The Influence of Strength, Flexibility, and Simultaneous Training on Flexibility and Strength Gains

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Abstract

Simão, R. Lemos, A. Salles, B. Leite, T. Oliveira, E. Rhea, M., and Reis, VM. The influence of strength, flexibility, and simultaneous training on flexibility and strength gains. J Strength Cond Res 25(5): 1333–1338, 2011—The purpose of this study was to examine the strength and flexibility gains after isolated or simultaneous strength and flexibility training after 16 weeks. Eighty sedentary women were randomly assigned to 1 of 4 groups: strength training (ST; n = 20), flexibility training (FLEX) (n = 20), combination of both (ST + FLEX; n = 20) and control group (CG; n = 20). All the groups performed pre and posttraining sit and reach test to verify the flexibility level and 10RM test for leg press and bench press exercises. The training protocol for all groups, except for the CG, included 3 weekly sessions, in alternated days, totaling 48 sessions. Strength training was composed of 8 exercises for upper and lower body, executed in 3 sets of periodized training. The flexibility training was composed of static stretching exercises that involved upper and lower body. Results showed that ST (30 ± 2.0 to 36 ± 3.0 cm), ST + FLEX (31 ± 1.0 to 42 ± 4.0 cm), and FLEX (32 ± 3.0 to 43 ± 2.0 cm) significantly increased in flexibility in relation to baseline and to CG (30 ± 2.0 to 30 ± 2.0 cm); however, no significant differences were observed between the treatment conditions. Strength tests demonstrated that ST and ST + FLEX significantly increased 10RM when compared to baseline, FLEX, and the CG. In conclusion, short-term strength training increases flexibility and strength in sedentary adult women. Strength training may contribute to the development and maintenance of flexibility even without the inclusion of additional stretching, but strength and flexibility can be prescribed together to get optimal improvements in flexibility.

Key Words strength training, performance, stretching

Introduction

Health- and fitness-related research has consistently sought to connect, or identify, benefits of exercise. According to the American College of Sports Medicine (2) physical aptitude is related to health through 5 basic components: body composition, aerobic fitness, strength, local muscular endurance, and flexibility. Among these, strength and flexibility are important variables of physical aptitude, and its adequate levels are necessary not only for the promotion and maintenance of health and the functional autonomy but also for safe and effective sports participation (1).

There are some studies (4–6,11) that have investigated chronic effects of strength training and flexibility. Fatouros et al. (7) have investigated the influence of aerobic training, strength training, and the combination of both in the movement amplitude of sedentary elderly men aged 65–78 years. In the group that had only strength training, significant differences were found for all the evaluated articulations. Barbosa et al. (4) have assessed the effects of a 10-week strength training on the flexibility behavior of sedentary elderly women, aged 62–73 years. Flexibility was evaluated by applying the Sit and Reach test before and after strength training. In conclusion, training has caused a significant flexibility increase, whereas no difference was found in the control group. Nóbrega et al. (13) have investigated the interaction between strength training and flexibility in sedentary young adults. After a 12-week follow-up, the authors have verified that strength training performed alone has not been able to increase flexibility. More recently, Monteiro et al. (11) have verified the effect of strength training on the flexibility in sedentary adult women and the strength training program was implemented through circuit training. The results have shown different behaviors for different articulations and movements before and after a training period. In conclusion, the results have suggested that strength training increases flexibility of sedentary women. However, studies describing the isolated or combined interaction among strength and flexibility training are limited in the literature.
The Influence of Training on Flexibility and Strength Gains

There are many factors that can influence both flexibility and increases in range of motion with training including the degree of physical condition, age, training specificity, and methodological prescription variables (exercises order, number of exercises, sets, repetitions, rest intervals, and system of training) (10,11). Although stretching exercises can enhance flexibility, questions remain regarding the impact of strength training on flexibility. Therefore, the purpose of this study was to verify strength and flexibility gains after isolated or simultaneous strength and flexibility training in sedentary women after 16 weeks of training.

METHODS

Experimental Approach to the Problem

Before the 16-week training program, 80 sedentary women were randomly assigned to 1 of 4 groups: strength training (ST; n = 20), flexibility training (FLEX; n = 20), combination of both (ST + FLEX; n = 20), and control group (CG; n = 20). The ST, FLEX, and ST + FLEX groups performed 2 weeks of familiarization to the exercises of the training programs (6 sessions). After training familiarization, and before 10RM tests and retests, the subjects performed 2 familiarization sessions covering the 10RM procedures. The flexibility measurement was taken 48–72 hours after the last 10RM test. After the flexibility measurement, the training groups underwent 16 weeks of training, under the supervision of experienced fitness professionals. After the 16-week training program, flexibility and strength were tested again after the same procedures as the pretests.

Subjects

The initial sample was composed of 240 untrained women. All participants underwent a clinical evaluation routine. To be included in the experiment, volunteers must have met the following characteristics: (a) be sedentary for at least 12 months; (b) agree to not perform any type of regular physical activity other than the prescribed strength training and flexibility training; (c) be free from any condition that would influence the collection or interpretation of the data. After the application of the inclusion criteria, only 80 women remained in the sample. The 80 women were randomly assigned to 1 of the 4 groups: ST (n = 20), FLEX (n = 20), ST + FLEX (n = 20), and CG (n = 20) (Table 1). Study details were explained both verbally and in writing, and all participants signed an informed consent form before participation in the study in accord with the declaration of Helsinki, and the study protocol was approved by the Research Ethics Committee of the Institution.

Strength Testing

After the strength training familiarization period (6 sessions), all participants performed 2 familiarization sessions regarding the 10RM test protocol with 48–72 hours between sessions. The 10RM testing protocol has been described previously (15). The 10RM tests were then performed on 2 nonconsecutive days for the machine bench press (BP) and leg press (LP) (Techno Gym™) using a counterbalanced order. On day 1, the first 10RM test was performed, and then, after 48–72 hours, the 10RM test was repeated to determine test–retest reliability. The heaviest load achieved on either of the test days was considered the 10RM load. No exercise was allowed in the 48 hours between 10RM tests so as not to interfere with the test–retest reliability result. To minimize the error during 10RM tests, the following strategies were adopted (15): (a) standardized instructions concerning the testing procedures were given to participants before the test; (b) participants received standardized instructions on exercise technique; (c) standard verbal encouragement was provided during the testing procedure. The 10RM was determined in fewer than 5 attempts with a rest interval of 5 minutes between them. After the 16 weeks of training, the 10RM test was performed similarly to the pretraining test to observe the possible strength gains. The 10RM tests were all conducted during the morning hours and kept consistent for each participant.

| TABLE 1. Characterization of the sample in pretraining situation.* † |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | ST (n = 20)     | FLEX (n = 20)   | ST + FLEX (n = 20) | CG (n = 20)  |
| Age (y)         | 35 ± 2.0        | 34 ± 1.2        | 35 ± 1.8        | 34 ± 2.1      |
| Height (cm)     | 162 ± 3.0       | 163 ± 2.0       | 165 ± 3.0       | 160 ± 4.0     |
| Body mass (kg)  | 60 ± 2.4        | 62 ± 3.1        | 61.2 ± 2.2      | 63.4 ± 2.0    |
| % Body fat      | 18.5 ± 1.1      | 19.8 ± 1.2      | 17.9 ± 1.1      | 19.4 ± 1.0    |
| BMI (kg m⁻²)    | 22.3 ± 0.9      | 21.8 ± 0.7      | 22.8 ± 0.7      | 22.4 ± 0.5    |
| 10RM (kg)–BP    | 70 ± 10         | 65 ± 10         | 70 ± 10         | 65 ± 10       |
| 10RM (kg)–LP    | 10 ± 5.0        | 12.5 ± 5.0      | 12.5 ± 5.0      | 10 ± 5.0      |
| Flexibility (cm)| 30 ± 2.0        | 32 ± 3.0        | 31 ± 1.0        | 30 ± 2.0      |

*ST = strength training group; FLEX = flexibility training group; ST + FLEX = strength and flexibility training group; CG = control group; RM = repetition maximum.
†Values are mean ± SD.

Journal of Strength and Conditioning Research
Flexibility Measurement (Sit and Reach Test)
Flexibility was measured before and after 16 weeks on the Sit and Reach Test (2). The flexibility measurement was taken 48–72 hours after the last 10RM test. The maximum flexibility measurement registered in 3 attempts with an interval of 10 seconds between attempts was considered (1). The same procedure was executed posttraining. All flexibility tests were conducted at the same time of the day. The data collected during the first evaluation were not made available to the evaluator to prevent information bias during measurements taken after training.

Before the flexibility test, a warm-up of 4 stretching exercises was performed for the muscle groups involved in the evaluation. Two sets were used for the static stretching warm-up protocol, holding the position for 10 seconds in each set, until a point of slight discomfort was reached. A 10-second interval was provided between the warm-up stretching sets. Given below is a detailed description of the 4 stretching exercise warm-up execution:

Sitting Hamstrings Stretch. This is performed—in a seated position with both legs straight and subjects bent at the waist attempting to grasp and hold both feet.

Hip Flexor Stretch. –In a lunge position with the knee on the ground and slightly to the rear of the body, subjects were instructed to lean forward with the lead leg while maintaining proper torso posture.

Knee Extensors. –From a standing position, subjects were instructed to grasp the foot, bending at the knee, and bring the foot upward toward the hamstring.

Gastrocnemius Stretch. From a lunging position, the subjects were instructed to place the hands on the floor while straightening the rear leg and attempting to place the heel of the rear foot to the floor.

Training Protocol
The training protocol for all groups, except the CG (which maintained its normal daily routine) included 3 weekly sessions, on alternate days, totaling 48 sessions (4 months). Minimum adherence for data inclusion was at least 46 sessions, and all 80 subjects completed the study. All sessions were supervised by experienced fitness professionals.

Strength training was composed of 8 exercises executed in 3 sets per workout with intensities varying in a linear periodized fashion. In the first month, 8–12RM was used; repetitions and load was then altered to 6–10RM in the second month, 10–15RM in the third month, and 8–12RM in the last training month. When the subjects exceeded the highest values of the established repetition training zone, the loads were readjusted. The order established for the strength training was the following: BP, LP, frontal lat pull-down (wide grip), leg extension, trunk extension, leg curl, seated military press, and abdominal crunch. Before each training session, the subjects executed a specific warm-up involving 15 repetitions with 50% of the load used in the first and second exercises of the sequence. The rest interval between the sets was set at a ratio of 1:4 (execution: recovery).

Flexibility training was composed of exercises that involved the upper and lower body, shoulders, hips and trunk. Static stretching was performed at the point of mild discomfort with stretches held for 15–60 seconds (1). Four repetitions of each stretch were completed with 15 seconds of rest between repetitions. Time under tension was progressively increased from 15 to 60 seconds over the course of the training program with exercise order remaining constant.

The combined training involved the performance of flexibility training protocol first, followed by the strength training routine. All testing and training were performed in the morning hours and was held constant throughout the study. To protect against bias, the investigators that conducted the randomization and training orientation did not conduct the testing measurements, and the investigators involved in the strength and flexibility tests were blinded to the group assignment.

Statistical Analyses
The Shapiro–Wilk normality test and the homoscedasticity test (Bartlett criterion) were performed to evaluate data distribution. Intraclass correlation coefficients (ICCs) were used to determine 10RM and flexibility measurement test–retest reliability. The ICC method was used based on a repeat measurement of strength and flexibility. Student t-tests were used to analyze for differences between 10RM test and retest, pretraining, and posttraining. The same procedure was taken to flexibility measure (test and retest) pretraining and posttraining. All variables presented normal distribution and homoscedasticity. A 2 (pre–post) by four (groups)-way analysis of variance was used to analyze for differences among the groups in the 10RM load and flexibility measures across time. When appropriate, follow-up analyses were performed using Tukey post hoc tests. An alpha level of $p < 0.05$ was considered statistically significant for all comparisons. Statistica version 7.0 (Statsoft, Inc., Tulsa, OK, USA) statistical software was used for all statistical analyses. The calculation of the effect size (the difference between pretest and posttest scores divided by the pretest standard deviation) and the scale proposed by Rhea (14) was used to examine the magnitude of any treatment effect.

RESULTS
Ten Repetition Maximum Tests
The 10RM test–retest reliability showed high ICC at baseline (BP, $r = 0.94$; LP, $r = 0.90$), and after 16 weeks of training (BP, $r = 0.96$; LP, $r = 0.92$). Student t-test did not show significant ($p > 0.05$) differences between the baseline and posttest reliability measures demonstrating that strength measures were consistent and reliable at both testing times. Analysis of variance identified significant differences in strength measures between pretest and posttest ($p < 0.05$). Post hoc analysis identified that ST and ST + FLEX showed
significantly greater 10RM improvement for BP and LP when compared to the FLEX and CG groups ($p < 0.05$) (Table 2) from pre to posttraining. There were no differences ($p > 0.05$) between groups in 10RM tests at baseline or after 16 weeks in both training groups involving strength exercises (ST and ST + FLEX). Effect size data demonstrated large strength improvements in LP for ST (5.00), ST + FLEX (4.00) groups, whereas the FLEX (0.50) group showed small strength improvement. For BP, large strength improvements for ST (4.00) and ST + FLEX (3.00) groups were also observed; however, the FLEX (0.00) group showed no strength improvements. The percentage strength improvements in LP for ST was 71%, for ST + FLEX it was 57%, and for FLEX it was 7.7%, and in BP for ST it was 200%, for ST + FLEX it was 150%, and for FLEX, it was 0%.

### Flexibility Measurement

Excellent day-to-day test reliability was obtained at baseline ($r = 0.96$) and at posttraining ($r = 0.96$). Additionally, a paired student $t$-test did not show significant differences between the baseline test and retest, nor was a different measured between the posttest reliability measures. There were no differences ($p > 0.05$) between groups in flexibility measurement at baseline (Table 3). The 3 training groups (ST, FLEX, and ST + FLEX) showed significant increases in flexibility in relation to baseline and to CG ($p < 0.05$), but no significant differences were noted between them ($p > 0.05$; Table 3). Effect size data demonstrated large flexibility improvements in ST + FLEX (11.00), ST (3.0), and FLEX (3.66) groups. The percentage flexibility improvement in ST was 20%, in FLEX it was 34%, and in ST + FLEX it was 35%.

### Discussion

The purpose of the present study was to examine, in adult sedentary women, strength and flexibility gains achieved through isolated or simultaneous strength and flexibility training. The main findings of this study were that strength training alone increases flexibility, and strength and flexibility can be prescribed together to increase flexibility to a greater extent. In fact, all groups, ST, ST + FLEX, and FLEX, demonstrated significant gains on flexibility in relation to the baseline situation and posttraining when compared to CG; however, no differences were observed between the different interventions. It is at times believed that strength training alone has little or no effect on a joint’s range of motion or flexibility. However, the effect size in the current study showed that strength training alone increases flexibility in previously sedentary women, and strength and flexibility can be prescribed together to get better results in flexibility improvements.

Few studies have investigated the influence of the strength training in flexibility. Nóbrega et al. (13) investigated the interaction of strength training and flexibility training in young sedentary men and women, with a mean age of 21 years. The subjects followed a strength training protocol with intensities initially set at 60% of 1RM and was continuously adjusted so that fatigue was achieved after 8–12 repetitions.

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**Table 2.** Strength results at baseline and posttraining situation.*†

<table>
<thead>
<tr>
<th>Groups</th>
<th>10RM (kg)–leg press</th>
<th>10RM (kg)–bench press</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre (g)</td>
<td>Post (g)</td>
</tr>
<tr>
<td>ST</td>
<td>70 ± 10</td>
<td>120 ± 10†§</td>
</tr>
<tr>
<td>FLEX</td>
<td>65 ± 10</td>
<td>70 ± 10</td>
</tr>
<tr>
<td>ST + FLEX</td>
<td>70 ± 10</td>
<td>110 ± 10†§</td>
</tr>
<tr>
<td>CG</td>
<td>65 ± 10</td>
<td>65 ± 10</td>
</tr>
</tbody>
</table>

*ST = strength training group; FLEX = flexibility training group; ST + FLEX = strength and flexibility training group; CG = control group; RM = repetition maximum. †Values are mean ± SD. ‡Significant difference in relation to the pretraining situation. §Significant difference in relation to the posttraining situation for FLEX and CG.
At the end of 12 weeks, the authors verified that strength training improved muscle strength either alone or in combination with flexibility training, but strength training alone did not change flexibility. Flexibility increased with specific training alone or in combination with strength training. In the present study, the sample was composed of sedentary adult women; however, the training was performed with periodized intensities for 16 weeks. Our results were similar to those found by Nóbrega et al. (13); both found strength gains in strength training alone and in combined strength and flexibility training groups. On the other hand, our study showed that strength training alone also increases flexibility in previously sedentary women, and strength training plus flexibility gave better results in flexibility improvements.

In our study, the ST + FLEX group performed the strength training after the flexibility training, in contrast to the study of Nóbrega et al. (13), where the subjects performed flexibility after the strength exercises. Nóbrega et al. (13) suggest that flexibility training after strength exercises does not interfere with gains in flexibility; however, comparing the gains in the opposite order, it had a greater magnitude. This could explain the flexibility improvements in the combined group being greater in our study.

More recently, Monteiro et al. (11) investigated the effect of strength training on flexibility in sedentary, middle-aged women through a 10-week circuit training protocol. Flexibility was measured in 10 movements before and after the training program. After 10 weeks, strength significantly increased, and 5 of the 10 flexibility movements demonstrated significant increases in range of motion. These findings agree with our results, showing that besides increases in muscle strength, strength training alone can increase flexibility.

Barbosa et al. (4) investigated the effect of the strength training on flexibility measurements in elderly women using the sit and reach test. The subjects performed a 10-week strength training program, which consisted of 8 exercises for the entire body, of larger to small muscle group, with different volumes and intensities. No stretching or aerobic exercise was performed before or after strength training session, and the effect of strength training was analyzed in independent way. The authors observed a significant increase in flexibility, whereas no difference was found in control group, showing that strength training without stretching exercises does also increase flexibility in elderly women.

Fatouros et al. (7) investigated the effects of aerobic training, strength training and their combination on range of motion of inactive elderly men, aged 65–78 years. Strength and combined strength and flexibility training groups increased strength and flexibility performance at the end of the 16-week training period. More recently, Fatouros et al. (5) also found that moderate- and high-intensity strength training improved both strength and flexibility among older men. In contrast, Girouard and Hurley (9) showed that the flexibility exercise increased range of motion significantly more than a combined flexibility and strength group. This study did not examine a group only performing strength training exercises.

In the present study, data related to specific physiological mechanisms that would explain the findings were not collected; however, the mechanisms that explain the flexibility gains derived from strength training are not well explained in the literature, and a few hypotheses have been suggested. It seems that such increases might be because of neuro-muscular responses and to variations in the mechanical properties of the muscular and connective tissues, with a substantial increase in the reflex activity of Golgi Tendon Organ and muscle fuses (8,12). Applying training during several sessions may cause changes when the limits to the performance of such structures are reached, generating different responses to the elastic and plastic structures, that might result in changes to the maximum movement amplitudes (3). It has also been suggested that strength exercises increase tension in tendons and ligaments, and improve muscle contractility, which may lead to a wider movement amplitude. Further investigations would be helpful in examining the effects of strength training on physiological make-up of connective tissues in an attempt to explain the potential increase in flexibility with strength training.

The fact that strength training alone increased flexibility in previously sedentary adult women to almost the same degree as stretching or combined training carries significant professional meaning. Further research is warranted to examine specific strength training exercises or routines to enhance total-body range of motion and optimal flexibility.

**Practical Applications**

Gaining multiple health and fitness benefits in 1 mode of training enables exercisers to garner the benefits of exercise despite limited time for training, common among the general population. The time saved by omitting separate stretching routines may help increase adherence to training by limiting exercise time. Strength training, performed through a complete range of motion, has been shown to increase flexibility to a similar extent as separate stretching exercises. Exercise professionals can prescribe strength training and flexibility together to enhance both strength and flexibility. This can condense the amount of training time needed to secure these health and fitness benefits.

**Acknowledgments**

Dr. Roberto Simão would like to thank the Brazilian National Board for Scientific and Technological Development (CNPq).

**References**


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