Effects of regular and slow speed resistance training on muscle strength

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Background. The study assessed a way to increase the intensity and effectiveness of resistance training by comparing training with a slower repetition speed to training with a conventional repetition speed. Slower repetition speed may effectively increase intensity throughout the lifting phase while decreasing momentum.

Methods. Two studies were done with untrained men (N=65) and women (N=82), (mean age 53.6) who trained two to three times per week for eight to 10 weeks on a 13 exercise Nautilus circuit performing one set of each exercise. Participants exclusively trained using regular speed repetitions for 8 to 12 repetitions per set at 7 sec each (2 sec lifting, 1 sec pause, 4 sec lowering) or a Super Slow® training protocol where they completed 4 to 6 repetitions per set at 14 sec each (10 sec lifting, 4 sec lowering). All of the participants were tested for either the 10 repetition-maximum (RM) weightload (regular-speed group) or the 5-RM weightload (slow-speed group).

Results. In both studies, Super-Slow training resulted in about a 50% greater increase (p<0.001) in strength for both men and women than regular speed training. In Study 1, the Super-Slow training group showed a mean increase of 12.0 kg and the regular speed group showed an increase of 8.0 kg increase (p<0.001). In Study 2, the Super-Slow training group showed a 10.9 kg increase and the regular speed group showed an increase of 7.1 kg (p<0.001).

Conclusions. Super-Slow training is an effective method for middle-aged and older adults to increase strength. Although studies still need to be done with at-risk populations, repetition speed should be considered when prescribing resistance training.

KEY WORDS: Muscle contraction - Muscle, skeletal - Exercise - Middle age.

Resistance training is becoming a critical component of health promotion and disease prevention programs for middle-aged and older adults because studies indicate that properly done resistance training increases strength, muscle mass, bone mineral density, glucose tolerance, functional abilities, and hence potentially reduces morbidity and premature mortality. Rather than frequency or volume of training, recent reviews of resistance training studies suggest that intensity is the major variable associated with increases in strength and muscle mass.

Progressive resistance training with high intensity should not be confused with lifting heavy weights. Intensity can be defined as degree of effort or per cent of momentary ability. Proponents of higher intensity training recommend that training be conducted so that the last repetition in a set is the last one that can be...
effectively completed signifying close to 100% of momentary ability.7

However, rather than simply increasing resistance as the means to maintain intensity when strength increases, other methods to increase intensity may be effective. From a theoretical perspective, doing a repetition slowly but with high intensity should maximize muscle tension throughout the full range of motion of an exercise, and, hence, result in greater strength and hypertrophy gains. Moreover, since more resistance can be handled in the eccentric (negative) or lowering phase of a movement compared to the concentric (positive) or pushing or pulling (lifting) phase, a repetition should be performed so that the concentric phase is longer than the eccentric phase. If the eccentric phase is longer, this would mean that there was a relatively long respite before the start of the concentric phase. Thus, certain repetition cadences appear to have theoretical justification and may have direct application to training programs.

In 1982, Ken Hutchins introduced a slow speed training technique for frail women involved in an osteoporosis study at the University of Florida.8 The exercise protocol, called Super Slow® training, consisted of one set per exercise of 4 to 6 repetitions completed within 55 to 85 seconds. Each repetition required 14 sec, with 10 sec for the concentric muscle action and 4 sec for the eccentric muscle action (a 10, 4 cadence). When 6 repetitions could be performed with perfect technique, the resistance was increased by about 5%.

Recommended “gold standard” speed repetitions—2 sec for the concentric part, 1 sec pause, and 4 sec for the eccentric part—are much quicker than Super Slow® training and violate the theoretical propositions about the relationship of concentric to eccentric speed described above.7 Yet, this 2, 1, 4 repetition cadence training is far slower than the quick and even explosive repetition speed often observed in health clubs and gyms, a cadence that is often as quick as 1, 1.7 A very quick cadence typically allows the use of a large resistance (high force) but with rapid acceleration at the beginning and end of movements, much like in Olympic weight lifting. Such rapid movements result in high muscle tension at the start and end of the range of motion.7 Using quick cadence repetitions may actually decrease intensity because excessive momentum is introduced, and it may increase the probability of injury to the musculoskeletal system.7 Thus, use of rapid movements may allow for the demonstration of strength (by literally almost throwing a resistance) but may not be the optimal way to safely build strength and muscle mass.7 The rapid lifting of a free weight or resistance on a machine does not necessarily equate to a high intensity stimulus.

Despite these theoretical underpinnings, there has been very little published research on repetition cadence. Current guidelines used world-wide from the American College of Sports Medicine1 do not prescribe an effective speed of movement for resistance training.1 Therefore, the purpose of these studies was to compare the efficacy of a Super Slow® protocol to conventional gold standard speed repetition training with primarily middle-aged to older men and women trained in a YMCA setting.

Materials and methods

Both studies were conducted at the South Shore YMCA Strength Research Center, Quincy, MA. Each training session was closely supervised and consisted of six participants and two instructors. Regular-speed trainees who performed 8 to 12 repetitions per set were assessed for their 10-RM weightloads (at 7 sec per rep; 2 sec concentric, pause, 4 sec eccentric), and slow-speed trainees who performed 4 to 6 repetitions per set were assessed for their 5-RM weightloads (at 14 sec per rep; 10 sec concentric and 4 sec eccentric). Every workout was carefully recorded on individual exercise cards, and training adherence was displayed on large class attendance posters. Overall, 82% of workouts were completed. There were no differential adherence rates. About 10% of participants dropped out of each condition and there were no training injuries in either condition.

Participants were recruited through the YMCA’s newsletters and the first author’s fitness column in a local newspaper. All participants had no prior history of resistance training. Participants completed a medical history form and if indicated received their physician’s clearance prior to signing informed consent forms. Because of scheduling constraints, participants chose the time of their training sessions but were unaware of the training protocol that would be used in their sessions. Study 1 contained 74 participants (regular speed=10 males and 29 females; slow speed=13 males and 22 females), and Study 2 contained 73 participants (regular speed=13 males and 30
females; slow speed=10 males and 20 females). The mean age of participants in both studies was 53.6 (range 25 to 82). All participants were from middle class socioeconomic backgrounds. The study was approved by the Institutional Review Board of the Quincy YMCA.

All aspects of the two training programs were identical except for the exercise speeds and number of repetitions. All participants trained on the same 13 station Nautilus circuit, using 1 set per exercise, 2-3 times per week for a period of 8 weeks in Study 1 and 10 weeks in Study 2. Each set of exercise required between 55 to 85 sec for the regular-speed trainees (8 to 12 reps at 7 sec each), and between 55 to 85 sec for the slow-speed trainees (4 to 6 reps at 14 sec each). When a repetition goal was reached with a given resistance, the resistance was increased by 5%. The basic difference between groups was the time spent in concentric muscle action. The regular-speed trainees completed about 20 sec (10 reps x 2-sec lifting phase) of concentric muscle work per set while the slow-speed trainees completed about 50 sec (5 reps x 10-sec lifting phase) of concentric muscle work per set. Each group used the following Nautilus SST model machines with the range of motion in radians noted for each machine: leg extension (2.09); leg curl (2.09); leg press (1.57); neck flexion (2.09); neck extension (2.09); pullover (3.14); chest press (2.09); chest cross (2.09); lateral raise (1.57); bicep curl (2.09); triceps extension (2.09); abdominal crunch (1.57); low back (1.57). For the machine with 3.14 rad range of motion, the concentric speed of movement was 0.31 and 1.57 rad/s for the slow and regular speed groups respectively. For the machines with 2.09 rad range of motion, the speed was 0.021 and 1.05 rad/s for the slow and regular groups, and for the machines with 1.57 rad range of motion, the speed was 0.16 and 0.79 rad/s for the slow and regular speed repetition groups. Each group used the same time (4 sec) on the eccentric part of each movement.

Using standard procedures, participants were tested for either the 10-RM weightload (regular-speed group) or the 5-RM weightload (slow-speed group) using their respective repetition cadence. In Study 1, participants were tested on all 13 exercises, while in Study 2 testing was only done on the chest press, a good indicator of overall upper body strength. Testing was done on weeks 2 and 8 in Study 1 and in weeks 2 and 10 in Study 2.

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+) Mean weight load for 13 standard Nautilus exercises. *p<0.001.

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* p<0.001.

**Results**

As shown in Table I, both groups in Study 1 began at about the same mean strength level for all 13 exercises. The regular-speed group gained 8.0 kg in strength, and the slow-speed group gained 12.0 kg in strength.

Initial pretraining strength levels were highly correlated with post-training strength levels (r=0.85) and, as expected, there was a wide range of strength levels. ANCOVA analysis of post-test strength levels with each individual's pretraining strength level as the covariate showed that the slow repetition training group performed better than the regular speed training group (F (1,70) = 16.17, p<0.001).

Table II presents the results for study 2 that evaluated only the chest press measure. Both training groups began at approximately the same average strength level. As in study 1, the slow-speed trainees gained about 50% more strength than the regular-speed trainees. ANCOVA showed a significant difference between conditions (F (1,70) = 15.11, p<0.001) favoring the slow exercise speed.

Using combined data from both studies (the mean for 13 movements in Study 1 and the mean for the chest press in Study 2), men and women using the same protocol showed about the same percentage of strength gains, 25% for regular speed and 44% for Super-Slow®.
Discussion and conclusions

To the best of our knowledge, these are the only studies comparing regular and slow strength training protocols with beginning exercisers, so clearly more research on this topic is warranted. Nonetheless, the similar results obtained in both studies for men and women are compelling. The specific repetition cadence with the long and slow concentric phase and the shorter but still slow eccentric phase has a theoretical basis in exercise science, the neuromuscular aspects of exercise training. The study's data support the theoretical rationale for increasing intensity and suggest exercise intensity is central to increasing strength.

The difference between conditions is appreciable and this difference needs to be seen in proper context. Many resistance training studies comparing different protocols have often found no difference between conditions on measures of strength or hypertrophy. This is especially the case for protocols that differ in training volume by varying the number of sets that are done for each exercise. A recent review encompassing studies done during almost a 40 year period indicated that there was virtually no evidence to suggest that doing more than one set per movement conferred any better outcomes than performing just one set. Since there is no physiological rationale for why the volume of training should positively affect strength or hypertrophy, these findings are perhaps not surprising. Yet, the practice of multiple sets is a common training strategy and even recommended by the American College of Sports Medicine for advanced trainees despite the lack of any empirical support.

The effect size for the added benefit of slower repetition training was about 0.6. Again, this effect size has to be seen in context in that it is an effect size comparing a new training protocol to a gold standard training protocol and not a treatment effect compared to a control condition.

There are at least five caveats about the studies. Participants were not randomly assigned to condition, but rather participants chose a time based on their schedules. However, participants did not know what condition was assigned to a specific time prior to agreeing to participate in the study.

Certainly another limitation of the study was the absence of a third testing protocol midway between the two protocols investigated in this study. For example, interesting and perhaps to some more compelling results would have been evident if both groups were also tested on a 6, 1, 4 protocol. However, the present procedures possibly biased the study against finding better outcomes for slow speed training because it is acknowledged that using slower cadence repetitions is generally more difficult than using conventional cadence repetitions. Nevertheless, future studies should use at least one common measure between conditions.

Training with slow or regular speed repetitions even when total time for the set is the same between conditions may mean that participants were training at a different percent of 1 RM. However, recent research suggests that quite varied training loads representing different percents of 1 RM's appear to result in about the same gains in strength and fat free mass as long as training involves a marginal overload.

Then too, since different machines have different ranges of motion, any training protocol using a fixed time for a repetition means that there will be an actual difference in speed depending upon the movement. Technically, the time for each repetition should be changed to reflect the range of motion and thus keep speed constant. In practice, we have found that participants find a varying time for repetitions in different movements difficult to use and, hence, the same time was used for each movement. How much such variations in actual speed affected the outcomes is not clear and a 10 sec cadence may be inappropriate for very short-range movements such as wrist curls or calf raises.

A final caveat concerns other potential risks for certain populations when very slow repetition training is used. For example, we did not measure and compare blood pressure responses between the two protocols and that should be done in future investigations.

As noted previously, because the concentric muscle action is more demanding than the eccentric muscle action with a given resistance, it may be that the greater concentric emphasis of the Super-Slow® protocol provided a higher intensity training stimulus. Another explanation of the better results attained by the slow-training participants may simply be the reduced role of momentum. Although relatively controlled compared to many exercise protocols, 2-sec lifting movements involve much more momentum than 10-sec lifting movements. Because there is basically an inverse relationship between momentum and muscle effort and, hence, intensity, the reduced momentum may represent a key advantage of Super-Slow® training. The duration of the concentric phase of the repetition, the role of
momentum, and the relative contribution of concentric and eccentric components need further scientific study with beginning and advanced trainees.

The present data suggest that Super-Slow® training effectively promotes strength increases and future investigations can further explore its effectiveness with diverse and at-risk populations.

References