compared to the young, however, recovery is sometimes mentioned simply as part and parcel of the workouts. It is Rippetoe, who, over the years in his earlier and current editions of “Practical Programming for Strength Training” [11] has supplied the strength training world with vital information on the stress/recovery/adaptation cycle, and has cautioned that “Recovery must occur before progress can be made.” Older lifters, very nicely classified under “Special Populations,” are not left out. Recovery, its processes, and the things that affect it, are covered in detail at every stage of development throughout the book, including that of the older lifter, whose recovery capacity lessens over the years.

Bone Strength

Bone strength is determined by properties that include bone mineral density, bone geometry (size and shape of bone), degree of mineralization, microarchitecture, and bone turnover (remodeling), a process by which mature bone tissue is removed (resorption) and new bone tissue is formed. When there’s an imbalance in the remodeling process, bone strength is compromised, resulting in osteoporosis or osteopenia and predisposing to an increased risk for fracture.

Osteoporosis is a common disease with serious consequences. About 50% of white women and 20% of men will have an osteoporosis-related fracture in their lifetimes. Fractures of the hip and spine are disabling and are associated with mortality rates that are about 20% greater than that of an age-matched un-injured population [9].

Bone mineral density, like muscle mass, peaks in the mid to late 20s and declines 0.5% or more per year after 40 years of age. For older women after menopause, there is a disproportionate loss of bone (2-3% per year), increasing the risk of fracture. If not earlier, at least at this point in a woman’s life, there is no question that strength training should be an important part of her schedule. Low-intensity walking won’t protect bones. Brisk walking, stair climbing and descending, walking with weighted vests or jogging have slightly more significant positive effects on bone mineral density [8], but it’s the actual weight-bearing training that gets it done.

Men. Bone density and geometry in healthy men 50-64 years old have been compared to 18-30 year old men. In this study [13], tibial bone mineral density was significantly lower in the 50-64 year old group compared to 18-30 year old men. For men ages of 50-64 years, the loss of bone mineral density was considered significant. Certainly, the risk is disproportionately higher for postmenopausal women.
than it is for men, but men need to take care too, so that their bones will be strong for a lifetime. Don’t wait. Preventing the loss of bone density with consistent programmed long-term strength training is more fun than the desperate effort to restore strength to your precious bones and muscles once lost.

**The Elderly Client**

Many old people are not aware of the need for and benefits of a safe strength training program. They may give it a try, but bone deep fatigue and fear because of problems with balance, proprioception and no immediate results can be discouraging. Those problems disappear with the strength acquired in a properly-designed program. It takes that kind of motivation for a weak, tired, elderly person to abandon the chronic inactivity that is crippling mitochondrial biogenesis and energy-restoring vascular remodeling in their aging body. They need information and a solid belief in the possibility for efficient and effective results. The informed elder can be motivated to resume or adopt an active lifestyle and resolutely stay on target by a strength training program that yields exciting results in the form of improved endurance and muscle mass.

**Trainners and Training for the Elderly**

Many strength trainers are reluctant to accept an elderly client, because they don’t find the process either challenging or rewarding. More often it’s because of their lack of understanding of aging physiology, or indeed any training in anatomy or physiology at all. They are therefore unable to evaluate the client’s needs regarding program adjustment. Some are actually afraid of the challenge because they are themselves rigidly programmed for the younger athletes through their own experience on the way up. Some of these “trainers” are merely former trainees with no prior formal education in physical fitness or even in anatomy and physiology, and who have slipped into a trainer’s position after successfully completing a two or three day course that proclaims them “certified.” They are simply uninformed, and their ignorance – quite justifiably – generates fear.

Training the elderly is about acquainting them with its benefits, and offering an intelligent, well-planned strength program. It’s knowing where to start, how to proceed, how often and how much. This important information is conveniently available to every trainer and trainee. Four bi-weekly barbell-based programs and a description of the lifts for the elderly can both be found on pages 225-234 of Rippetoe and Baker’s 3rd edition of *Practical Programming for Strength Training*. If you are an elder looking for a trainer, check it out. If you are a coach or trainer and there are older potential clients at your gym door, don’t miss this superb strength training section for the elderly. The bonus is a big smile from a stronger, safer, happier, healthier, independent elderly man or woman.

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