Influence of Moderately Intense Strength Training on Flexibility in Sedentary Young Women

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Abstract

Santos, E, Rhea, MR, Simão, R, Dias, I, Freitas de Salles, B, Novaes, J, Leite, T, Blair, JC, and Bunker, DJ. Influence of moderately intense strength training on flexibility in sedentary young women. *J Strength Cond Res* 24(11): 3144–3149, 2010—The present study is the first to examine whether moderately intense resistance training improves flexibility in an exclusively young, sedentary women population. Twenty-four, young, sedentary women were divided into 3 groups as follows: agonist/antagonist (AA) training group, alternated strength training (AST) group, or a control group (CG). Training occurred every other day for 8 weeks for a total of 24 sessions. Training groups performed 3 sets of 10 to 12 repetitions per set except for abdominal training where 3 sets of 15 to 20 reps were performed. Strength (1 repetition maximum bench press) and flexibility were assessed before and after the training period. Flexibility was assessed on 6 articular movements: shoulder flexion and extension, horizontal shoulder adduction and abduction, and trunk flexion and extension. Both groups increased strength and flexibility significantly from baseline and significantly when compared with the CG ($p \leq 0.05$). The AST group increased strength and flexibility significantly more than the AA group ($p \leq 0.05$) in all but one measurement. This study shows that resistance training can improve flexibility in young sedentary women in 8 weeks.

Key Words stretching, resistance training, articular movements, exercise order, physical fitness

Introduction

Adequate flexibility allows full joint range of motion potentially improving sports performance and daily function (2,9). Adequate flexibility subjects have less injury risk than poor flexibility subjects, and excellent flexibility subjects may have dramatically less injury risk than poor flexibility subjects (14). Adequate flexibility increases quality of life (1,2) and stretching is recommended for most populations.

Although stretching is the most popular recommendation for improving flexibility, some populations may not adhere to a stretching program (4). Resistance training increases ligament and tendon strength and may improve contractility and joint integrity. One of these traits or a combination thereof may increase joint range of motion, thereby improving flexibility (17). Although there is much that remains unknown about resistance training and flexibility, several recent studies examine resistance training's flexibility impact.

Whether resistance training flexibility gains are produced by increased connective tissue strength, increased muscle strength, greater motor learning, or neuromuscular coordination (11) is not yet clear. It appears settled that resistance training does not limit flexibility gains absent extreme strength gains (12).

Resistance training can unquestionably improve strength, power, and muscle hypertrophy across various populations. If resistance training can increase flexibility without stretching in some populations, greater training time can be devoted to resistance training and greater resistance training benefits may result (5,10).

Resistance training flexibility studies produce varied results. Although methodological limitations limit broad inferences in some cases, resistance training's flexibility impact may be partially population, protocol, and articulation specific.

To our knowledge, no previous study has examined resistance training's flexibility impact in an exclusively young sedentary women population. The study's purpose was to consider 2 moderately intense strength training protocols' impact on flexibility in sedentary young women.

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Methods

Experimental Approach to the Problem

This study considered whether 8 weeks of moderately intense resistance training increases flexibility in sedentary young women. Before beginning the 8-week program, subjects were randomly assigned to 1 of 3 groups: alternated strength training (AST) group (upper and lower body), alternated agonist/antagonist (AA) group, or control group (CG). Due to the subjects' sedentary history, both training groups performed 1 week of exercise familiarization before 1 repetition maximum (1RM) testing.

Initial flexibility was assessed 48 to 72 hours after the initial 1RM testing procedure. At the end of the 8-week training period, flexibility was reassessed 48 hours after the final training session. The second 1RM test was conducted 48 hours after the second flexibility assessment. Training included 3 weekly sessions, performed every other day, for 24 total sessions. All subjects completed all sessions. Training ran for an 8-week period.

Subjects

Twenty-four, young, sedentary women were divided into 3 groups as follows: AA ($n = 8$; age 26.8 ± 1.6 years; body mass 55.1 ± 3.3 kg; height 161 ± 2.7 cm; body mass index [BMI] 21.3 ± 1.2 kg/m^2); AST ($n = 8$; age 24 ± 2.3 years; body mass 60.3 ± 4.5 kg; height 164.3 ± 6 cm; BMI 22.3 ± 1.1 kg/m^2); CG ($n = 8$; age 25.4 ± 2.4 years; body mass 54.1 ± 3.5 kg; height 160 ± 4.1 cm; BMI 21.1 ± 1.3 kg/m^2). For 6 months preceding the study, subjects engaged in no physical activity. During the study period, subjects engaged in no regular physical activity other than the study's strength training program. Subjects were not allowed to present any condition that could influence data collection or interpretation. All volunteers were verbally briefed on the risk associated with the study and signed a written agreement acknowledging the risk in compliance with the Castelo Branco University ethical committee. The University ethics committee approved this study.

Flexibility Measurement

Flexibility was assessed on 6 articular movements: shoulder flexion and extension, horizontal shoulder adduction and abduction, and trunk flexion and extension. Except for trunk movements, all assessments were collected on the right side. Trunk flexion, trunk extension, and shoulder adduction were performed in the orthostatic position. The shoulder abduction movement was performed while the subject was seated. Shoulder flexion and extension were assessed on a trolley to limit compensatory movement.

To assess flexibility, the evaluator adjusted the subject's body to the point of pain or anatomical limitation. The measurements were taken using a Lafayette Goniometer (Sammons Preston Rolyan 7514), following the procedures described by Norkin and White (13). Initial collected data were not available to the evaluator during subsequent assessment. Excellent day-to-day flexibility reliability was shown before and after strength training for each exercise in each group.

Repetition Maximum Testing

One repetition maximum machine bench press (BP) tests were performed on 2 non-consecutive days (Life Fitness, Inc., Franklin Park, IL). The 1RM testing protocol has been previously described (16). The heaviest load achieved was recorded as 1RM. The first 1RM test was repeated 48 to 72 hours after initial assessment to determine test-retest reliability.

Several strategies minimized error risk during 1RM testing. Standardized instructions concerning testing procedure and exercise technique were provided before the test. Verbal encouragement was provided during the 1RM testing process. The 1RM was determined in fewer than 5 attempts. Five-minute rest interval was allowed between 1RM attempts to allow full recovery.

Training Protocol

Training included 3 weekly sessions, performed every other day, for 24 total sessions. All subjects participated in and completed all organized sessions. Before each training session, subjects performed a specific warm-up. Warm-up included 20 repetitions with 50% of the weight used in the first training exercise.

Both training groups performed 3 sets with 10 to 12 repetitions per set in all exercises except the abdominal exercise. In the abdominal exercise, subjects performed 3 sets of 15 to 20 repetitions. When subjects could exceed 12 repetitions, the amount of weight was increased to keep the repetition capacity at 10 to 12 repetitions per set. During the exercise sessions, participants received verbal encouragement to exercise to concentric failure. One repetition maximum range of motion standards were used to assess a successful repetition.

The exercise order for AST group was machine seated row (MSR), leg extension (LE), machine BP, seated leg curl (LC), machine seated arm curl (BC), abdominals (ABS), machine triceps extension (TE), and trunk extension machine (TEM). In the AST program, subjects performed 2 consecutive paired exercises followed by 2 minutes of rest. Subjects then moved to the next 2 paired exercises followed by 2 minutes of rest and continued until all exercises were completed.

The AA group exercise order was MSR-BP, TE-BC, ABS-TEM, LE-LC. Exercises were paired in AA groups (e.g., MSR-BP) and executed sequentially. On completing 3 sets of one exercise pairing, subjects rested 2 minutes before proceeding to the next exercise pairing. The CG performed no strength training intervention.

Statistical Analyses

Total work was determined by multiplying the number of sessions, the number of sets, and repetitions and resistance load (session × sets × load). Intraclass correlation coefficients

Table 1. Flexibility measures (degrees) for shoulder movements pre and post 8-week training (mean ± *SD*).*

	Shoulder flexion		Shoulder extension		Shoulder adduction		Shoulder abduction	
Groups	Baseline	8 wks	Baseline	8 wks	Baseline	8 wks	Baseline	8 wks
AA ($n = 8$)								
Flexibility	111.3 ± 4.2	117.7 ± 4.0†‡	50.1 ± 5.4	57.2 ± 4.1†‡	97.5 ± 3.5	102.7 ± 5.3†‡	47.5 ± 6.2	57.2 ± 7.2†‡
Effect size	1.5‡		1.3‡		1.4‡		1.6‡	
Magnitude	Moderate		Moderate		Moderate		Large	
AST ($n = 8$)								
Flexibility	113.0 ± 3.3	119.1 ± 3.0†‡	50.6 ± 4.6	58.8 ± 5.7†‡	95.1 ± 5.6	106.5 ± 5.1†‡	48.5 ± 6.4	59.7 ± 7.0†‡
Effect size	1.8‡§		1.7‡§		2.0‡§		1.7‡	
Magnitude	Large		Large		Large		Large	
CG ($n = 8$)								
Flexibility	108.1 ± 5.1	106.8 ± 5.7	50.4 ± 4.3	50.1 ± 3.4	97.8 ± 6.4	98.5 ± 5.9	47.4 ± 3.6	47.0 ± 3.8
Effect size	−0.3		−0.0		0.1		−0.1	
Magnitude	Trivial		Trivial		Trivial		Trivial	

*AA = agonist/antagonist training method; AST = alternated strength training method; CG = control group.
†Significant difference from baseline.
‡Significant difference from CG.
§Significant difference from AA group.

Table 2. Flexibility measures (degrees) for trunk movements pre and post 8-week training (mean ± *SD*).*

Groups	Trunk flexion Baseline	Trunk flexion 8 wk	Trunk extension Baseline	Trunk extension 8 wk
AA ($n = 8$)				
Flexibility	28.1 ± 6.1	36.8 ± 4.7†‡	18.5 ± 5.2	25.6 ± 3.1†‡
Effect size	1.4‡		1.3‡	
Magnitude	Moderate		Moderate	
AST ($n = 8$)				
Flexibility	28.3 ± 5.7	38.8 ± 5.2†‡	20.5 ± 3.8	26.4 ± 4.8†‡
Effect size	1.8‡§		1.5‡§	
Magnitude	Large		Large	
CG ($n = 8$)				
Flexibility	24.7 ± 1.5	25.0 ± 1.9	17.2 ± 1.2	16.9 ± 1.6
Effect size	0.2		−0.2	
Magnitude	Trivial		Trivial	

*AA = agonist/antagonist; AST = alternated strength training; CG = control group.
†Significant difference from baseline.
‡Significant difference from CG.
§Significant difference from AA.

(ICCs) were used to determine 1RM and flexibility measurement test-retest reliability. The ICC method was based on a repeated measurement of maximal strength and flexibility. The statistical analysis was initially done by the Shapiro-Wilk normality test and by the homoscedasticity test (Bartlett's criterion). All variables presented normal distribution and homoscedasticity. A 2 (pre-post) by 3 (groups) way analysis of variance (time [baseline vs. 8-week training] × group [AST vs. AA vs. control]) was used to analyze group 1RM and flexibility differences. Strength and flexibility effect size were calculated using Rhea's proposed scale (15). When appropriate, follow-up analyses were performed using Tukey's post hoc tests. Student's *t*-tests were used to analyze differences between pre- and post-training 1RM tests and for total work. The same procedure was applied to flexibility measurements (test and retest) pre and post training. An alpha level of $p \leq 0.05$ was considered statistically significant for all comparisons. Statistica version 7.0 (Statsoft, Inc., Tulsa, OK) software was used for all statistical analyses.

Results

Both training groups showed moderate or large flexibility gains at all measured articulations, whereas the CG showed trivial gains or lost flexibility at all articulations. Moderate intensity strength training can increase flexibility in young sedentary women in a short time.

Flexibility Measurement

All pre- and post-test flexibility measures showed excellent day-to-day test reliability, with ICCs ranging between 0.90 and 0.98. Additionally, a paired Student's *t*-test indicated no significant differences between training group flexibility assessments. There were no differences ($p > 0.05$) in baseline flexibility measurements between groups on 6 articular movements (Tables 1 and 2). In both trained groups, flexibility increased significantly for 6 articular movements (Tables 1 and 2). Effect size data (Tables 1 and 2)

Table 3. 1RM tests at baseline and after 8 weeks of strength training (mean ± *SD*).*

Groups	BP Baseline	BP 8 wk
AA ($n = 8$)		
1RM (kg)	33.2 ± 5.0	40.5 ± 4.8†‡
Effect size	1.4‡	
Magnitude	Moderate	
AST ($n = 8$)		
1RM (kg)	29.5 ± 2.9	42.0 ± 1.7†‡
Effect size	4.3‡§	
Magnitude	Large	
CG ($n = 8$)		
1RM (kg)	23.5 ± 2.3	24.0 ± 3.0
Effect size	0.2	
Magnitude	Trivial	

AA = agonist/antagonist; AST = alternated strength training; BP = bench press; CG = control group; 1RM = 1 repetition maximum.
†Significant difference from baseline.
‡Significant difference from CG.
§Significant difference from AA.

demonstrated differences between the training groups in all measurements except shoulder abduction.

Total Volume and Total Work

There was no difference between training groups in total volume (repetitions × sets). However, the AST group performed a higher amount of work than the AA group although the difference was not significant (349933.5 ± 102052.4 kg).

One Repetition Maximum Tests

The 1RM test-retest reliability showed high ICC at baseline (BP, $r = 0.90$) and after 8 weeks of training (BP, $r = 0.92$). The T-tests showed no significant differences between 1RM tests. There were no differences ($p > 0.05$) between groups in 1RM tests at baseline. After 8 weeks, both trained groups showed a significant 1RM BP improvement when compared with CG (Table 3). There was no significant 1RM BP gain difference between the trained groups. However, effect size data (Table 3) showed differences between trained groups.

Discussion

The present study considered two 8-week, moderately intense, resistance training programs' impact on sedentary young women's flexibility. Both training groups increased flexibility significantly from baseline and when compared with CG. The AST group increased both strength and flexibility more than the AA group.

Several recent studies considering resistance training's flexibility impact have produced mixed results. Some populations can apparently improve flexibility through resistance training, whereas some may not be able to do so.

Age and gender apparently impact strength training's flexibility. Low (60%) strength training intensity may increase older adult flexibility although higher intensity training may produce greater flexibility gains (5). Younger subjects may need greater intensity to produce the same relative benefit (6).

Strength training improves elderly women flexibility for some joint movements (3,6,7). Flexibility exercises alone were more effective than strength training combined with flexibility exercises for improving hip flexion, shoulder flexion, and shoulder abduction in elderly men (8). However, some limitations should be considered. Shoulder abduction was the only articulation where the flexibility-only group showed significantly better gains than the strength plus flexibility group. Furthermore, shoulder abduction was not resistance trained. Some resistance training protocols may not sufficiently train the respective articulations that are being assessed for flexibility. This issue has been previously noted as a potential program design limitation when attempting flexibility increase through resistance training (5).

Middle-aged women (±37 years) increased flexibility at some joints after performing circuit strength training (10). The 8 to 12 RM circuit training routine increased flexibility at some but not all joints.

Strength training did not improve young adult flexibility (12). However, gender differences were not considered. Furthermore, 28 men and 15 women (65% men and 35% women) participated. The resistance training group was even more gender skewed: 69% men and 31% women. The authors listed gender specificity as a potential study limitation. The authors also noted that the results may be protocol specific, and another resistance protocol may produce a different flexibility outcome. Other commentators have noted the impact of varying resistance protocols on flexibility (10).

A brief review of recent resistance training for flexibility gains indicated multiple set training between 6 and 12 repetitions, which can increase flexibility in sedentary middle-aged and older men and women in a short period (10). Our findings applied a similar resistance protocol to young sedentary women and also increased flexibility.

Considering the total literature support for resistance training's capacity to increase flexibility, particularly in women, and in light of the Nóbrega et al. (12) limitations, the present study's flexibility gains provide more support for resistance training as an effective method to increase flexibility in many populations.

Practical Applications

Our study supports the hypothesis that moderate intensity strength training increases strength and flexibility during initial training stages in young sedentary women. Specificity of population (age and gender), gender, and training protocol may limit conclusions about the present findings to the present population and protocol.

Given exercise's time cost and the universal desire to achieve maximal physical results in minimal time, enhanced exercise efficiency serves fitness professionals, athletes, and the general population. This may be particularly true with a sedentary population. Exercise professionals working with young sedentary women may use limited training time for strength training exercises knowing that moderate intensity strength training improves both strength and flexibility. As the first study to show increased flexibility through resistance training with an exclusively young sedentary women population, this study contributes to the evidence that appropriate intensity resistance training increases flexibility in some populations and at some articulations. Two resistance protocols that increase strength and flexibility in young women are also provided. Therefore, this study provides important programming information for the exercise professional.

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