By Byung-Kon Yoon, PhD, and Len Kravitz, PhD

single- versus multiset resistance exercise in older adults

Comparing the two for muscular-fitness and functional-performance benefits.

Galvão, D.A., & Taaffe, D.R. 2005. Resistance exercise dosage in older adults: Single- versus multiset effects on physical performance and body composition. Journal of American Geriatrics Society 53, *2090–97.*

Advancing age is often associated with a number of physical changes, such as losses in skeletal muscle mass, strength and power, and an increase in fat mass. These factors are related to important clinical outcomes, including mobility impairments, disability, falls and fractures. There is accumulating scientific evidence from studies focused on middle-aged and mature populations that consistent resistance training will improve functional abilities, prevent osteoporosis, slow sarcopenia (age-related loss of muscle mass, strength and function) and help prevent falls, fractures and disabilities (see Table 1).

Despite a number of published guidelines for resistance training of older adults, the mode, frequency, volume and intensity of resistance training required to optimize muscular strength gains are still unclear. In brief, research has been published investigating the effects of resistance training intensities of 50%–100% of 1RM (repetition maximum), performed for 1–3 sets per exercise, at frequencies of 1–3 times per week on machines and free weights, with protocol durations of 8 weeks to 1 year. Nevertheless, there is no clear evidence whether multiple-set protocols are necessary to gain and optimize strength in older populations. If a single-set program is comparatively effective for muscle strength and daily physical performance, it will save time, possibly minimize residual soreness in the initial workout stages and perhaps enhance exercise participation and compliance.

The main goal of this investigation was to compare the muscular-fitness and functional-performance benefits of a single-set resistance training program versus a multiset training scheme in older men and women.

Methods

Thirty-two sedentary men and women, aged 65–78, were randomly assigned either to a single-set or a 3-set exercise group. Four subjects from the single-set group withdrew from the study. Each subject obtained medical clearance and completed an informed-consent agreement and health history questionnaire before participating. Table 2 shows the physical characteristics of subjects at baseline.

table 1: the intervention of resistance training in elderly populations

Health-Related Outcomes	Study	Clinical Outcomes	Benefits/Intervention
weight and body fat loss	Lemmer et al. 2001	risk factors for diabetes and heart disease	increases in strength and resting metabolic rate by preserving lean body mass with 24-week strength program
central (or visceral) obesity	Ross et al. 1996	colorectal cancer, insulin resistance, glucose intolerance, abnormal lipoprotein, hypertension, etc.	significant reduction in visceral fat with caloric restriction and low-volume resistance training for 16 weeks
glucose metabolism	Rubin et al. 1998	glucose tolerance and insulin sensitivity	Increases in chromium absorption, strength and body composition with 16-week training programs
osteoporosis	Layne & Nelson 1999	bone health and osteoporosis prevention	increase in erector spinae muscle strength and vertebrae bone mineral density with resistance exercise
functional ability	Kalapotharakos et al. 2005	fall prevention and activities of daily living	increases in strength, walking speed, stair-climbing power with 12 weeks of resistance exercises

All subjects participated in a total of 40 supervised exercise sessions, which were held twice a week for 20 weeks. Make-up sessions were provided for subjects missing a training session owing to travel, illness or personal commitments. Both groups performed chest press, seated row, triceps extension, biceps curl, leg press, leg curl and leg extension exercises on resistance training machines at an intensity of 8RM (the maximal weight that could be lifted eight times). Isotonic, isokinetic and isometric muscle strength and muscle endurance (maximal repetitions in the leg press and chest press at 70% of 1RM) were assessed. On a separate day from the muscle-fitness tests, various tests (chair rise to standing, 6-meter walk, 6-meter backward walk, floor rise to standing, stair climb and 400-meter walk) were completed for functional performance.

table 2: characteristics of subjects

Characteristic	Single-Set Group	3-Set Group
age	68.9 ± 4.8	69.7 ± 4.4
female/male	5/7	6/10
height (centimeters)	169.8 ± 10.1	168.6 ± 9.7
weight (kilograms)	74.3 ± 13.6	75.2 ± 12.0
body mass index (kg/m^2)	25.7 ± 4.0	26.4 ± 3.6
fat mass	23.1 ± 5.6	24.2 ± 5.7
% of fat	31.5 ± 5.8	32.6 ± 5.8

Results

Dynamic Muscle Strength

After the 20-week training intervention, both groups showed significant and very meaningful strength improvements in all seven exercises. Improvements were significantly greater for the 3-set group than for the single-set group in the seated row, triceps extension, biceps curl and leg extension exercises (see Table 3).

Isokinetic and Isometric Strength

As shown in Table 3, there was no difference between groups in the isokinetic and isometric tests of the knee extensors. In the isokinetic peak torque test of the knee, both groups improved after training. However, only the 3-set group significantly increased strength in the isometric peak knee extensor torque test.

Muscle Endurance

At the beginning of the study, there was no difference in the maximum number of repetitions the subjects could perform in the chest press and leg press at 70% of 1RM. However, after 20 weeks of training, the groups differed, with only the multiset group showing significant improvements in chest press and leg press endurance.

Physical Performance

Table 4 shows the percent improvement within each group and the difference between groups after 20 weeks of training. There were significant improvements in the chair rise, 6-meter backward walk, 400-meter walk and stair-climbing tests for both groups, while only the 3-set group improved in the 6-meter walk and the floor rise to standing tests. There was no significant difference between groups for any test except the 400-meter walk test. Importantly, the changes within each group were similar.

table 3: dynamic muscle, isokinetic and isometric strength after 20 weeks of training

Exercise	Percent Improvement		Difference Between Groups?
	Single-Set	3-Set	
chest press	14.1 ± 13.5*	24.4 ± 17.6*	no
seated row	7.7 ± 6.0	19.1 ± 8.6*	yes
triceps extension	15.2 ± 9.4*	34.5 ± 21.0*	yes
biceps curl	39.9 ± 34.9*	60.0 ± 30.4*	yes
leg press	14.2 ± 12.2*	17.0 ± 9.4*	no
leg curl	31.0 ± 16.2*	36.8 ± 19.5*	no
leg extension	20.8 ± 19.9*	38.9 ± 24.7*	yes
isometric knee extensor peak torque	6.3 ± 17.7	20.9 ± 16.0*	no
isokinetic knee extensor peak torque	23.7 ± 32.1*	19.7 ± 19.0*	no

*= statistically significant improvement

Discussion

This major peer-reviewed study substantially validates the efficacy of single-set training (performed 2 times a week for 20 weeks) for enhancing functional performance and strength in older men and women. Although the multiset training scheme resulted in greater improvements in some of the strength and muscle fitness parameters, the complete findings indicate that low-volume resistance training elicits similar and very meaningful responses and is an effective strategy for a mature population. This investigation contributes prominently to a broader understanding of the benefits of resistance exercise for functional performance and muscular strength in older adults.

Applications

Given that single-set resistance training economizes on exercise time and may reduce injury risk, dropout rate and muscle soreness, this protocol is an excellent exercise design option for personal trainers and fitness professionals to use with their mature clients. The sidebar, on the next page, provides 10 resistance training tips for mature adults.

Byung-Kon Yoon, PhD, earned his doctoral degree in spring 2006 in the exercise science program at the University of New Mexico, Albuquerque (UNMA). He plans to return to his home country of Korea to teach at the university level. Presently, he is collaborating on several research projects and papers with colleagues.

Len Kravitz, PhD, is the program coordinator of exercise science and a researcher at UNMA, where he won the 2004 Outstanding Teacher of the Year Award. He was honored with the 1999 Canadian Fitness Professional International Presenter of the Year Award and the 2006 Canadian Fitness Professional Specialty Presenter of the Year Award. He also was cho-

table 4:

functional performance after 20 weeks of training

Note: **Negative** *percent changes reflect* **positive** *improvement (as subjects improve, they complete the tasks in less time)!*

Exercise	Percent Improvement		Difference Between Groups?
	Single-Set	3-Set	
chair rise	10.1 ± 10.2*	-13.2 ± 12.8*	no
6-meter backward walk	-14.3 ± 14.4*	-14.8 ± 13.1*	no
6-meter walk	-0.2 ± 11.1*	-5.3 ± 11.3*	no
6-meter fast walk	-5.1 ± 9.1	-0.2 ± 11.2	no
400-meter walk	-3.8 ± 4.1*	-7.4 ± 5.4*	yes
stair climb	-7.7 ± 10.6*	-6.4 ± 11.3*	no
floor rise to standing	-3.4 ± 13.3	-8.4 ± 9.0*	no

*= statistically significant improvement

sen as the American Council on Exercise 2006 Fitness Educator of the Year.

References

Kalapotharakos, V.I., et al. 2005. Effects of a heavy and a moderate resistance training on functional performance in older adults. *Journal of Strength and Conditioning Research, 19* (3), 652–57.

Lemmer, E.T. et al. 2001. Effect of strength training on resting metabolic rate and physical activity: Age and gender comparisons. *Medicine & Science in Sports & Exercise, 33(4)*, 532–41.

Layne, J.E., & Nelson, M.E. 1999. The effects of progressive resistance training on bone density: A review. *Medicine & Science in Sports & Exercise, 31* (1), 25–30.

Ross, R., et al. 1996. Influence of diet and exercise on skeletal muscle and visceral adipose tissue in men. *Journal of Applied Physiology, 81* (6), 2445–55.

Rubin, M.A., et al. 1998. Acute and chronic resistive exercise increase urinary chromium excretion in men as measured with an enriched chromium stable isotope. *Journal of Nutrition, 128* (1), 73–78.

10 helpful tips for resistance training (RT) with senior populations

1. Make sure clients who have uncontrolled clinical conditions, such as hypertension, chest pain, metabolic disturbances or acute illnesses, are medically assessed for appropriate RT participation.
2. Be sure clients warm up with light exercise before lifting weights.
3. Direct RT at the large multijoint muscle groups that are important in everyday activities.
4. Include at least one set of 8–15 repetitions for each exercise at an intensity that elicits a somewhat hard perceived exertion.
5. Have clients perform RT at least twice per week, separating workout sessions by a minimum of 48 hours.
6. Spend extra time teaching proper execution of all RT exercises.
7. Cue clients to perform both the lifting (concentric phase) and lowering (eccentric phase) motions with control. Avoid explosive lifting exercises.
8. Make sure clients do not hold their breath during exercises. Teach them to breathe normally during RT.
9. Begin an RT program with several weeks of minimal to moderate resistance loads, to allow adequate time for the joint connective and supportive tissues to adapt progressively to the RT program.
10. Avoid 1RM testing unless you are collecting data for research (and the testing is supervised by qualified professionals). Excessive and near-maximal RT loads may aggravate pre-existing health conditions.