

Effects of Resistance Training on the Sit-and-Reach Test in Elderly Women

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ABSTRACT

The study showed the effects of a 10-week resistance training program on flexibility of elderly women ($n = 11$) between 62 and 78 years of age. The control group was composed of 8 women (62 to 73 years old) who were physically inactive. Flexibility was evaluated through the sit-and-reach test, performed both before and after the training program. After an initial evaluation, individuals started a training program, which consisted of 8 exercises for the entire body, without the performance of any flexibility exercise. The training program resulted in significant increase ($p < 0.001$) of flexibility in elderly women ($\cong 13\%$). No significant differences were found in the control group. We conclude that weight training without performance stretching exercises does increase flexibility in elderly women.

Key Words: flexibility, strength training, aging

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Introduction

Older people (over 60 years old) have been increasing in number throughout the world in the last decades. This increase in the number of elderly people comes along with a growing interest in physiological alterations of normal aging and those alterations resulting from lifestyle changes (20, 23).

Many studies point to the benefits of resistance training (RT) as an essential element for health improvement and increased quality of life, even when this training takes place at advanced ages (5–7)). There is evidence that RT brings about functional and metabolic adaptations that aid in the prevention of sarcopenia, osteoporosis, and obesity, and increases the functional capacity of elderly individuals (4, 11, 19, 27).

However, these studies didn't evaluate the effects

of RT on the flexibility of the elderly. Flexibility is an important component of health, and has been associated with disability and distress in elderly people (24, 33). Thus, the objective of our study was to investigate the effects of RT on flexibility in elderly women using the sit-and-reach test as a criterion measure of flexibility.

Methods

Subjects

Subjects were 12 women in the intervention group and 10 in the control group between 62 and 78 years of age, selected from the neighborhood area of the Medical Rehabilitation Division of the Hospital das Clínicas, of the Medical School of University of São Paulo (Brazil). The study protocol was approved by the ethics committees of the Public Health School and Medical School of the University of São Paulo. All participants gave their written informed consent before initiation of the research project.

The control group was composed of individuals who, even after being informed of the benefits of physical activity, wished not to participate in the training program, although they were able to perform physical activity.

All participants underwent a medical evaluation that included clinical and biochemical examinations. Included in the evaluation was resting arterial blood pressure and an exercise electrocardiogram. Before participation subjects had to demonstrate no severe heart, respiratory, renal, or hepatic problems, including intense osteoporosis, unstable diabetes, disabling neurological diseases, or severe arterial hypertension. To participate in the study, the individual couldn't have engaged in any kind of physical activity program for the 3 months preceding the study.

The participant was also excluded from the study if she had 3 consecutive absences. The participants were also instructed not to participate in any other

physical activity programs, and not to alter their daily habits during the study. The individuals in the control group were instructed to keep their normal activity level throughout the study.

Training Protocol

Patients underwent a dynamic RT program that included exercises for the torso and upper and lower limbs. The training program lasted 10 weeks, with 3 sessions per week, with at least 1 day of rest between sessions. Each session lasted approximately 85 minutes. A total of 27 sessions were completed. In the week before the beginning of the training, 3 exercise sessions were conducted, every other day, so that individuals would feel more comfortable with both the equipment and the exercise techniques.

All exercises were performed using a lever-type RT machine with free weights (Maxiflex Bidelta, Joinville, SC, Brazil).

Eight different exercises were performed: (a) chest: seated chest press. Main active muscles: pectoralis major; deltoid; serratus ant., and triceps; (b) back: seated row. Main active muscles: latissimus dorsi, teres major, teres minor, rhomboid, trapezius, infraspinatus, paravertebral muscles, gluteus and upper thighs, biceps, brachioradialis, brachialis, wrist and finger flexors; (c) shoulder: seated shoulder press. Main active muscles: deltoid, triceps, and trapezium; (d) biceps: seated curl (unilateral). Main active muscle: biceps, brachialis, brachioradial, wrist and finger flexors; (e) triceps: seated triceps extension (unilateral). Main active muscle: triceps; (f) thigh: seated leg press. Main active group muscles: quadriceps, gluteus maximus, upper thighs, and paravertebral muscles; (g) calf: seated calf press. Main active muscles: gastrocnemius and soleus; (h) abdomen: seated abdominal crunches. Main active muscles: rectus abdominis, transversus, ext. oblique, int. oblique, iliopsoas. Exercise order was large to small muscle group. No stretching or aerobic exercise was performed before or after the weight training. The warm-up consisted of 3 minutes of general exercises, including ample nonresisted motion of all major body articulations. After doing the warm-up, the following exercise protocol was followed:

- 5 sets of 6 to 10 repetitions with progressive loads for the chest, back, and thigh exercises. The first set was performed with low intensity; the second with moderate intensity, and all others with a load such that only between 6 and 10 repetitions could be performed (with no maximum muscular contraction). When the individual could perform 10 repetitions easily, the resistance was increased so that only 6–7 repetitions per set could be performed.
- 3 sets of 6 to 10 repetitions for the shoulder, biceps, and triceps exercises. The first set was performed with moderate intensity; and the last 2 sets at such a load that only between 6 and 10 repetitions could

be performed (with no maximum muscular contraction). When the individual's strength was increased to the point where 10 repetitions could easily be performed, the resistance was increased so that only 6–7 repetitions per set could be performed.

- 3 sets of 10 to 15 repetitions for the calf and abdominal exercises. The first set was performed with moderate intensity, and all others with a load that allowed only 10 and 15 repetitions. When the individual's strength increased to the point where 15 repetitions could easily be performed, the resistance was increased so that only 10–11 repetitions could be performed.

All sets and exercises were separated by 2 minutes. If the individual's heart rate went over 75% of the age-predicted maximum heart rate ($220 - \text{age in years}$), the individual's resting time was increased. The individual's heart rate was checked after each set. Subjects were encouraged to exhale during the concentric action and inhale during the eccentric action. The last repetitions of a resistance exercise set leads to accentuated rises in arterial blood pressure and heart rate (8, 18, 22). So, to prevent excessive increases in heart-pressure product, the subjects were instructed to stop the set when nearing the momentary muscular failure. We assumed that near concentric there is a tendency to Valsalva maneuver.

The training was conducted by a physical education professional and supervised by a physician.

Flexibility Evaluation

Flexibility was measured using a sit-and-reach test, using a sit-and-reach box (height = 30.5 cm.). The test was performed both before and after the 10-week training program. The subjects sat with their heels firmly against the testing box. Subjects kept their knees extended and placed their right hand over the left, with the long fingers even, and reached forward as far as they could by sliding their hands along the measuring board. A tape measure on top of the measuring board indicated in centimeters how far beyond the toes each individual reached. The score (in centimeters) is the greatest distance contacted by the fingertips past the toes. After 2 standard 10-second warm-up stretches, 3 trials were performed, and the average was used for data analysis.

Statistical Analyses

Pre- and posttest means and standard deviations (*SDs*) for the experimental and control groups were calculated. The difference between the means of each variable (initial minus the final value) was calculated for both groups, and also their respective *SDs*. The level of significance of the difference between the means was concluded on the basis of the paired *t*-test (applied to small samples), as recommended by Spence et al. (28). Results were considered statistically signif-

Table 1. Physical characteristics of the individuals of the intervention and control groups.

Variable	Intervention (<i>n</i> = 11)		Control (<i>n</i> = 8)	
	Mean ± <i>SD</i>	Extension	Mean ± <i>SD</i>	Extension
Body mass (kg)	64.13 ± 10.78	50.00–86.40	71.15 ± 9.46	54.20–84.80
Height (cm)	155.01 ± 5.26	147.80–163.30	157.25 ± 7.11	151.00–169.30
Age (y)	68.91 ± 5.43	62–78	65.13 ± 4.09	62–73

Table 2. Results of the sit-and-reach test.

	Intervention (<i>n</i> = 11)		Control (<i>n</i> = 8)	
	Mean ± <i>SD</i>	Extension	Mean ± <i>SD</i>	Extension
Initial (cm)	30.4 ± 6.0*	19.2–38.4	33.8 ± 6.6	23.5–42.8
Final (cm)	34.4 ± 6.6*	21.7–43.0	33.1 ± 5.9	24.0–41.0

* $p < 0.001$, significant change pre- to posttesting.

icant if $p \leq 0.05$. The software used to process and analyze statistically all data is INSTAT (version 2.01, Graphpad Software, San Diego, CA).

Results

Twenty two elderly women were selected for the initial sample of the present study: 12 in the experimental group, and 10 in the control group. Of the 22 initially selected, 3 elderly women abandoned the study for personal reasons—1 was in the experimental group, and the other 2 were in the control group. Thus, the final sample consisted of 19 elderly women, 11 in the experimental group and 8 in the control group.

Table 1 presents the physical characteristics of the individuals in the intervention and control groups. Table 2 presents the mean, *SD*, and minimum and maximum values for both groups (intervention and control) for the initial (IT) and final (FT) test. The IT average value for the sit-and-reach test is 30.4 ± 6.0 cm; and 33.8 ± 6.6 cm for the experimental and control groups, respectively. The FT, flexibility mean for the experimental group, was 34.4 ± 6.6 cm, an average significant increase of $13 \pm 9\%$ ($p < 0.001$) between IT and FT. As for the control group, average FT was 33.1 ± 5.9 cm, corresponding to a nonsignificant average loss of 1%.

Discussion

There is no general test for flexibility of the entire body. Flexibility of muscular groups and joints must be analyzed separately. The test used in the present study (sit-and-reach test) was chosen for being the most frequently used flexibility test for all ages. It measures the flexibility of both the lumbar region and muscles on the posterior thigh (1, 3, 25, 26).

The muscles of the posterior thigh and lumbar region are particularly relevant to the mobility of the torso and lower back, which is an essential factor especially for elderly people (21). In addition, this test is a more reliable measure of flexibility than using a goniometer (25).

The sit-and-reach test's validity as a measure of lower back and hip flexibility is, however, controversial. Jackson and Baker (12) concluded that the sit-and-reach test does not validly assess lower back flexibility. Some studies reported that this test had excellent criterion-related validity as a test of hamstring flexibility but was moderately related to low back flexibility (13, 15, 26).

It is generally believed that RT training could have adverse effects on the range of motion. According to this hypothesis, after RT a muscle should display an increased resting tension and decreased flexibility (30). However, previous studies performed with youngsters and adults demonstrate that RT does not cause a decrease in flexibility (18, 36), but have not indicated whether stretching exercises were included in the training program (17) or have used only circuit weight-training programs at 40–55% of 1 repetition maximum (RM) (36). Another study showed that RT may increase the range of joint motion without any additional flexibility training (31).

However, we are aware of only one study examining the effects of RT on flexibility in elderly people (9). Girouard and Hurley (9) compared the effects on flexibility of a 10-week RT program in men between 50 and 74 years of age to an inactive control group. The training sessions began with a 3-minute warm-up on a cycle ergometer, followed by a series of 13 stretching exercises for the entire body, followed by the RT. After RT, the series of stretching exercises was performed again. The study demonstrated that the flexibility of the individuals in the intervention group was improved. However, any conclusion concerning the effect of RT on flexibility is confounded by the performance of flexibility training.

No stretching or aerobic exercise was performed in the present study, so the effect of RT on flexibility is not confounded by the performance of other types of training. For RT to have a positive effect on flexibility, repetitions should be performed with a full range of

movements and both the agonist and antagonist muscle groups of a joint should be trained (8, 29, 31, 35), as was the case in the present project.

However, some authors (9, 32) believe that stretching exercises must be performed along with RT, so that a decrease in flexibility due to RT does not occur in elderly individuals. Performance of flexibility training is thought to be necessary to counteract the increase in muscle tension brought about by RT, which would decrease flexibility.

This conclusion is, however, not supported by research (34). This study compared the effects of RT, static and ballistic stretching, and ergonomic cycling on extension movements and muscular tension in the upper part of the thigh at rest. According to the authors, although people usually perform stretching exercises to reduce muscular tension, no diminishment in muscular tension after RT was observed.

The data collected in the present study provide no information regarding mechanisms for the altering of the elderly individual's flexibility. However, joint movement is related to morphological factors such as muscles, bones, structures, and conjunctive tissue (14), and physical inactivity is one of the factors responsible for flexibility reduction. As one gets older, cartilage, ligaments, and tendons change mechanically and biochemically; these structures consist mostly of collagen and nonelastic conjunctive tissue (17). Alterations in these structures with age increase muscular stiffness (10), resulting in decreased flexibility.

According to Johns and Wright (14), muscle and fascia are responsible for 41% of the joint resistance to movement, and these factors seem to be the most important and changeable relating to an increase in flexibility (2). Thus it is likely that the RT in the present study altered the stiffness of muscle and fascia, resulting in increased flexibility. In conclusion, the present study demonstrates RT, in the absence of flexibility or aerobic training, can increase flexibility in the elderly.

Practical Applications

Resistance training by itself can increase flexibility in the elderly. This has important applications to rehabilitation and physical conditioning of seniors.

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