Age-specific programming

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Programming for the elderly obviously requires special consideration when it comes to strength training. However, these considerations are a bit different than what you may intuitively think.

Sarcopenia: How bad is aging for your gains?

As we age, we lose muscle mass and strength. This weakening with age is formally called sarcopenia: sarx means “flesh” in Greek and penia means “loss” or “low”. At what age does sarcopenia set in and how bad is it?

It’s common to hear that in your 30s, everything starts to go downhill. Indeed, most top athletes of popular sports are in their 20s. For example, Olympic Weightlifters on average peak at age 26 [2]. However, the age of peak performance varies dramatically per sport from early 20s to the early 40s. Many top athletes retire not because they’re past their physical prime but because of injuries, drug-related health risks, better career opportunities or simply because they have nothing left to improve and don’t really need to work anymore for the rest of their life.

If we look specifically at sports where strength and muscle mass are the primary determinants of performance, athletes peak considerably later. Powerlifters reach their prime on average at age 35. Research on bodybuilders is scarce, in part because performance cannot be measured objectively, but if we look at the greatest bodybuilders of all time as judged by the Mr. Olympia competition, we can see that they were all in their prime until at least in their 30s.

- Arnold Schwarzenegger, 7-time Mr. Olympia, made his comeback to win the 1980 Mr. Olympia in his early 30s before he re-retired.
- Moving on to 1984, Lee Haney dominated the Mr. Olympia for a world-record 8 years until he retired undefeated in his early 30s.
- Then Dorian Yates won the Mr. Olympia 6 consecutive times until he was in his mid 30s, after which he retired mainly due to injuries, not because he was defeated.
- After Yates, Ronnie Coleman started his reign as the greatest bodybuilder on the planet for 8 years of Mr. Olympia until he was pushed down to a silver medal in his early 40s.
- The bodybuilder that beat Coleman was Jay Cutler, who took the last of his 4 Mr. Olympia titles in his late 30s.
- Then Phil Heath reigned for 7 years as Mr. Olympia. He was still widely regarded as one of the most likely contenders to win afterwards when he was in his 40s.
- The first person to beat Heath was Shawn Rhoden at age 43.

These data are very much in line with those from scientific research by Lowndes et al. (2009). If we look at muscle growth and strength development after standardized strength training in 18- to 39-year-olds, there is no relation between age and the rate of muscle growth or isometric strength development. Age did seem to affect biceps curl 1RM strength development, but the researchers commented that "Although age was negatively associated with improvements in 1RM, the effect of age was small relative to the improvements induced through resistance training, **thus suggesting age does not limit response to training in any practical way during early adulthood**."

But what about after age 40? Is age 40 the end of our prime? The fact top athletes on average are no longer in peak condition could be due to numerous factors other than age: enough money to move on, injuries, loss of motivation, injuries, the toll on the body of heavy drug use… did we mention injuries?

Another way to look at this question is to see when sarcopenia sets in in the general population. As it turns out, muscle loss in the general population is well modelled by linear decline starting at age…
20: look at the data below from [Melton et al. (2015)] and you can see muscle mass decline steadily over time as people get older. There is no ‘breaking point’. It’s slow but steady decay over time.

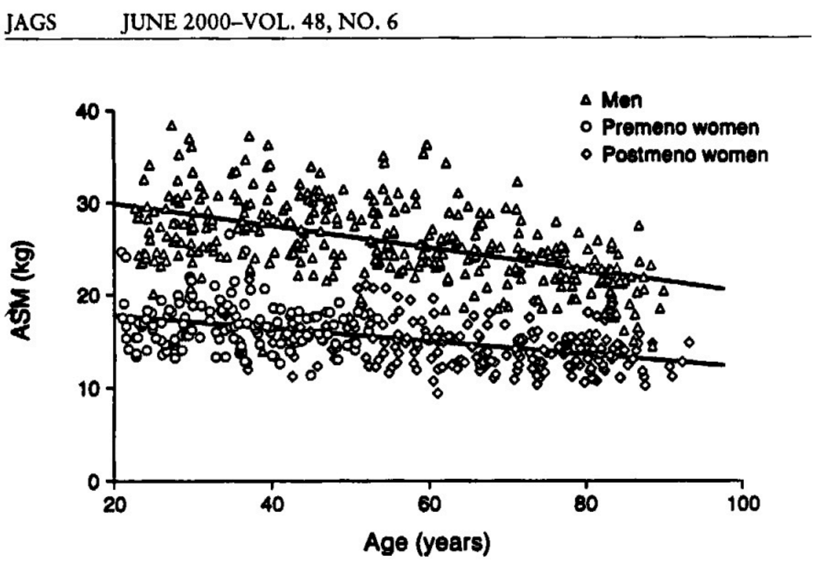


Figure 1. Regression on age of appendicular skeletal muscle mass (ASM) among Rochester, Minnesota, men and women. The pattern for total skeletal muscle mass (ASM × 1.33) was identical.

Source

What is going on here? How can sarcopenia set in in our 20s while powerlifters and bodybuilders stay in their prime until age 40 and scientific research shows our rate of gains also stays the same until at least age 40?

It's because age is not the primary determinant of sarcopenia. Sarcopenia is not primarily a problem of age but of disuse. Muscle biopsies suggest that muscle tissue does not suffer from age per **at all**. In real life, age will certainly have some effects at some point, but as a scientific review on sarcopenia by Kim et al. (2010) concluded: "The primary causes of sarcopenia include a sedentary lifestyle and malnutrition." Most people don't get weak because they get older. They get weak because they spend their lives in front of the TV eating Doritos.

Research by Wroblewski et al. (2015) in high-level masters athletes found **no significant loss of lean body mass or strength from 40 to 81 years of age in people that kept exercising**. Now, if you look at the data, there are some downward trends and these were mostly endurance athletes, not bodybuilders pushing the limits of their genetic muscular potential, but heck, by age 81 most people have already passed away. The authors concluded: "This study contradicts the common observation that muscle mass and strength decline as a function of aging alone. Instead, these declines may signal the effect of chronic disuse rather than muscle aging."

Multiple scientific studies support that age per se is not the major cause of frailty in the elderly and does not affect our gains nearly as much as most people think.

- In a study by Roth et al. (2001), elderly men and women aged 65-75 years gained just as much muscle as men and women in their 20s during 6 months of strength training. "The results indicate that neither age nor gender affects muscle volume response to whole-body strength training."
- Ivey et al. (2000) found no difference in muscle growth rates between trainees in their 20s and trainees around age 70. They concluded: "Aging does not affect the muscle mass response to either strength training or detraining".
- In a study by Mayhew et al. (2009), a group of ~64-year-olds gained just as much muscle and strength as a group of ~27-year-olds during 4 months of

strength training. They also had comparable anabolic gene expression, though there was reduced protein synthesis in the elderly. Going by the data, the lower protein synthesis may have been in other lean body mass, like connective tissue, not myofibrillar protein (contractile muscle tissue).

- Loenneke et al. (2017) found no difference in the rate of muscle and strength development during strength training in 18-25 and 50-65-year-old women.
- Kittilsen et al. (2021) found no difference in the rate of maximal strength gains between 5 different age clusters ranging from 20 to 76 years old.
- Marcuza-Nassr et al. (2023) found no differences in strength development or muscle growth between 65-75-year-olds and 85+-year-olds in response to a 12-week strength training program.

Ernestine Shepherd at age 82.

Even in your 90s your muscles remain responsive to strength training: 8 weeks of strength training increased strength by an average of 174% in one study.

Based on these data, you may wonder if there's even any evidence at all that age reduces our muscular potential, but there is. A 2020 meta-analysis by Straight et al. concluded that when we look at all available studies, muscle growth from strength training does diminish after age 60, but age only explains about 10% of the variance in muscle growth. The small effect of age explains why most individual studies can't detect it. A 2021 meta-analysis also found a trend for a negative effect of age on muscle growth, but it did not reach statistical significance ($p = 0.07$).

In conclusion, it's never too late to start lifting. While competing with the best of the best in the world may not be realistic anymore after age 40, you can always stay lean and you can likely retain the majority of your muscle mass all the way into your 80s, at least with hormone replacement therapy. Exercise is truly a panacea. We evolved to run, hunt, travel, dance, live. Give your body what it needs, stay lean and fit, and it will serve you for many decades for a long and muscular life.

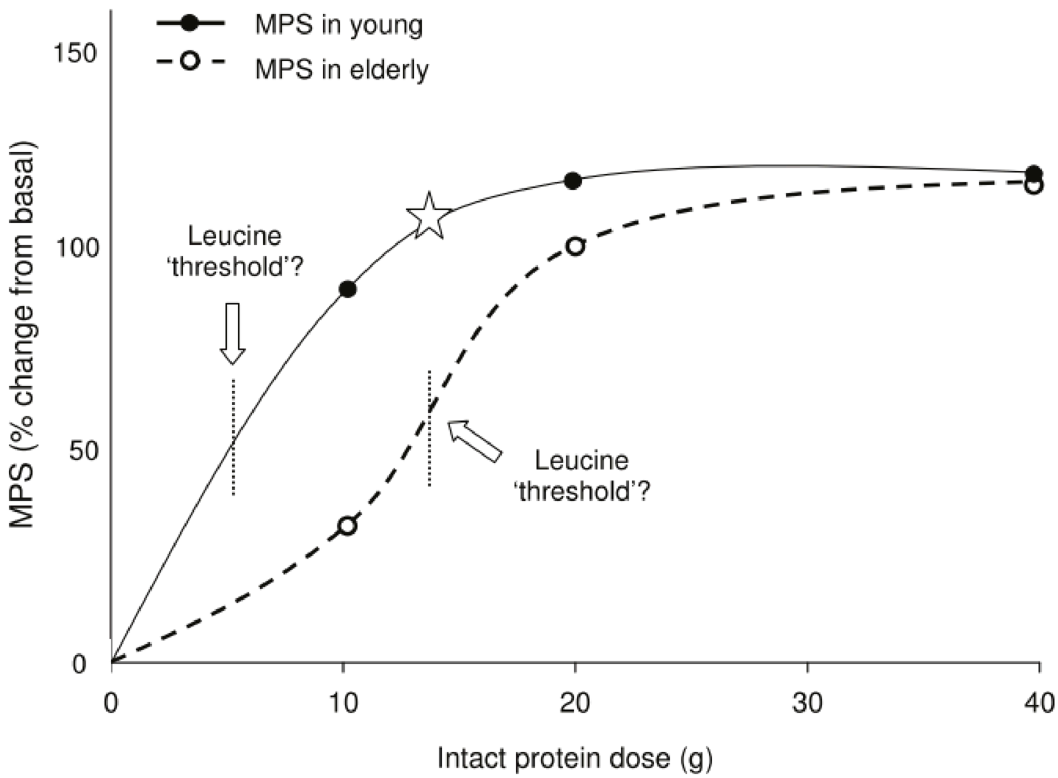
Anabolic resistance

Sarcopenia is in part the result of anabolic resistance. Anabolic resistance refers to a reduced rate of anabolism (protein synthesis) after meals and strength training. Anabolic resistance is, just like its associated sarcopenia, the result of inactivity and aging, though carb tolerance and inflammation seem to operate via similar mechanisms.

So how do we counter it? There's no true treatment other than staying lean and healthy and continuing strength training. However, we can manage anabolic resistance very effectively with special nutritional program design.

A primary mechanism of anabolic resistance is that the leucine threshold increases (see the course topic on protein if you don't remember what the leucine threshold is). A 2023 systematic review of 38 studies found that a meal's leucine dose didn't significantly predict muscle protein synthesis in younger lifters, but it did in older (57+ years old) lifters.

As such, elderly individuals with anabolic resistance require a higher leucine dose and thus more protein to maximize muscle protein synthesis compared to young individuals [2, 3]. Whereas young individuals experience little further increase in protein synthesis beyond 20 grams of high-quality protein, elderly individuals show a dose-response increase in protein synthesis all the way up to 45 grams protein.



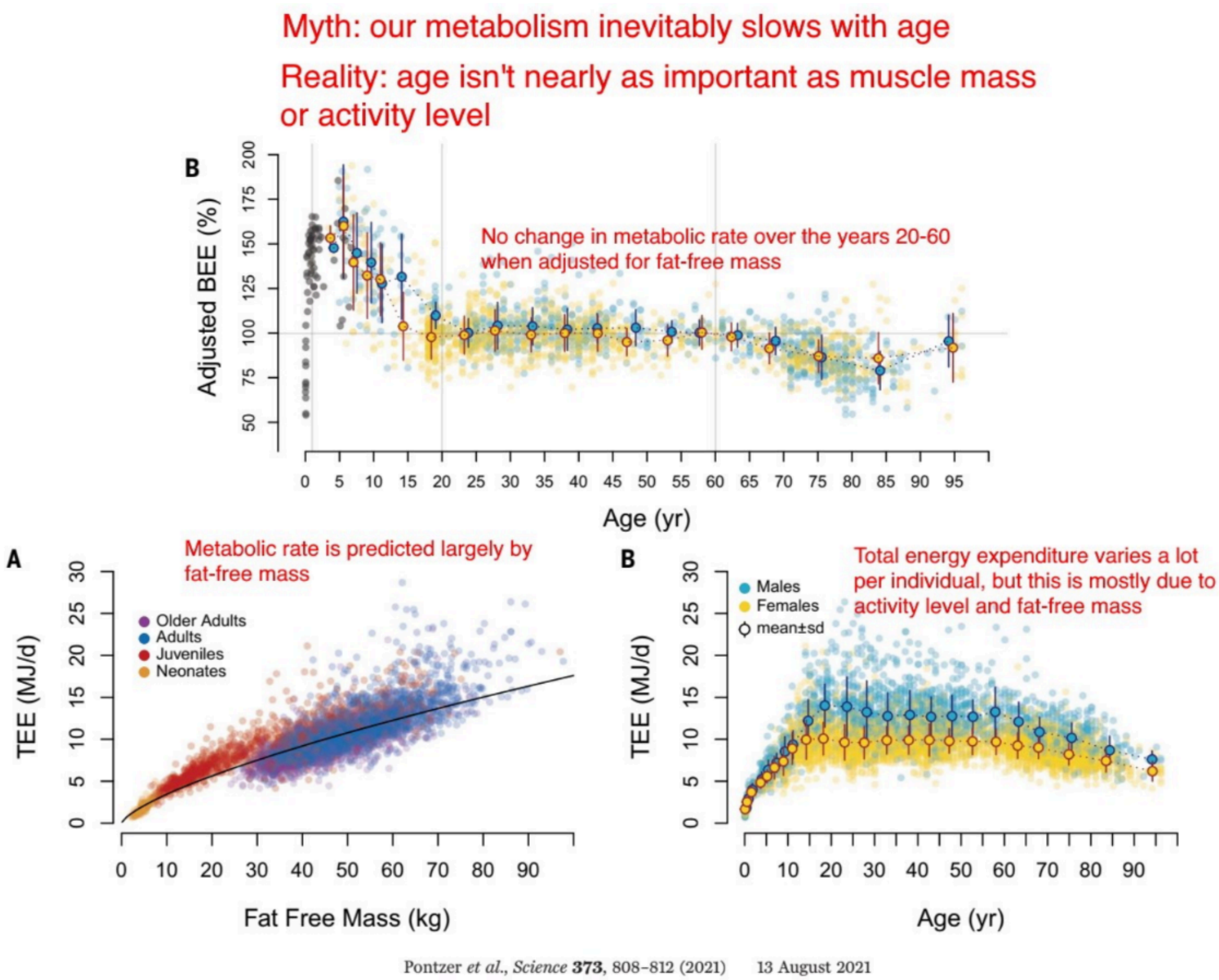
Note that *total daily* protein requirements do not increase with age [2], as you learned in the protein module.

In terms of application, counteracting anabolic resistance thus simply comes down to prescribing fewer, larger meals to induce clear anabolic signals. Concretely, elderly individuals should consume a minimum of 0.4 g/kg (0.2 g/lb) protein with each meal and never less than 40 g for men. Fortunately, ensuring that the leucine threshold is overcome with each meal tends to completely overcome the negative effects of anabolic resistance.

A higher per-meal protein intake means that 2-4 meals a day are generally ideal for older trainees and higher meal frequencies may not maximize protein balance and muscle growth or at least require a needlessly high total daily protein consumption.

What about fat loss?

Just like muscle mass, our metabolic rate isn't affected much by age at all. It's mostly inactivity and loss of fat-free mass, notably muscle mass, that slow down our metabolic rate as we get older. Between 20 and 60 years old, our metabolic rate is completely unaffected by age if we adjust for fat-free mass: see the data below. After age 60, our metabolism starts slowing down, but the decline doesn't tend to get worse than 20%, so you can absolutely still lose fat. You just have to eat a bit less to get the same fat loss.



Nutrition program design for the elderly

Overall, elderly trainees can set up their macronutrient profiles mostly the same way as younger trainees. The most notable exception is that lower meal frequencies with at least 0.4 g/kg (0.2 g/lb) protein per meal, preferably > 40 g protein, are advised to counteract anabolic resistance. For energy intake, err on the lower side. You don't need much of an energy surplus if you think muscle growth rates will be low and after age ~65, you should err on the side of lower maintenance energy intake estimates. A decent rule of thumb is to decrease estimated resting energy intake by 1% for each year after 65 up to a maximum of a 20% decrease.

Strength training for the elderly

Anabolic resistance can be counteracted by proper training design. Training itself will ward off anabolic resistance, but the later phases of anabolic resistance will require special considerations in terms of strength training program design.

Training intensity

Just like younger trainees, elderly trainees experience the same muscle growth from lower and higher intensities in most studies, but a 2020 meta-analysis by Straight et al. found higher training intensities are associated with less muscle growth in elderly trainees. Moreover, a 2023 RCT of 101 older women found greater muscle growth in a group training with 10-15RM loads than a group training with 8-12RM loads. Increases in upper and lower limb lean soft tissue, as well as total skeletal muscle mass as per DXA, were greater in the 10-15RM group. The group training for lower reps gained more strength, in line with most research. Functional improvements in fitness were similar between groups. The 10-15RM group also experienced greater increases in hydration status (intracellular, extracellular and total body water via BIA). The intracellular water increase could be the natural result of the greater muscle growth – and it was smaller than the muscle growth, so it's not like they just gained more water – but the extracellular water increase is peculiar. The validity of these measurements could therefore be questioned. Macronutrient intakes were similar between groups, so that wasn't an obvious culprit for the odd results.

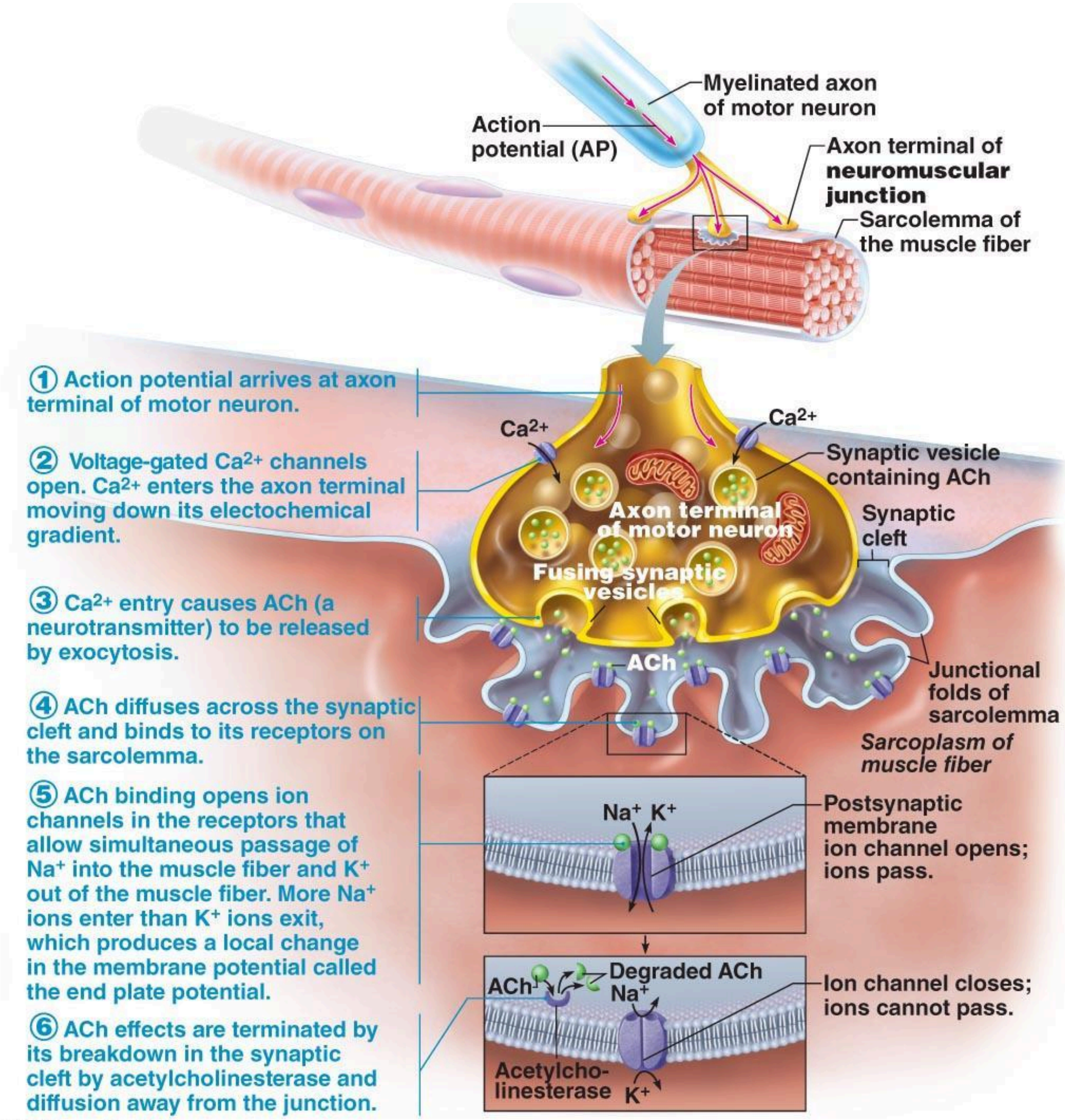
Regardless of whether higher-rep training directly improves muscle growth in the elderly, there are several reasons why high-intensity training is often not worth it for elderly trainees and you're better off sticking with high-rep work.

Preferential type II fiber loss

The first consideration is the loss of type II fibers and motor units as a result of decreased protein synthesis and reduced satellite cell activity. Fast twitch muscle fibers atrophy and eventually completely denervate with age. Type 2 fiber counts can decrease by 25-60%, while type 1 fiber counts only decrease by 0-25%. Again, this is mostly the result of disuse and not age per se, but age itself likely also plays a role. This makes elderly individuals become more slow-twitch dominant, so they may have to gain from high-rep sets and less from low-rep sets (see course module on optimal program design).

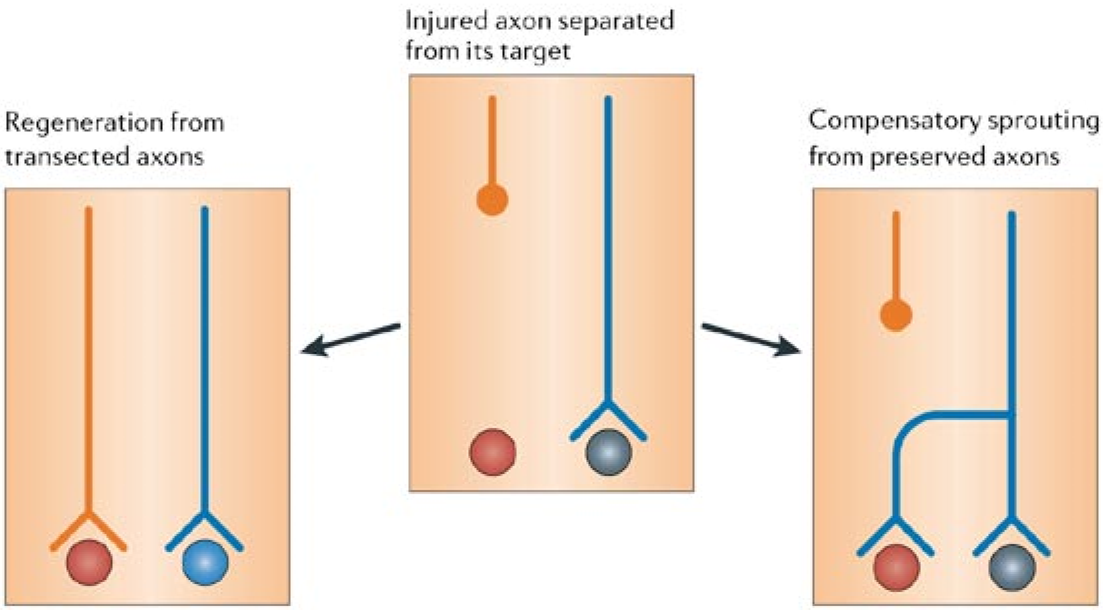
Decreased motor performance

The second consideration is a loss of movement efficiency. With age, the nervous system's motor performance decreases. The neuromuscular junctions (synapses) that transfer signals from the motor cortex in your brain to your muscles become unstable, like a noisy radio signal. This results in impaired and more variable motor unit action potential discharge rates and slower muscle fibers. The overall muscles show more variable and decreased contractile velocity. Maximum voluntary muscle activation decreases [2, 3] due to the lower motor neuron firing rates [2] and greater antagonist co-activation.



How your brain signals your muscles to contract (Source: Pearson Education).

Moreover, spinal motor neuron cells can die (apoptosis) along with a reduction in the amount and diameter of myelin, which insulates nerve cell axons to increase the speed of neural signal conduction. The body compensates for the degradation of motor neurons and myelin by '[sprouting'](): connecting the remaining motor axons together. This forms larger motor units and can reduce force production loses by up to 50%.



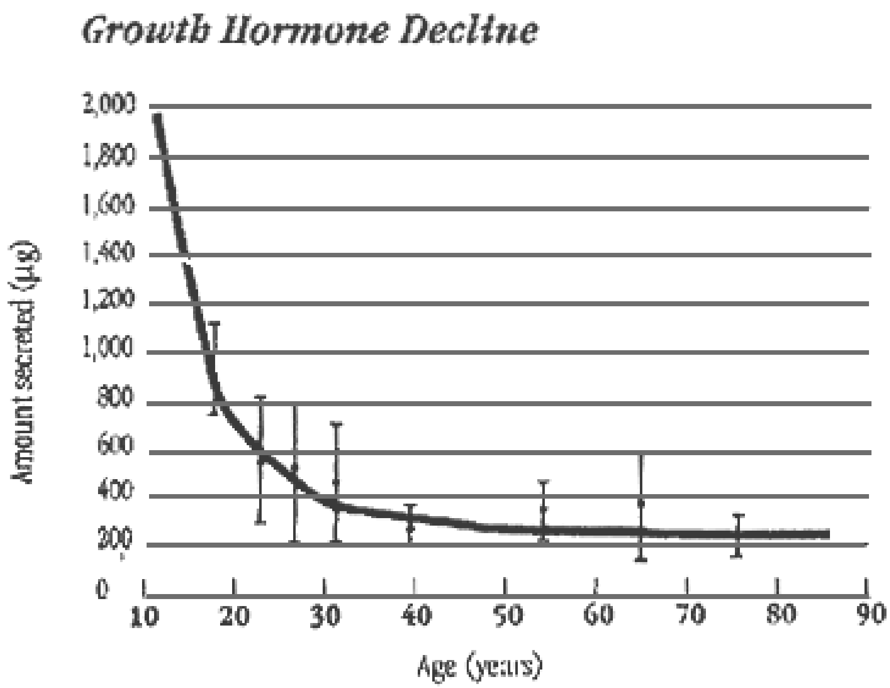
Sprouting: loss of a neuron is compensated for by another neuron connecting with the detached muscle fiber, allowing the body to still activate the muscle fibers and preserve strength, albeit with less control than before.

Of course, there's only so much function sprouting can save. After a certain amount of damage, strength starts decreasing rapidly, 2-5 times faster than muscle mass.

Basically, aging makes you clumsier. The nervous system becomes less capable of directing your muscles how to move, like an old computer that's no longer as fast or reliable was it used to be. The loss of motor efficiency makes elderly people particularly less explosive, even when strength is preserved.

Connective tissue strength

Elderly people have weaker and stiffer connective tissues due to a lower rate of protein turn-over, which makes their joints and tendons weaker [2]. One important reason for this is the loss of growth hormone production with age. Growth hormone is required to maintain high rates of protein synthesis in connective tissue.



Weaker connective tissue makes older trainees considerably more prone to injury, so great extra care should be taken to avoid overuse injuries. High training intensities pose significantly greater injury risk than lower training intensities (see injuries module).

Unlike in younger trainees, high training intensities are also not required in elderly trainees to stimulate connective tissue adaptations. Elderly trainees may not benefit from or need training intensities above 55% of 1RM to stimulate tendon growth.

Application

Since elderly trainees become more type I fiber dominant and less capable of producing high force and power outputs while being at greater risk for connective tissue injury, they have less to gain and more to lose from going heavy. Higher rep work often provides a better cost-benefit. If you implement the muscle-specific hypertrophy method, this will already be autoregulated, but it's still worth erring on the side of prescribing higher rep targets. To be conservative, you may want to err towards the lowest possible training intensity that allows for progressive overload and strength development. Well-trained elderly lifters may want to include some loading over 70% of 1RM to strengthen their connective tissues, but they can generally spend most time training at lower intensities than that if strength is not a primary goal. A conservative strategy for general health and body recomposition is to perform most training in the 15-30RM range.

Repetition tempo

In line with the loss of motor efficiency, you also want to prescribe a slower repetition tempo for older individuals. Elderly trainees fatigue faster than younger trainees when performing explosive reps but not when performing moderate or slow reps [2]. If you use an autoregulated repetition tempo, this should happen automatically.

(We'll discuss repetition tempo in more detail in its own course topic.)

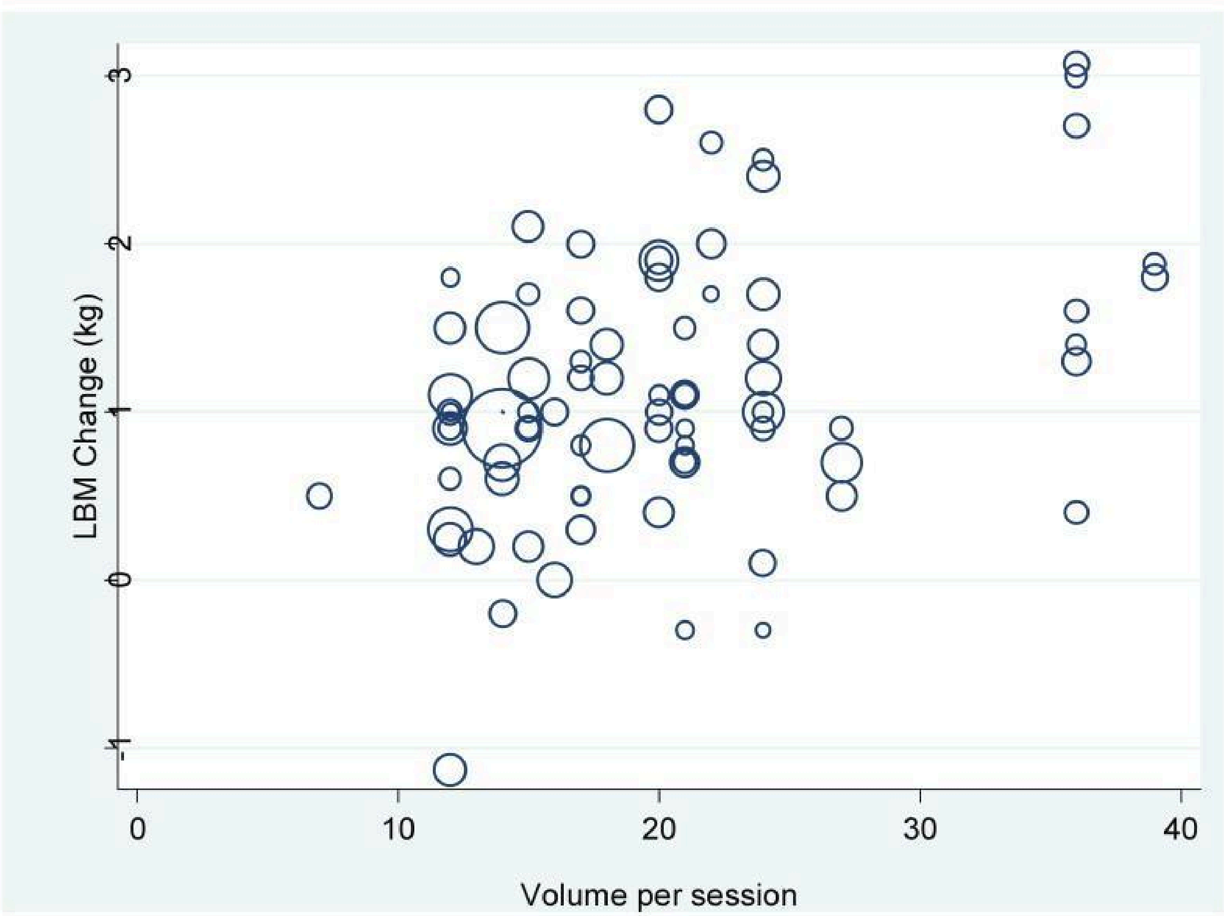
Training volume

Many coaches assume older trainees should train with lower volumes than younger trainees because of impaired recovery capacity. However, a 2021 review concluded that most studies do not find significant differences in recovery indicators after training between trainees in their 20s and trainees in their 50s or 60s, especially not when matched for training status. Just like for anabolic resistance, age per se is probably not that important for neuromuscular recovery up to ~65 years old, but being overweight, having systemic inflammation, having low anabolic hormone levels and being deconditioned of course do affect recovery capacity.

For women the effects of age are more visible in recovery capacity, likely due to the sharp decrease in estrogen levels during menopause. Post-menopausal female trainees quite consistently show greater muscle damage after exercise than younger women.

Since set training volume is the driving force of strength training adaptations, compromising on training volume should be a last resort. In fact, research suggests that elderly trainees may have *more* to gain from higher set volumes than younger trainees, possibly due to their anabolic resistance. Elderly trainees experience greater increases in protein synthesis and anabolic signaling than younger trainees when doing 6 instead of 3 sets per workout for a muscle.

A 2011 meta-analysis found that 50+ year olds have a positive dose-response to training volume with no evidence of detrimental effects at higher volumes. See the figure below.



Lean body mass change by training volume (sets per session), weighted by number of subjects in the study. [Source]

We have one particularly interesting study on how much volume elderly trainees should use. [Stec et al. (2017)] compared 4 groups of sarcopenic 60-75-year-old men and women with a different combination of regular heavy strength training (H) and light, concentric-only power workouts (L).

- HHH: high-resistance concentric-eccentric training 3 days per week
- HH: H training 2 days per week
- HLH: 3 days per week mixed model consisting of H training 2 days per week separated by 1 bout of low-resistance, high-velocity, concentric only training

- HL: 2 days per week mixed model consisting of H training 1 day per week and L training 1 day per week

They measured arm, thigh and total lean body mass changes, so we should look at the training volume for each independently. The heavy workouts consisted of 2 exercises for the biceps, 3 for the triceps (but one being the overhead press which doesn't train the triceps heavily) and 3 for the quads. Each exercise was performed with 3 sets of 8-12 reps to failure. However, 'to failure' can be taken with a grain of salt here, as the intensities used were on the lower end of the 60-75% of 1RM range, which would normally be 10-20 reps. So each heavy workout had 9 sets for the thighs and ~6 sets for the arms. Based on the results shown below, for the quads the optimal volume was in between 18 and 27 sets per week(!) and for the arms it was over 18 sets.

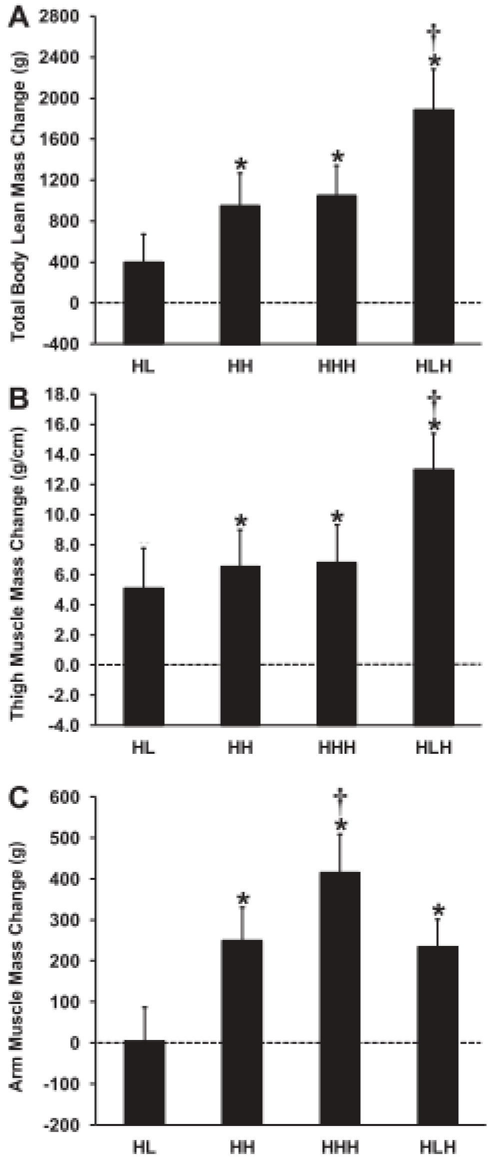


Fig. 2. Effects of the dose-response RT trial on gains in total body lean mass (A), bilateral thigh muscle mass (adjusted to femur length) (B), and bilateral arm muscle mass (C) from week 0 to week 35. *Significant change from pre-training, $P < 0.05$. †Magnitude of change different from other groups: In (A), HLH is different from HL and HH ($P < 0.05$) and tends to be different from HHH ($P = 0.1$). In (B), HLH is different from HL ($P < 0.05$), and tends to be different from HH ($P = 0.07$) and HHH ($P = 0.09$). In (C), HHH is different from HL ($P < 0.05$).

As per the course topic on the optimal training volume, this is an outlier. Most studies do not find such clear benefits of higher training volumes for untrained elderly individuals. The results were probably attributable to a definition of 'training to failure' that was more liberal than Greenpeace. A 2024 meta-analysis found no significant dose-response effect of weekly set volume on leg muscle size in 65+ year olds. However, the analysis had limited statistical power due to only investigating leg muscle size and not grouping together different measurement methods of muscle hypertrophy. They therefore ended up with considerably fewer studies than the 2021 meta-analysis. Moreover, the analysis did not specifically look at studies of different training volumes but rather compared different studies with different training volumes, so the results are confounded by between-study differences, a common problem in meta-analyses.

Overall, for trainees up to 50 years old, training volume does not necessarily have to decrease compared to younger trainees. After menopause or 60 years of age, you should err on the side of caution. After 65 years of age, recovery capacity will most likely be impaired and injury risk increases, so you should take that into account when estimating the optimal training volume. A reasonable guideline is to assuming a decrease in volume tolerance of 12% for every decade of life starting at age 50. So an 80-year old would have a 4 × 0.12 = 0.48 lower volume tolerance than someone below 50 years old. In other words, they should train with roughly half the volume. The course's training volume calculator uses this approach.

Training frequency

As we age, our recovery capacity deteriorates. However, just like for our hormonal health and body composition, this decline is much weaker than commonly believed. In some research, there is in fact no significant difference between younger and elderly trainees in recovery capacity.

- Chapman et al. (2008) found that a group of ~64-year-olds recovered muscle force more slowly than a group of ~24-year-olds after high-volume eccentric-only biceps training, but the elderly individuals experienced *less* muscle soreness.

- Buford et al. (2014) found that over-70-year-olds recover just as quickly as 18-to-30-year-olds during 72 hours after a brutal eccentric-only workout. There was no difference in the recovery time course of force production, hormone levels and inflammatory markers.
- Gordon et al. (2017) found that ~50-year-olds recover just as quickly as ~20-year-olds in the 48 hours after a high-volume isokinetic workout. There was no difference in the recovery time course of measures of strength, inflammation or muscle damage.
- Lavender & Nosaka (2017) found no difference in the rate of or pattern of isometric force recovery up to 5 days after submaximal eccentric exercise in groups aged around 20, 50 or 70 years old.
- Fernandes (2019) did find a difference in force recovery speed between trainees around 20 and 40 years old after 10 sets of 10 rep squats, but in this sample the younger trainees were also in much better shape (significantly better body composition and greater strength).

Overall, these findings support that age per se has comparatively little effect on recovery capacity and training status is much more relevant. The typical 70-year-old is likely to have much poorer recovery capacity than the typical 20-year-old but not because they're older: because they're very deconditioned and in worse shape.

According to a 2011 meta-analysis, training frequency does not influence muscle growth independently of training volume in elderly trainees. However, since higher training frequencies are a highly effective way to increase training volume while mitigating fatigue per session, elderly trainees can benefit from high frequency training just like younger trainees. Just be careful to keep total weekly training volume reasonable for the individual's training level.

Health conditions

Elderly trainees frequently have health conditions, such as cardiovascular disease. Working with someone with serious pathologies may be daunting for coaches. As a result, many coaches take it very easy with their training stress for these individuals. This is often not necessary, beyond adjusting the training stress for their likely low level of conditioning. Exercise is the closest we have to a panacea. Almost all common health conditions benefit from exercise. Exercise is the cure, not the problem. Most chronic health conditions do not require special programming.

- The American Heart Center recommends strength training for most individuals with or without cardiovascular disease.
- Individuals with diabetes, especially type II, should absolutely engage in strength training, as it's one of the most effective treatments there is (see health science module for further details).
- Strength training reduces the side-effects of cancer and its common treatments [2], so it's highly recommended when possible.

In the case of very serious *acute* health conditions, such as someone who just had open heart surgery, you of course do need to make sure the individual is cleared for exercise by a medical professional.

Conclusion: program design for the elderly

In conclusion, optimal training program design for elderly individuals is characterized by the following.

- A slower, more controlled repetition tempo.
- A lower average training intensity with more reps per set.
- Not necessarily a decrease in training volume or frequency but extra emphasis on prehabilitation.

Working with youth

Working with minors obviously requires special considerations as a coach. However, you generally shouldn't shy away from strength training. Strength training is a very healthy activity for children, just like it is for adults. It's nonsense that strength training will stunt bone growth or result in muscle deformities. Strength training is a very safe form of exercise compared to most sports for children, just like it is for adults. A 2023 review on youth athletes concluded that "Injury rates among youth participants were low and less concerning in well-designed, progressed, supervised and technique-oriented resistance training programs." Until children reach puberty, they won't be able to build a as much muscle mass as adults yet, but even prepubertal children can already achieve significant body recomposition and improve their athletic performance, not to mention their health, physical and mental. A 2023 meta-analysis found that strength training improved overall cognitive, academic and on-task behaviors in school-aged youth.

If you work with minors, especially pre-pubertal youth, there's not that much different you have to do in terms of programming compared to adults. A few good guidelines to err on the side of safety are:

- Strongly emphasize appropriate exercise technique and controlled movements. In-person supervision is strongly recommended. Purely online coaching for minors is not advisable.
- Don't go below 5 reps per set or above 85% of 1RM.
- Don't perform strength training more than every other day or 4x per week.
- Err on the side of minimally effective training volumes.

While it's good to err on the side of caution, physiologically speaking, youths may actually handle higher training volumes than adults. Youths suffer less muscle damage and neuromuscular fatigue than adults from a given workout, according to a 2023 meta-analysis.