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Original Research

Early-Phase Resistance Training Strength Gains in Novice Lifters Are Enhanced by Doing Static

Stretching

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Abstract

Kokkonen, J, Nelson, AG, Tarawhiti, T, Buckingham, P, and Winchester, JB. Early-phase resistance training strength gains in novice lifters are enhanced by doing static stretching. *J Strength Cond Res* 24(2): 502-506, 2010-This study investigated differences in lower-body strength improvements when using standard progressive resistance training (WT) vs. the same progressive resistance training combined with static stretching exercises (WT + ST). Thirty-two college students (16 women and 16 men) were pair matched according to sex and knee extension 1 repetition maximum (1RM). One person from each pair was randomly assigned to WT and the other to WT + ST. WT did 3 sets of 6 repetitions of knee extension, knee flexion, and leg press 3 days per week for 8 weeks with weekly increases in the weight lifted. The WT + ST group performed the same lifting program as the WT group along with static stretching exercises designed to stretch the hip, thigh, and calf muscle groups. Stretching exercise sessions were done twice a week for 30 minutes during the 8-week period. WT significantly ($p < 0.05$) improved their knee flexion, knee extension, and leg press 1RM by 12, 14, and 9%, respectively. WT + ST, on the other hand, significantly ($p < 0.05$) improved their knee flexion, knee extension, and leg press 1RM by 16, 27, and 31, respectively. In addition, the WT + ST group had significantly greater knee extension and leg press gains ($p < 0.05$) than the WT group. Based on results of this study, it is recommended that to maximize strength gains in the early phase of training, novice lifters should include static stretching exercises to their resistance training programs.

Introduction

Although stretching is commonly used by many athletes in different sports, recent research has established an adverse effect of acute static stretching on various different maximal performances. Pre-event stretching has demonstrated an inhibitory effect on maximal force or torque production (([16,24,27]) and references cited therein), vertical jump performance ([4,5]), running speed ([22,32]), and muscle endurance ([23]). In contrast to pre-event stretching, doing regular (i.e., daily or 2-3 times per week) stretching seems to have some performance benefit. For example, Worrell et al. ([33]) and Handel et al. ([14]) found increases in hamstring isokinetic torque. Godges et al. ([12]) found increased trunk strength, whereas Wilson et al. ([30]) found improvements in the bench press. In addition, Dintiman ([8]) reported improved sprint performance, and Hunter and Marshall ([15]) saw increases in a countermovement vertical jump. Finally, Kokkonen et al. ([17]) have reported that 10 weeks of static stretching alone improved jumping, sprinting, strength, and endurance performances.

Notwithstanding strength and flexibility exercises being common components of many exercise programs, it is not clear at this time how best to include both of these elements in a single training program or if it is even prudent to do so. Unfortunately, training studies, which employ either strength or flexibility training, do not appropriately answer this question. As mentioned above, flexibility training can increase strength ([12,14,17,30]). In addition, strength training has been shown to increase flexibility ([18,20]). It has not been shown however whether strength training combined with flexibility training results in an alteration in the magnitude of strength gains when compared with a strength training-only program.

How the stretching programs might cause strength gains is up to speculation; however, in a manner similar to resistance training, passive stretching is related to increases in muscle hypertrophy (for reviews see ([10,13])). For instance, placing a muscle on stretch can induce Z-line ruptures ([13]), increase protein synthesis ([13]) and growth factor production, and trigger myoblast proliferation ([7]). Moreover, Coutinho et al. ([6]) reported a 16% increase in rat soleus fiber area by stretching the muscle for 40 minutes 3 days per week for 3 weeks, whereas Stauber et al. ([28]) stretched rat soleus muscles 3 times a week for 4 weeks and found fiber area to be increased by 30%. Interestingly, these stretch-induced gains in hypertrophy are similar to those reported after the initial 6-8 weeks of resistance training ([3,13,26]).

Because the responses to stretching and resistance training are similar, it is possible that if both resistance training and stretching are included in a training program, their effects could be additive. It was hypothesized that performing stretching exercises on the no-lifting days would maintain the strength gain stimuli without metabolically stressing the musculature. Therefore, it was the purpose of this study to determine if combining resistance and flexibility exercises to novice exercisers would result in greater early-phase strength gains than performing resistance training alone.

Methods

Experimental Approach to the Problem

To compare the effect of stretching and resistance training to resistance training alone, participants' strength was assessed before and after engaging in either a resistance training program or a resistance training combined with stretching. Before starting the training, pre-1 repetition maximum (1RM) values were obtained on the following exercises: knee extension, knee flexion, and leg press. After initial strength testing, participants were pair matched for strength and one person from each pair was randomly assigned to either the resistance training-only program (WT) or the resistance training and stretching group (WT + ST). When more than 2 individuals matched up for 1RM, the 2 with the closest body masses were paired. Among the volunteers, 8 pairs of men and 8 pairs of women were found to fit the matching criteria. After selection into either the WT or WT + ST group, subjects were required to participate in an 8-week training program, details of which are outlined below. After the 8-week training program, post-testing for 1RMs were repeated in the same manner in which they were performed during pre-testing.

Subjects

Thirty-two college students (16 men and 16 women) enrolled in fitness classes at Brigham Young University-Hawaii volunteered to be in the study. Descriptive values are presented in Table 1. Before participation in the study, participants were either physically inactive or recreationally active. For the purposes of this study, recreationally active was defined as sporadic participation in physical activity, or in other words, anyone who participated in 2 or more days of physical activity during a week was excluded from participation. The appropriate institutional review board approved the study, and each participant gave both written and oral consent before engaging in the experiment.

Group	Age (y)	Mass (kg)		Height (cm)
		Pre	Post	
Resistance training (WT)				
Women ($n = 8$)	21 ± 1	65 ± 7	65 ± 6	167 ± 3
Men ($n = 8$)	23 ± 3	75 ± 15	74 ± 15	171 ± 8
Resistance training and stretching (WT + ST)				
Women ($n = 8$)	23 ± 4	73 ± 28	72 ± 28	163 ± 7
Men ($n = 8$)	25 ± 2	67 ± 10	67 ± 9	179 ± 4

*Values are mean ± *SD*.

Table 1:
Subject descriptive data.*

Procedures

Knee flexion 1RM was done in the prone position using the same Nautilus knee flexion machine (Nautilus, Inc., Vancouver, WA, USA) and protocol described previously ([16]). The knee extension was done in a seated position on a Nautilus knee extension machine using the same machine and protocol as described previously by Kokkonen et al. ([16]). These protocols have been used in numerous studies, and the test-retest reliability is high with $r > 0.98$.

The leg press 1RM was done using a Paramount plate-loaded bilateral 45° leg press machine (Paramount Fitness Corp., Los Angeles, CA, USA). The starting weight was set at the person's body weight. The weight was then increased by 111 N (25 lb) for the next 2 lifts. After which the weight was incremented by 44 N (10 lb) until failure was achieved. The load was then decreased by 22 N (5 lb), and a final attempt was performed. A 1-minute rest was instituted among all lifts, and all subjects reached their 1RM in 5-6 trials.

WT and WT + ST groups performed the same weight training program 3 days (Monday, Wednesday, and Friday) each week for 8 weeks. Three different lifts were performed and they were identical to those used in the 1RM measurements. The training consisted of 3 sets of 8 repetitions, and the initial weight was 85% of the pre-1RM. When participants were able to perform more than 8 repetitions on set number 3, they were instructed to increase their resistance for the next workout. Rest times between sets were 2-3 minutes, and 3-5 minutes elapsed between the 3 different lifts.

The stretching program lasted approximately 30 minutes and was performed 2 days (Tuesday and Thursday) each week for 8 weeks. The same 15 different static stretches designed to stretch all the major lower extremities muscle groups (i.e., hamstrings, quadriceps, adductors, abductors, external and internal rotators, plantar flexors, and dorsiflexors) as reported previously ([17]) were used. Each of the subjects actively performed (i.e., unassisted stretching) the 15 exercises. For each stretch, the muscle was held in the stretched position for 15 seconds, and this was repeated 3 times. A 15-second rest period was implemented between trials, and a minimum period of 1 minute separated the different exercises.

Statistical Analyses

A 2-way (treatment vs. pre-post) repeated measures analysis of variance (ANOVA) was used for analysis. Post hoc ANOVA analysis involved, where appropriate, the use of Tukey's protected *t*-test. The level of significance was set at $p \leq 0.05$. Based on the results of Kokkonen et al. ([17]), a minimum of 7 subjects were needed in each group to achieve a statistical power of $\beta \geq 0.80$. In addition, effect size was expressed via the generalized omega squared (ω^2_G) statistic, using the formula recommended for repeated measure designs ([25]). Olejnik and Algina ([25]), however, point out that ω^2_G by itself has little meaning and is best used when comparing results between differing experiments with similar experimental designs.

Results

The average (±*SD*) 1RM values are presented in Table 2. There was no significant difference between pre-WT and pre-WT + ST for knee extension 1RM ($p = 0.74$), knee flexion 1RM ($p = 0.76$), or leg press 1RM ($p = 0.68$).

Type of lift	WT pre (N)	WT post (N)	WT + ST pre (N)	WT + ST post (N)
Knee extension	647 ± 224	733 ± 247‡	621 ± 224	781 ± 238‡§
Knee flexion	506 ± 200	562 ± 220‡	528 ± 190	609 ± 216‡
Leg press	972 ± 451	1052 ± 478‡	917 ± 280	1190 ± 389‡§

*Values are mean and SD.
†1RM = 1 repetition maximum.
‡Significant improvement ($p < 0.05$) over the prescore.
§WT + ST had significant improvement ($p < 0.05$) over that of WT.

Table 2:
Average 1RM for the resistance training-only (WT, *n* = 16) and resistance training plus stretching (WT + ST, *n* = 16) groups.*†

The WT knee extension 1RM increased on average 13.7%, and WT + ST had an average 26.8% increase. A 95% confidence interval for the difference between the WT and WT + ST changes was 13.1 ± 7.3%. The main effect for pre-post was significant ($F(1,30) = 124.1$, $p < 0.0001$, $\omega^2_G = 0.061$, power = 1.0). Likewise, the interaction between treatment and pre-post was significant ($F(1,30) = 10.3$, $p < 0.0032$, $\omega^2_G = 0.005$, power = 0.855). The post hoc analysis showed that this significance could be attributed to WT + ST having a larger gain than WT.

For knee flexion 1RM, WT increased on average 11.6% and WT + ST had an average 16.2% increase. A 95% confidence interval for the difference between the WT and WT + ST changes was 4.6 ± 4.6%. The main effect for pre-post was significant ($F(1,30) = 93.2$, $p < 0.0001$, $\omega^2_G = 0.027$, power = 1.0). The interaction between treatment and pre-post, however, only approached significance ($F(1,30) = 3.2$, $p < 0.0854$, $\omega^2_G = 0.001$, power = 0.281).

Leg press 1RM increased on average 8.8% for WT, whereas WT + ST experienced an average 30.8% increase. A 95% confidence interval for the difference between the WT and WT + ST changes was 22.0 ± 10.9%. The main effect for pre-post was significant ($F(1,30) = 36.7$, $p < 0.0001$, $\omega^2_G = 0.044$, power = 1.0). Likewise, the interaction between treatment and pre-post was significant ($F(1,30) = 11.0$, $p < 0.0024$, $\omega^2_G = 0.013$, power = 0.881). The post hoc analysis showed that this significance could be attributed to WT + ST having a larger gain than WT.

Discussion

The primary purpose of this study was to determine if stretching exercises have a synergistic or additive influence on the strength gains normally seen during the early phase of a standard resistance training program. The results of this study suggest that for people beginning a resistance training program, the addition of stretching activities on the non-lifting days may accelerate strength gains.

Although this study was not designed to investigate the responsible mechanism(s), it is most probable that the stretching-based strength improvements are related to morphological changes. As mentioned above, passive stretching is similar to resistance training in that it can induce changes in the musculature that associated with increases in muscle hypertrophy (for reviews see ([3,10])). Placing a muscle on stretch can induce Z-line ruptures ([13]) and increase protein synthesis ([13]) and growth factor production ([13]). The relationship between static stretching and increases in muscle hypertrophy also has support in cell and animal research. For instance, a continually applied stretch for 10 days can trigger myoblast proliferation ([7]). In addition, Stauber et al. ([28]) stretched rat soleus muscles 3 times a week for 4 weeks and found muscle mass to be increased by 13% and fiber area by 30%. Similar results were reported by Coutinho et al. ([6]) who reported a 16% increase in rat soleus fiber area by stretching the muscle for 40 minutes every 3 days for 3 weeks.

The synergistic influence of the stretching program on strength gains might also be related to increases in muscle length. Increases in length lead to increases in both contractile velocities and the forces generated at a given shortening velocity ([19]). In situ lengthening has been reported through the application of diverse mechanisms of continuous stretch such as casting a muscle in a stretched position, increasing bone length, or relocating tendon insertions (for a review see ([19])). Also, muscle lengthening results from programs of intermittent stretching performed for several days. For example, Williams ([29]) reported that 30 minutes of daily stretching was sufficient to cause an increase in the number of sarcomeres in series. Likewise, Coutinho et al. ([6]) reported a 5% increase in length and a 4% increase in serial sarcomere number after stretching for 40 minutes every 3 days for 3 weeks.

As pointed out by Sale ([26]) and Folland and Williams ([10]), many studies using a typical 8-week strength training program involving nascent lifters have shown that the strength changes are greatly associated with neural adaptations and learning. Some of these changes include improvements in motor unit recruitment, agonist activation, firing frequency, motor unit synchronization, and antagonist coactivation. Because stretching activities involve movements in that are generally opposite to movements used in a 1RM (e.g., knee flexors are stretching by doing knee extension), it is difficult to see how stretching would enhance the learning component of a 1RM test. Moreover, using electromyogram and twitch interpolation techniques, several researchers have determined that pre-event stretching causes a decrease in muscle activation ([1,2,11]). Hence, static stretch induces a neurological response that is opposite to that coinciding with resistance training. Therefore, it seems unlikely that the strength gains seen in this study have a close tie with any neural adaptations and learning.

Although the improvements in muscle strength are a desired training modification for the athletic population, the results of this study do not suggest that the addition of stretching exercises to traditional resistance exercise will enhance existing training programs. Although stretching improved the performance of sporadically active individuals, it is not known if people with more trained muscles will respond similarly to the stretching stimulus. On the other hand, improvements in muscle strength, endurance, and power can also be important to the nonathletic population. Several studies have established a link between muscular fitness and overall health or the likelihood of early death ([4,9,21]). Unfortunately, most persons who are at the lowest end of the muscular fitness continuum also have difficulty performing the usual activities found to generate improvements in muscular fitness. It is possible that these individuals as well as those who have limited access to facilities where they are able to perform traditional resistance exercises may be able to enhance their strength capabilities through participation in a regular stretching program without the need for a specialized facility.

The results of this study would suggest that the addition of stretching exercises on days where one is not participating in resistance exercise can offer some benefit in addition to regular strength training. What is not known at this time and still needs to be addressed is whether or not stretching, when added to resistance exercise on the same day in close proximity to other forms of exercise, will have an additive benefit on performance. Considering that many individuals perform stretching as part of a cool down process upon cessation of other forms of exercise, it would be interesting to discover whether or not stretching, when added to the end of a strength training workout, can enhance gains in muscular performance. Other information that is not known at this time is the dose-response relationship between chronic stretching activity and strength gains. In other words, how much stretching does it take before gains in muscular performance are realized? Recent research into the deleterious effects of preexercise stretching suggests that as little as one 30-second stretch can lead to a reduction in maximal strength in an acute sense ([31]). Could the reverse be true for chronic stretching? Or are multiple stretches per muscle group needed to see chronic gains in strength? Additional research is warranted to investigate the possible mechanisms behind stretch-induced strength gains along with the relationship between the volume and duration of stretching and muscular performance adaptations. In addition, future research should attempt to investigate the manner in which the timing of stretching in relation to other forms of exercise affects possible strength and power gains.

Practical Applications

Our results suggest that practitioners wishing to maximize strength gains in relatively untrained individuals should consider the inclusion of static stretching on their non-training days. It is possible that the addition of static stretching to more traditional resistance exercise will lead to enhanced gains in strength over participation in resistance exercise alone.

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