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Antifrail: Why Muscle (Power) Matters in Aging

by Ashley Gluchowski, Ph.D., CSEP-CEP, NSCA-CSPS and Stuart M. Phillips, Ph.D., FACSM, FCAHS

Apply It!

- Reductions in muscle power begin earlier in the life course and occur at a greater rate when compared to declines in muscle strength.
- Power training in older adults may lead to a greater improvement in physical function than traditional resistance training alone.
- Muscle power is a product of force and velocity — if either force or velocity are underdosed, improvements in muscle power are less likely to be realized.
- Higher-functioning older adults may show functional performance plateaus; however, having a reserve of muscle power may still be important.

Key words: Older Adults, Frail, Resistance, Exercise, Training

INTRODUCTION

Aging is unavoidable and gradually reduces physical resilience and independence. A major factor in this decline is the progressive loss of muscle mass (termed sarcopenia), strength, and muscle power, which affects physical mobility, function, and overall health. The concept of "antifrail" aging focuses on reducing physical frailty and building physical resilience through targeted interventions, particularly by emphasizing muscle strength and power (1). Indeed, a recent review superbly highlights the health benefits that are unique to strengthening exercise and, in certain cases, enhanced by power training (2). The current article examines the importance of muscle power in aging, its role in maintaining independence, and the strategies that can be used to enhance it in older adults (3).

Aging is an unavoidable process that gradually reduces physical resilience and independence. A major factor in this decline is the progressive loss of muscle power, which affects physical mobility, function, and overall health.

DEFINING KEY TERMS

Muscle power refers to the ability to generate force rapidly, defined as the product of force and velocity (4). Unlike muscle strength, which is a measure of maximal force-generating capacity, power is essential for executing quick and functional movements such as rising from a chair or climbing stairs (5).

Frailty is a condition marked by increased vulnerability to stressors, often due to a decline in key functional reserves of muscle mass, strength, and power (6). Frailty and weakness are associated with a higher risk of falls, disability, and even mortality (7).



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Several terms describe different aspects of muscle deterioration. Sarcopenia refers to the loss of muscle mass. Dynapenia pertains to the decline in muscle strength, whereas kratopenia (powerpenia) specifically refers to the loss of muscle power, which is particularly crucial for maintaining functional independence (1).

Physical function encompasses an individual's ability to carry out daily activities, such as walking, lifting objects, and maintaining balance. A reduction in muscle power has been strongly linked to declines in these abilities (8).

PARTICIPATION RATES

A recent review encompassing 30 observational studies with 2,629,508 participants showed that 22.8% of healthy adults adhere to the muscle-strengthening guidelines (9). While the prevalence varied from 1.3% to 76.2% across the studies, two outliers, including a population of military personnel, were included in the analysis. Trends in the United States indicate that adherence to engaging in muscle strengthening has increased across all age groups from 1997 to 2018, although prevalence remains low, at 27.2% (10). Observational research likely overestimates participation as research in this area is still subject to self-report questionnaires (unlike objective measures available for aerobic activity). Questionnaires of muscle-strengthening participation typically include one single question on frequency and include large variations on the kind of activities that are considered muscle strengthening, and therefore subject to misclassification, recall, and social desirability bias. As national or international physical activity guidelines do not recommend power training, much less is known about the prevalence or adherence to power training in the general population. It is reasonable to presume that participation rates in power training, especially among older adults, are even lower than that for muscle strengthening.

IMPORTANCE OF MUSCLE POWER IN AGING

Muscle power is closely associated with functional decline, more so than muscle strength alone (4). Studies have shown that individuals with higher muscle power tend to perform better in activities of daily living and maintain independence for longer periods (11). Faster power output has been correlated with improved balance and a reduced risk of falls, as demonstrated in a systematic review and meta-analysis (8). Additionally, greater muscle power has been linked to a lower mortality rate, even in people with higher body mass index (BMI), waist circumference, and body fat percentage, underscoring its role in promoting longevity (7,12).



Muscle power is a stronger predictor of functional decline than muscle strength alone. Research indicates that power training enhances mobility, lowers the risk of falls, and improves overall quality of life.

Studies show that power-based training effectively counteracts the age-related decline in muscle power, which deteriorates faster than muscle strength. Improved power helps in daily tasks like walking and stair climbing, reducing the risk of falls (13,14). A meta-analysis of randomized trials highlights moderate to large improvements in physical and cognitive outcomes, with interventions lasting at least 10 weeks showing the most pronounced results (13). Similarly, power training improves task-specific performance, such as sit-to-stand transitions and stair climbing, better than traditional strength training, possibly due to enhanced motor unit activation and faster muscle contractions (14,15).

Beyond physical benefits, power training also enhances quality of life metrics. A study comparing power and strength training found that power training led to significant improvements in self-efficacy, satisfaction with physical functioning, and overall life satisfaction. These gains stem from greater independence and confidence in performing everyday activities (16). Further studies with quality of life–based outcomes would be welcome as this is likely an important reinforcement mechanism to continue training. The health benefits of power training for older adults with mobility limitations also may include improved estimated bone strength at non–weight-bearing sites (17) and executive function (18).

Power training results in short-term neural and muscle power adaptations, making it a crucial preventive strategy for mitigating age-related risks and promoting healthy aging. However, the long-term effects require further research to confirm sustained benefits. Incorporating higher-speed, targeted exercises into regular routines could help older adults maintain mobility, reduce healthcare burdens, and improve their overall quality of life (13,16).

ASSESSING MUSCLE POWER IN OLDER ADULTS

Assessing muscle power is essential for establishing a baseline, setting realistic training goals, and tracking progress over time. The prevalence of leg power asymmetry has been shown to be greater in older adult fallers compared to nonfallers (19). Several tests have been developed to evaluate muscle power in older adults. The Senior Fitness Test (SFT) is a comprehensive battery

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of assessments that measure functional fitness (5). The Short Physical Performance Battery (SPPB) evaluates balance, walking speed, and sit-to-stand transitions (4). The Medicine Ball Chest Throw is used to assess upper-body power, while the Sit-to-Stand Power Test has been identified as more closely correlated with gait speed than knee extension strength (4).

Since most activities of daily living require older adults to support their body mass, relative muscle power appears to be better associated with physical function than absolute muscle power. The five-repetition Sit-to-Stand (STS) Power Test instructs participants to sit and stand as quickly as possible, starting and finishing in the seated position after the fifth STS repetition with their arms crossed over their chest. The time to complete the task is recorded to the nearest 0.01 seconds.

$$\text{STS mean power} = \frac{\text{Body mass (kg)} \times 0.9 \times 9.8\ \text{m/s}^2 \times [\text{Height (m)} \times 0.5 - \text{Chair height (m)}]}{\text{STS time (s)} \times 0.1}$$

Relative STS power ($W \cdot kg^{-1}$) is calculated as the ratio of STS mean power and body mass. Cut-off points for a low relative STS Power Test have been listed as $<2.5\ W \cdot kg^{-1}$ in Spanish men and $<1.9\ W \cdot kg^{-1}$ in Spanish women (20). Lower muscle power cut-off values using <1 SD ranged from 1.78 to 1.01 and 1.32 to 0.79 $W \cdot kg^{-1}$ in Colombian older men and women, respectively (21). Individuals below these values were more likely to be frail and were at significantly higher risk of adverse events (20,21).

The Stair Climb Power Test (SCPT) requires participants to climb a flight of 10 stairs as quickly as possible. The SCPT is calculated as follows:

$$\frac{[\text{Body mass (kg)} \times 9.8\ \text{m/s}^2] \times \text{Stair height (m)}}{\text{Time (s)}}$$



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The SCPT threshold for mobility limitation was 3.07 and 2.59 $W \cdot kg^{-1}$ for American men and women, respectively, and associated with an SPPB score of ≤9, indicating moderate to severe mobility limitations (22). For more on assessments, be sure to read the feature article, "The 'Power' of Assessments for Optimizing Fitness, Function, and Fall Risk in Older Adults," in this issue (23).

STRATEGIES TO ENHANCE MUSCLE POWER

Power training differs from traditional resistance training by focusing on speed and explosive movements that may better represent real-world functional requirements. Training to enhance muscle power requires the use of a range of loads across the entire force-velocity spectrum. High-force (heavier load) exercises, including traditional resistance training exercises such as squats, leg presses, and deadlifts, can improve muscle power if performed with an emphasis on rapid force generation by encouraging clients to perform each concentric action "as fast as possible" or with intent of performing the action as fast as possible (3). The actual movement velocity will be determined by the load used and appears to be less important when compared to maximal intent. Higher-velocity (low-moderate load) movements, such as jump squats, medicine ball throws, and kettlebell swings, also are effective for increasing muscle power (7). Power training at lower to moderate loads appears to be more effective for individuals with lower levels of baseline strength and mobility.

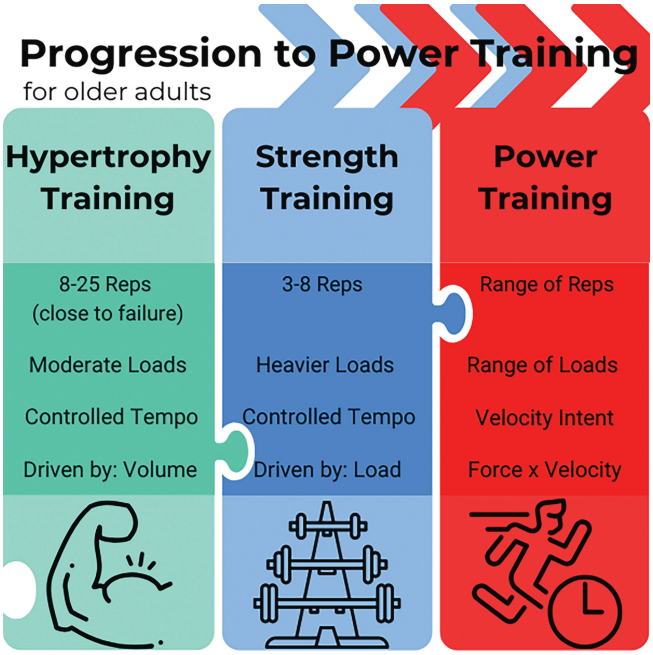
Power training differs from traditional resistance training by focusing on speed and explosive movements .... High-velocity-oriented movements, such as jump squats, medicine ball throws, and kettlebell swings, are effective for increasing muscle power.

A solid foundation of muscle strength should be present before progressing to power training. Progression should be carefully adjusted based on an individual's capabilities. Studies have demonstrated that both higher- and lower-load (70% and 40% 1RM, respectively) power training can lead to significant improvements in older adults' power; however, higher-load training is often associated with greater gains in power (1). Ensuring safe implementation through proper supervision with gradual load regression coupled with velocity progression is crucial for minimizing the risk of injury (6) (see the Figure).

ADDRESSING BARRIERS AND IMPLEMENTATION CHALLENGES

Despite the numerous benefits of power training, it is often underutilized in aging populations due to misconceptions regarding its feasibility and safety (24,25). With any exercise, some older adults may have mobility limitations that require modifications to exercises (5). Safety concerns can be alleviated by gradually introducing power training following strength training and ensuring that sessions are conducted under supervision (4,26,27). Collaboration between healthcare professionals, including physicians, physical therapists, and personal trainers, is essential for integrating power training into comprehensive care plans and promoting its adoption among older adults (6).

Figure. Suggested progression of loading schemes for older people wishing to move to power training.



A systematic review of plyometric training in older adults revealed that interventions lasting from 4 weeks to 12 months showed no reports of increased injuries or adverse effects. In studies involving individuals aged 58 to 79 years, plyometric exercises, including jumps, bounding, and hopping, led to improvements in muscle strength, bone health, balance, and overall physical performance. Proper supervision and gradual progression were key factors in ensuring safety and preventing injuries (28).

A meta-analysis found that power training offers small but meaningful advantages over conventional resistance training in enhancing functional outcomes, balance, and muscle power in older adults. Although evidence on safety remains limited due to the small number of studies, the reported adverse effects were minimal and included minor musculoskeletal discomfort and a few fall-related incidents, comparable between power and strength training groups (29).

Beyond the known barriers related to traditional resistance training participation (being female, older age, lower educational attainment, poorer self-related health), not much is known about the barriers to participation or the acceptability of power training in older adults (25).

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CONCLUSION

Power training addresses the rapid decline in muscle power commonly seen with aging, which is crucial for maintaining balance and preventing falls. By focusing on dynamic force absorption and rapid force production, these training methods help older adults enhance their ability to react quickly during balance-related tasks. Thus, with appropriate program design, including adaptation periods and supervision, plyometric and power training can be safely incorporated into exercise regimens for older individuals, contributing to their functional independence and overall quality of life. Muscle power clearly plays a vital role in "antifrail" aging by directly impacting mobility, independence, and overall quality of life. However, power training remains an underutilized intervention for aging populations (3). Integrating muscle power assessments and targeted training programs into health initiatives can significantly enhance functional capacity and longevity in older adults (11). Researchers, exercise professionals, healthcare providers, and policymakers must recognize the importance of muscle power and prioritize its incorporation into strategies aimed at promoting healthy aging (1).

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BRIDGING THE GAP

Muscle power is one of the first components of physical fitness to deteriorate with age. Muscle power appears to be more strongly associated with functional decline than muscle strength alone. Assessing muscle power is essential for establishing a baseline, setting realistic training goals, and tracking progress over time. Traditional resistance training exercises, such as squats, leg presses, and deadlifts, performed with high intended movement velocity, are an effective way to incorporate power training.

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