

A close-up photograph of an older man with white hair, smiling broadly as he lifts a black dumbbell. He is wearing a bright yellow polo shirt. The background is a blurred green, suggesting an outdoor setting. The text is overlaid on the right side of the image.

Developing
strength in
older adults:
how much
training is
'enough'?

Confused by the one set versus multiple sets debate? These scientists clarify what the science says on this topic and different ways to apply it

by Wayne T. Phillips, Ph.D., FACSM,
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Just 11% of adults ages 65 and older regularly perform any kind of strength training (Kruger et al., 2004), despite its ability to help maintain function. One major reason for this low level of engagement among older adults is the *bad rep* strength training had until the last decade or so.

Health and wellness professionals still hear comments such as *I'm too old. It's not safe at my age.* or *It's only for men*, when they suggest strength training to older clients. These statements are hardly surprising. Less than 50 years ago, scientific journals were reporting that strength training was unsafe for older adults unless performed at the lowest intensity (Muller, 1957) and, even if performed, would "have no discernible effect after the age of 60" (Hollman, 1964).

At the beginning of the 1980s, strength gains for older adults were reportedly due only to "neuromuscular improvements" (Moritani and DeVries, 1980), implying an age-related barrier to strength and hypertrophy (or muscle growth). The situation is different today. Yet the perceptions of danger and unsuitability have yet to be shaken, and misgivings about strength training still exist in the minds of physicians, caregivers and many older adults (Phillips, 2003). However, the safety and effectiveness of strength training for older adults is now widely communicated in both the scientific literature and the commercial field.

This increased attention has resulted in scientific journals specifically focused on physical activity for older adults. As a consequence, the number of scientific studies using moderate- and high-intensity strength training of different modes has increased dramatically. Their outcomes have not been limited simply to reports of increased strength. The wider benefits of strength training are coming to light and include mobility, balance, functional fitness and endurance, among others (e.g. Phillips et al., 2004). Scientists have not investigated all these outcomes in older adults to date, but there is good reason to suppose the results will be similar.

Having established the safety of strength training using a range of intensities and volumes of training, studies are now addressing the question of how much is enough, particularly for maximum strength gains. Disagreements on this topic among scientists have provoked intense, long-lasting discussion.

Creating a debate

In 1998, the journal *Sports Medicine* published a review article, entitled "Strength training: single vs. multiple sets," that stirred vigorous debate. In the article, Carpinelli and Otto analyzed the results of 33 studies designed to compare the strength gains between single set and multiple set protocols. Of these studies, only two reported statistically significant differences between these approaches, according to the authors. Even in these two studies, Carpinelli and Otto pointed out some methodological shortcomings, which in their opinion cast doubt on the accuracy of the findings. They concluded that single set training to failure and multiple set training to failure were equally effective for strength gains.

A response to the authors written by a group of reputable strength training coaches strongly disagreed with the

review's findings and conclusions. The authors' rebuttal comments added more fuel to the flames—and the debate was on. Since then, these arguments have been blurred by discussions of whether single set training is *better* than multiple set training—something never claimed by Carpinelli and Otto.

Our article aims, firstly, to better focus this debate by clarifying what *the science* says and, secondly, to show a variety of ways to apply this science to maximize the effectiveness of approach. In other words, to apply *the art* of exercise prescription. (This article should be read in conjunction with Dr. Phillips' *Functional U* article "Prescribing and developing strength training programs for older adults: 'Art' as well as 'science'"—see reference on page 37.)

Although focused on older adults in this article, the principles we discuss apply equally well to all ages.

Reviewing the literature

The best way to find out about the effect of one set of strength training compared to multiple sets is to review the scientific literature, locate as many studies as possible on that topic and look at what they found. That's exactly what Carpinelli and Otto did in their review.

These Adelphi University scientists tracked down 33 studies specifically designed to compare one set and multiple set training, then looked at the results. Carpinelli and Otto simply counted the studies that found statistically significant differences in strength and the ones that didn't. This traditional approach to reviewing the literature is known as a *narrative review*. The recommendations and/or conclusions of these type of reviews are based predominantly on something like

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studies in the review, and provides a widely accepted statistical method for numerically combining and comparing the results of studies. Many regard the meta-analysis as the preferred method of analytical literature review.

In our Department of Exercise and Wellness at Arizona State University East, we decided to enter the fray over protocols, but from a much less emotional perspective.

Addressing the controversy

Prompted by the limitations found in the Carpinelli and Otto review, we compiled a series of meta-analyses "to address the controversy" (Rhea et al., 2003a; Rhea et al., 2003b). We summarize the major findings below:

1. Most of the studies comparing single and multiple set training actually found greater increases in strength for multiple set training—the differences just were not statistically significant. However, the majority of these studies were conducted with small numbers of participants. Strong statistical analysis depends on fairly large numbers of participants, so it is much harder to find statistically significant differences in these studies.
2. The meta-analysis of more than 140 studies found that untrained groups of **any age** received maximal strength gains with an average intensity of 60% of one repetition maximum (1RM), using four sets per muscle group and training each muscle group three days per week. This finding is especially interesting, as it is commonly believed that about 90% of strength gains are elicited in the first set. In contrast, the more quantitative meta-analysis has shown that utilization of a one set protocol elicits just over 50% of the strength gains. It takes almost three sets to reach 85% and four sets to elicit 100% of the possible gains.

a vote count—so many votes for single set, so many votes for multiple set. While this method says something about the results of the studies, it doesn't usually tell much about the quality of their design, or take these factors into consideration.

An extensive explanation of how to read scientific literature is outside the scope of this article. But obviously people will have more confidence in the results of a well-designed study than a poorly designed one—even if they were both published in the scientific literature. For example, the Carpinelli and Otto review included studies that utilized few participants, were short in duration and had no control or comparison group. Even abstracts were included in the analysis. This is not to say it was a bad review. On the contrary. Simply put, the quality of the studies examined was variable, and this would have had a bearing on the authors' analysis and findings.

In recent years, scientists have devised a method of reviewing the literature that can take quality of methodology much more into account—and also come up with a more quantitative or numerical method of analyzing studies and comparing their results. Called a *meta-analysis*, this technique utilizes rigorous criteria of acceptability for including

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These meta-analyses present strong evidence that multiple sets appear able to increase strength to a greater magnitude, although single set training can increase strength in a meaningful fashion. Four sets per exercise seem optimal for maximizing strength gains.

Does this finding mean multiple set training is *better* than single set training? *It depends.* The effectiveness of any program depends on goals set versus goals achieved. Therefore, the best strength training program will depend on what its goals are and the probability of the participant not only achieving them, but also sticking to the program.

For a participant who wants to maximize strength gains, the most effective approach would appear to be building progressively to a four set per exercise routine. However, this particular piece of science presents major problems, since such a routine would likely take well over an hour to perform. How many people have the time or energy to complete such a program? The situation is even more problematic for older adults, because

strength training does not readily appeal to them.

Individuals in the 65–90 year-old age group were brought up in a time when strength training was really not advocated for any population, except perhaps circus strongmen or athletes. This cultural and historical nuance makes it all the more difficult to insist that older adults do four sets. (Read Dr. Phillips' *Functional U* article for more information about these and other barriers to strength training among older people.)

The bottom line is a person can increase strength with a single set or a multiple set program. This applies to individuals of any age, as we found in the 140 studies examined.

Prescribing exercise: the art and the science

The findings of our two meta-analyses are in line with the American College of Sports Medicine's most recent position stand on the *Progression Model for Strength Training* (ACSM, 2002). It is appropriate, even desirable, to start novices on a single set strength training program. Such individuals will continue to increase their strength with this protocol simply by progressively increasing the amount of resistance they use. However, if their goal is to maximize strength gains, they will need to increase the overall volume of training, i.e. do more sets—again, this is only necessary if such increases match the goals and capabilities of individuals. It would be unwise to start everyone on a four set program, or even to expect most people to adhere to a four set program.

The *art* of prescription is the ability to put each individual on a specific program that fits his or her needs. There is no one ideal program. In setting up a routine for someone who wants to

induce muscular strength gains, a health or wellness professional must look at such variables as the time the individual is willing to commit, the person's familiarity with strength training, and the overall goals of the program.

There are two questions a professional must ask when prescribing strength training exercise for a client:

- How much is really enough?; and
- How much is really necessary for this person?

The answers to these questions will determine the prescription.

Finally, *the science* tells us that both single and multiple sets are effective programs to increase strength in meaningful ways. And *the art* tells us that the number of sets prescribed will depend on clients' goals, and the time available to achieve them. The science gives us the possible; the art gives us the feasible. Health and wellness professionals need to know something about their client to administer either effectively. ▼

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