Acute Effect of Passive Static Stretching on Lower-Body Strength in Moderately Trained Men

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ABSTRACT

Gergley, JC. Acute effect of passive static stretching on lower-body strength in moderately trained men. J Strength Cond Res 27(4): 973–977, 2013—The purpose of this investigation was conducted to determine the acute effect of passive static stretching (PSS) of the lower-body musculature on lower-body strength in a 1 repetition maximum (1RM) squat exercise in young (18–24 years) moderately trained men (n = 17). Two supervised warm-up treatments were applied before each performance testing session using a counterbalanced design on nonconsecutive days. The first treatment consisted of an active dynamic warm-up (AD) with resistance machines (i.e., leg extension/leg flexion) and free weights (i.e., barbell squat), whereas the second treatment added PSS of the lower body plus the AD treatment. One repetition maximum was determined using the maximum barbell squat following a progressive loading protocol. Subjects were also asked to subjectively evaluate their lower-body stability during 1RM testing sessions for both the AD and PSS treatments. A significant decrease in 1RM (8.36%) and lower-body stability (22.68%) was observed after the PSS treatment. Plausible explanations for this observation may be related to a more compliant muscle tendon unit and/or altered or impaired neurologic function in the active musculature. It is also possible that strength was impaired by the PSS because of joint instability. The findings of this study suggest that intensive stretching such as lower-body PSS should be avoided before training the lower body or performing the 1RM in the squat exercise in favor of an AD dynamic warm-up using resistance training equipment in the lower-body musculature.

KEY WORDS muscle tendon unit (MTU), reflex sensitivity, neural inhibition, range of motion (ROM)

INTRODUCTION

Correct biomechanical execution of lower-body resistance training exercises in health, fitness, and sport conditioning settings requires a high level of joint flexibility (11,23). Adequate joint flexibility not only permits proper form but also allows the trainee the ability to work against resistance through a full range of motion (ROM) (11,21). This type of training allows strengthening of the trained musculature through a full ROM while also contributing to the maintenance of existing joint flexibility (11,21). The reported benefits of stretching also include a reduced chance of injury (12,13,36,38,40). Therefore, most health, fitness, and sport enthusiasts include some form of flexibility training at a point in time (i.e., before, during, or after) into their training regimens. The timing of performing stretching exercises, however, remains speculative. It is the author’s view that much of the controversy in the stretching literature can be attributed to the failure to differentiate between warm-up/stretching protocols that are typically applied before performance or training, static in nature, and held for shorter amounts of time compared with rehabilitative stretching to improve ROM that is typically performed after a performance or training session, may be static, passive, or both active or passive (i.e. proprioneuromuscular facilitation), and stretches are held for longer durations. This consideration is imperative at making accurate interpretations from the literature concerning warm-up/stretching protocols.

Static stretching exercises are commonly used during the warm-up phase before practice or competition in sport activities (3,21). As referenced above, the general belief that increased ROM will translate into reduced incidence of injury (38,40,45). Interestingly, however, a recent investigation provided evidence that the acute effects of stretching may be harmful because of joint instability (30), whereas another study reported a higher incidence of injury in subjects with very high or low levels of flexibility (9).

From a performance perspective, several contemporary studies have examined the effects of various stretching protocols and reported decreased maximal isometric strength (2,4,15,31), decreased isometric peak torque (34), decreased dynamic strength (25,31,32,34,47), decreased
muscle endurance (16), decreased eccentric torque (10), decreased sprint performance (14, 33, 46), decreased golf performance (17–20), decreased cycling sprint performance (44), and decreased jump performance (6, 8, 32, 35). Thus, it may be detrimental to stretch before training, practice, or competition. These findings have implication for closed chain resistance training exercises such as the squat because high levels of sequenced force production from the foot into the legs, hips, and back are necessary to perform a maximal lift (11, 21, 23). Any acute changes in these joints because of passive static stretching (PSS) would impact movement and therefore performance in the 1 repetition maximum (1RM) squat.

The mechanisms responsible for the stretch-induced decreased force production remain speculative (4, 15). Plausible explanations include a more compliant muscle tendon unit (MTU) (8, 25, 32, 34), decreased neuromuscular reflex sensitivity (8, 25, 31, 34), neural inhibition (1, 4, 15, 43), and tissue damage because of creatine kinase associated with PSS (41). Localized impairment has also been explained because of joint angle (31), contraction types (8, 47), or contraction velocities (34).

Nevertheless, the performance of stretching exercises before bouts of training or competition continues despite the lack of evidence supporting the relationship between prestretching warm-up regimens on 1RM squat. Therefore, this study was designed to answer the question of whether intensive PSS before performing a 1RM in the squat exercise is detrimental to performance.

**METHODS**

**Experimental Approach to the Problem**

Two different warm-up treatments were applied before each performance testing session using a counterbalanced design on nonconsecutive days. The first treatment consisted of an active dynamic warm-up (AD) with variable resistance training machines (i.e., leg extension/leg flexion) and free weights (i.e., barbell squat), whereas the second treatment added PSS of the lower-body musculature before the AD warm-up treatment. The addition of the PSS treatment was different from the subjects’ normal warm-up procedure, which more closely modeled the AD warm-up. One repetition maximum was determined using the maximum barbell squat after a progressive loading protocol. Subjects were also asked to subjectively rate their lower-body stability/balance during the performance of the 1RM squat exercise by responding to the question, “How stable and balanced did you feel during that lift?” This measurement, although not empirical, is appropriate for moderately trained fitness trainees. Any impairment attributable to PSS would manifest itself in this measure.

**Subjects**

The study subjects (n = 17) were young moderately trained men who regularly participate in resistance training for the lower-body musculature. This type of training incorporates multiple sets at submaximal loads in the 10RM repetition range with the goal of gaining both strength and skeletal muscle hypertrophy. Before testing, the subjects were provided with a complete written and oral explanation of the study. After the explanation, each subject was asked to sign an informed consent document that was approved by the Stephen F. Austin State University’s Institutional Review Board. Table 1 outlines subject demographics.

**Procedures**

The application of warm-up treatments to the study subjects incorporated a counterbalanced design. Subjects were normally hydrated and rested (i.e., 48 hours since last bout of exercise) before testing. The AD warm-up treatment consisted of 2 sets of 10 submaximal repetitions in the leg extension, leg flexion, and squat exercises. Table 2 outlines AD warm-up regimen. The PSS warm-up treatment included PSS of the lower body using 3 sets of 10-second stretches for the quadriceps, hamstring, calf, abdominal,
Comparison of warm-up treatments on 1RM squat and balance/stability.*

<table>
<thead>
<tr>
<th>Measure</th>
<th>AD</th>
<th>PSS</th>
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<tbody>
<tr>
<td>1RM squat (kg)</td>
<td>124.81</td>
<td>112.95</td>
</tr>
<tr>
<td>Balance/stability (scale of 1–10)</td>
<td>8.82</td>
<td>6.82</td>
</tr>
</tbody>
</table>

*AD = active dynamic warm-up; PSS = passive static stretching; 1RM = 1 repetition maximum.

A significant (p < 0.05) difference was observed between warm-up treatment means.

The present investigation supports previous findings reporting decreased force production or performance following various stretching modalities. The nature of this performance decrement after stretching may be related to the MTU (8,25,32,34). Rosenbaum and Hennig (37) and Kubo et al. (26) suggest that this decrease in force production is a result of slack in the tendon after stretching exercises. Therefore, less force can be applied to the bone, which results in a correspondingly lower force production for movement and attenuated athletic performance. Cornwall et al. (8) report that observed decreases in performance are a result of the inability of MTU to store elastic energy. Interestingly, the amount of elastic energy that can be stored in the MTU is a function of the units' stiffness (22,27,39). Other authors have demonstrated that tendon compliance and muscle contraction can occur simultaneously in both animals (42) and humans (7). Collectively, these investigations support the theory that a more compliant MTU results in a greater time interval until external force is expressed in powerful kinesthetic movements.

There may also be a neuromuscular explanation for decreased performance after stretching. Avela et al. (2) measured reflex sensitivity of skeletal muscles after repeated PSS. The results showed a significant decrease in reflex activity and force production. Kokkonen et al. (25) attributed these observations to a reduction in the sensitivity of the muscle spindles and theorized that repeated stretching also reduced the number of motor units available because of autogenic inhibition. Kurudus et al. (24) hypothesized that a decrease in vertical jump performance was associated with decrease in neural transmission because they found no change in the kinematics of the movement. Additional investigations provided evidence that reduced force production and performance were attributable to acute neural inhibition from passive stretching and consequently reduced the neural drive to the muscle (1,22,28).

In the present study, significant decrease was observed in both the 1RM squat and the subjects’ perception of balance/stability during this exercise. There are several explanations that apply to these performance observations. First, it is plausible that the skeletal muscles were normally and sufficiently innervated by the central nervous system, but less muscular torque was applied to the skeleton because of a more compliant MTU. Second, altered neurologic activity may have caused the skeletal muscles to fire without synchronization or adequate action potential, thus reducing force production. Moreover, altered neurologic activity
may have also impacted proprioception evidenced by the observed decrease in perception of balance/stability. A final explanation is that both (i.e., dual effect) the transfer of force from the skeletal muscles to the skeleton and the neurologic system were temporarily impaired because of the PSS treatment. The author supports the later explanation because both force production and neuromuscular coordination are necessary for the IRM squat exercise (11,21,23). That is, decreased force production and neuromuscular coordination are a result of a dual effect caused by temporary slack in the MTU and an altered neurologic state. Nevertheless, the question of whether these reductions in performance are attributable primarily or collectively to a more compliant MTU, reduced neurologic sensitivity of the muscle spindles, or neural inhibition remains speculative and requires further study.

This inquiry was specific to performance in the IRM squat exercise. The squat exercise is a closed kinetic chain exercise moving in a vertical plane that categorizes it a unique skill. Thus, other resistance exercises may not be comparable to the squat exercise. Adequate ROM in the legs, hips, and back are paramount for the squat to be learned, improved, and performed (11,21,23). Other resistance exercises also require specific expressions of flexibility. Therefore, each exercise should be evaluated for its specific ROM requirements for optimal performance and the consideration of preventing injury.

The scientific literature addressing warm-up and stretching routines for specific resistance training or sport movements is scarce at best. Fowles et al. (15) reported impaired isometric force for up to 1 hour after passive stretching. Rosenbaum and Hennig (37) found a decrease in the rate of force development after static stretching yet force development remained to pretest values after a 10-minute run. Gergley (17–20) reported impaired golf performance in both acute and latent phases after PSS that included a recovery period. In the present study, it is possible that the effect of the PSS treatment would “wear off” at some point after PSS, but this to the author’s knowledge has not been studied using the IRM squat exercise and should be studied in future investigations.

**Practical Applications**

The design of warm-up routines for resistance training movements involving high-intensity power output, biomechanical efficiency, and coordination such as the squat exercise should minimize the amount of stretching before training or attempts at maximal lift. It is recommended that trainees employ an AD consisting of submaximal sets of resistance exercises activating the skeletal muscles involved in the maximum lift. Therefore, coaches and strength and conditioning professionals should continue to use static stretching for short durations and move progressively toward an AD. If the trainee has poor form because of lack of flexibility, intensive flexibility training should be performed after a conditioning session or final maximal lift attempt.

**References**


