

The Senior Section

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Resistance Training for Power, Strength, and Functionality: A Long-Term Prescription

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The link between muscle strength and functionality in older persons is well established.^{1,2} In fact, it has been argued that the functional limitations seen in older individuals are contingent more on strength than on cardiovascular performance.³ More recently, power, or the rate of doing work, has gained prominence as a major factor associated with maintaining independence^{4,5} and reducing the probability of falls.⁶ Some researchers have hypothesized that the higher levels of disability seen in elderly women, compared to elderly men, may be related either to their lower capacity to produce power⁷ or to their lower power-to-body weight ratios.⁸ Recognizing the link between power and functionality in seniors, a number of researchers have examined the feasibility of applying high-speed power training techniques to an older population. In this column, we will examine the histologic and functional arguments that favor such training and review studies that have used high-speed training to develop power in younger and older subjects. We will then present our hypothetical model for including strength and power phases in a periodized training program. This program is based on diagnostic assessment and is designed to optimize results and allow continued training in older individuals through prescribed cycles of training and recovery.

The Histology of Aging Muscle

Sarcopenia, the loss of muscle cross-sectional area, is a natural consequence of aging, increasing exponentially after the age of 50. Most of the tissue loss is due to an age-related reduction in the number of motor units and their associated muscle fibers. An important aspect of this loss, with regard to resistance training, is

that the loss primarily targets the faster-contracting, type II fibers.^{9,10} As muscle ages, a distinct shift occurs, from a more heterogeneous to a more homogeneous muscle fiber type distribution, favoring the clustering of the slower, type I fibers.⁹

Functional Implications

The most obvious consequence of age-related loss in muscle cross-sectional area is a reduction in the contractile force, or strength, of the muscle. Because most of this loss occurs in type II fibers, contractile speed is slowed, which contributes to the loss in power seen with aging. Between the ages of 65 and 89, explosive lower limb extensor power declines at 3.5% per year, compared to a 1%–2% per year decrease in strength.¹¹ Additionally, maximal anaerobic power has been reported to decline 8.3% per decade, from age 20–70.¹² Such power losses have been linked to reduced functional capacity,^{4,5} increased risk of falls,⁶ and longer periods of rehabilitation after injury.¹³

The Rationale for Training Speed and Power

Resistance training can improve power in older individuals^{14–16}; however, movement speed is an important training component if power development is to be optimized. Findings presented at “Sarcopenia and Physical Performance in Old Age,” a multidisciplinary workshop convened by the National Institute on Aging, support this concept.¹⁷ Workshop participants noted that many activities of daily living must be done quickly in reaction to

Table. Functional Performance Results for High-Speed, Low-Speed, and Active-Assisted Stretching Programs

	ACTIVE-ASSISTED STRETCHING MEAN±SEM (P VALUE)	LOW-SPEED ISOKINETIC TRAINING MEAN±SEM (P VALUE)	HIGH-SPEED ISOKINETIC TRAINING MEAN±SEM (P VALUE)
Agility (s)	-1.26±0.45 (NS)	-1.44±0.36 (0.005)	-1.50±0.24 (0.0003)
Anaerobic power (W)	12.77±2.98 (0.005)	14.40±6.09 (NS)	16.91±3.88 (0.002)
Functional reach (cm)	1.42±1.23 (NS)	6.98±2.43 (NS)	11.16±1.43 (0.0001)
Gait speed (m/s)	0.84±0.11 (0.0003)	0.53±0.05 (0.0001)	0.69±0.07 (0.0001)
Small-object lift (s)	-1.52±0.42 (0.01)	-3.14±0.61 (0.001)	-1.50±0.39 (0.005)
Stand-up (s)	-1.06±0.48 (NS)	-1.02±0.61 (NS)	-1.70±0.34 (0.001)

Data and *p* values represent changes within each group.
Data derived from Carmel et al.³¹

external factors, thus establishing speed as a crucial training prescription variable. Moreover, it has been reported that movement velocity, rather than force production, is the greater determinant of maximal instantaneous muscle power in healthy older women, 50–75 years of age.¹⁸ Researchers have demonstrated that improvements in strength^{19,20} and power²¹ are specific to the speed at which the individual trains. In addition, research concentrating on athletic performance has confirmed the importance of high-speed, explosive movements in maximizing power development.^{22–24}

Power Training in Older Individuals

Some researchers have applied the principle of speed-specificity to older individuals in an attempt to address age-related decrements in both strength and movement speed of the joint being trained.^{25,26} They have also shown that high-speed resistance training can be used effectively to target increases in mechanical power (Figure 1).^{27,28} Some questions remain concerning the impact of high-speed resistance training on anaerobic muscle metabolism.²⁹

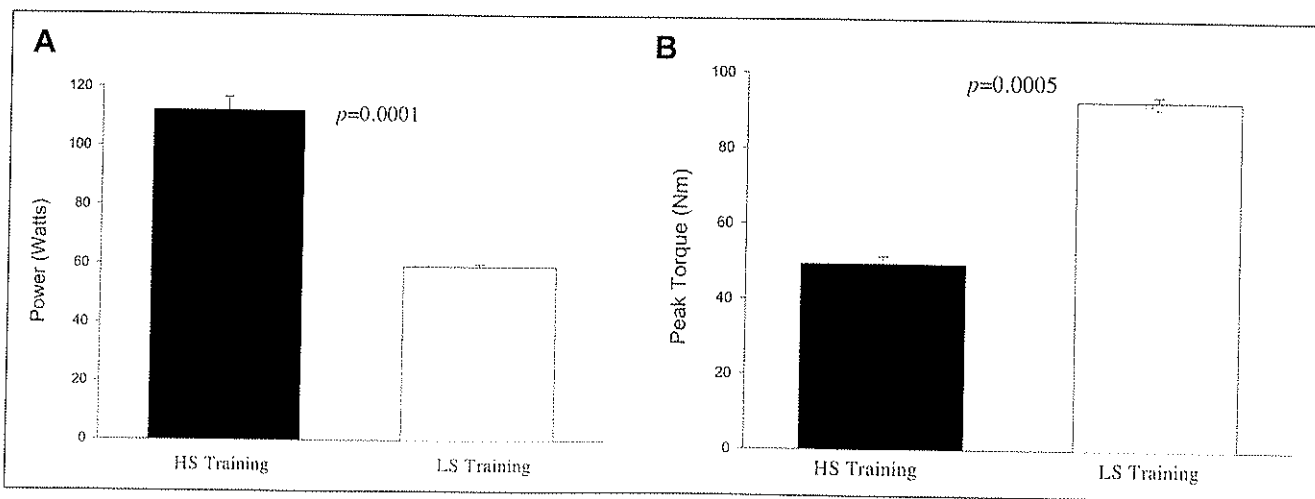


Figure 1. Changes in power (A) and torque (B) resulting from high-speed (HS) versus low-speed (LS) training over a 12-week training period³²

Preliminary studies²⁹⁻³¹ suggest that increasing mechanical power through high-speed resistance training, rather than applying standard, low-speed techniques, can be more effective in improving many aspects of functional performance. However, other training techniques such as standard low-speed lifting and stretching, may provide similar, if not greater, improvements in everyday activities such as small-object lifting and gait speed, respectively (Table).³¹ In addition, it appears that the effectiveness of high-speed training on mechanical power may be joint-specific. A recent study³² demonstrated that high-speed training may be more effective for the larger muscle groups associated with longer skeletal levers (e.g., knee extensors), than for the muscle groups with lower inherent contractile speeds and shorter lever systems (e.g., plantar flexors and dorsiflexors).

Periodization as a Prescriptive Strategy in Older Persons

It is well accepted that periods of recovery are necessary during any training protocol if maximal benefit is to be realized. The intensity of a recovery period ranges from complete rest, as when one takes a vacation, to periods when training is reduced in order to concentrate on another component of fitness. For example, a higher-intensity resistance training cycle may be followed by a lower-intensity cycle, where the focus is on mobility or balance training.

These recovery periods are necessary because the training stresses that induce positive adaptations can also cause performance reductions due to fatigue and tissue damage.^{33,34} To this end, periodization programs providing specific periods of overload (depletion), recovery (repletion), and adaptation (supercompensation) have been designed to maximize training.³⁵ Moreover, in studies examining resistance training, periodization has proven more effective than the standard progressive resistance protocols commonly used to increase strength and power.^{36,37} Figure 2 shows a periodized prescription lasting about 6 months, with a series of work and recovery cycles that might be used to target neuromuscular improvements and functional performance variables specific to older persons.

The need for periodization programs in older individuals has been well demonstrated. In a year-long study of resistance training in older individuals, Pyka et al.³⁸ reported that after a period of significant strength gain over the first 8 weeks of training, no noteworthy gains were made across the subsequent 10 months of progressive resistance training. These data confirm the results reported for younger individuals, showing that an effective exercise prescription must incorporate training cycles of specific length that target strength, speed, and power.³⁸ However, to our knowledge, only our group has attempted to ascertain the optimal length for cycles targeting specific needs of an older population.²⁷ Our results should be useful for the design of proper cycling patterns during resistance training and related functional performance training methods. We found that a tissue adaptation period of at least 5 weeks is necessary to prepare healthy older individuals (aged 62-78 years) for high-intensity resistance training. This period allows the muscle and connective tissue to adapt slowly in preparation for the stresses of resistance training, thus reducing the potential for injury resulting from ultrastructural damage associated with lifting. The adaptation period also allows enough time to teach proper lifting techniques and to determine suitable training loads. Rather than risk the potential injury associated with the use of maximal lifts to compute training loads, an adaptation period allows a gradual increase based on a systematic empirical change in resistance to establish an initial training load. We also noted that training cycles of about 3-4 weeks appeared optimal for power and strength training, whether the exercise prescriptions used isokinetic (Figure 3A) or isotonic (Figure 3B) resistance training. The time required for power and strength training recovery cycles appeared to be 2 and 4 weeks, respectively; however, preliminary results from a recent study³⁹

WORK	RECOVERY	WORK	RECOVERY	WORK
Tissue Adaptation	↔	Hypertrophy and Strength	↔	Power
	Balance Training		Mobility and Agility	
Flexibility training throughout the training program				
Low Speed 30%→70% of 1RM 1→2→1 sets 8-12 reps Machines: stacks, rods pneumatics; resistance bands or tubing	Balance drills: static→dynamic→ locomotion	Low Speed 70% of 1RM 1→2→1 sets 8-12 reps Machines: stacks, rods pneumatics; resistance bands or tubing	Line, ladder and obstacle drills, variable surface, chair and lateral movement drills; 1 maintenance resistance set/week if desired	High Speed 30%-50% of 1RM 1→2→1 sets 8-12 reps Machines: rods or pneumatics; resistance bands or tubing. Avoid stack machines
~5-8 weeks 3 days/wk	~2-3 weeks 2-3 days/wk	~3-4 weeks 2-3 days/wk	~3-4 weeks 2-3 days/wk	~3-4 weeks 2-3 days/wk

Figure 2. A sample periodized training prescription featuring specific work and recovery cycles
RM=repitition maximum

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