Acute Effects of Contract-Relax versus Static Stretching on Strength Loss and the Length-Tension Relationship

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ABSTRACT

Introduction: It is known that static stretching (SS) and contract-relax stretching (CRS) results in stretch-induced strength loss. After SS strength loss occurs at short, but not long muscle lengths, which is consistent with a shift in the length-tension relationship. Since CRS places additional stretch on the tendon we hypothesized that there would be a greater muscle length-specific effect of CRS versus SS. Purpose: To determine the acute effects of SS versus CRS on strength loss and the length-tension relationship. Methods: 20 healthy people volunteered. Isometric hamstring strength was measured at 4 different knee joint angles (90°, 70°, 50° and 30° of flexion) before and after SS and CRS. One leg received SS and the contralateral received CRS, with side (right vs. left) and test order (SS vs. CRS) alternated using a Latin square randomized order. Stretching and strength testing took place in a dynamometer chair; back rest at 90°, test thigh elevated 50° from horizontal. SS was performed as 6 sets of 1 min with leg extended to maximal stretch tolerance. CRS was initiated with a 10 s submaximal (~70%) isometric contraction performed at the point of maximal stretch tolerance and then held at this joint angle for a further 50 s. Effect of stretch technique on strength loss and the length-tension relationship was assessed using repeated measures ANOVA. Results: SS resulted in significant strength loss (p=0.025), which was more apparent at short versus long muscle length (Stretching*angle p<0.0001; 11.7% at 90° p<0.01; 5.6% at 70° ns; 1.3% at 50° ns; -3.7% at 30° ns). CRS also resulted in significant strength loss (p<0.0001), which was also more apparent at short versus long muscle length (stretching*angle p<0.0001; 17.7% at 90°, 13.4% at 70°, 11.4% at 50°, all p<0.01, 4.3% at 30° ns). Stretch-induced strength loss (averaged across all angles) was greater (p=0.015) after CRS (11.7%) versus SS (3.7%). The muscle length effect on strength loss (length-tension relationship) was not different between CRS and SS (stretching*angle*stretching technique p=0.43). Conclusion: Both SS and CRS resulted in stretch-induced strength loss, which was most apparent at short muscle lengths. Contrary to the hypothesis, CRS did not result in a greater shift in the length-tension relationship, and in fact, resulted in greater overall strength loss compared with SS.

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INTRODUCTION

Stretch-induced strength loss has been shown to be most apparent at short muscle lengths (1-4). This effect is thought to indicate a rightward shift in the length-tension curve with greater sarcomere shortening at a given muscle length during maximum voluntary contractions after stretching (3). Such an effect implies that stretching increases tendon and aponeurosis compliance, thereby, allowing greater sarcomere shortening during isometric contractions.

To date the length-dependent effect on the stretch-induced strength loss has only been examined in response to static stretching (1-4). Proprioceptive neuromuscular facilitation is a popular stretching method within rehabilitation, especially contract-relax stretching of the stretched muscle (5-6). Contract-relax stretching involves a short-duration isometric contraction of the target muscle, while in a stretched position. Upon relaxation the stretch is either maintained or increased to a greater range of motion for a certain period of time. Compared to static stretching, contract-relax stretching should provide greater tension on the tendon and aponeurosis as a consequence of the isometric contraction. Therefore, the contract-relax stretching technique has the potential to increase tendon and aponeurosis compliance more than static stretching. Such an effect would theoretically allow greater sarcomere shortening during isometric contractions compared with contractions following a static stretching intervention. Thus contract-relax stretching may result in a greater rightward shift in the length-tension curve than static stretching.

Purpose

The purpose of this study was to determine the acute effects of static versus contract-relax stretching of the hamstring muscle on strength and the length-tension relationship. It was hypothesized that contract-relax stretching would have a greater effect on the length-tension relationship.

METHODS

Isometric hamstring strength at 90°, 70°, 50°, 30° of knee flexion was assessed before and after one of the two stretching interventions, static and contract-relax stretching. Five minutes after completed testing of one leg, the protocol was repeated on the contralateral leg with the other stretching intervention. Test order for the stretching intervention (static stretching or contract-relax stretching) and leg (right or left) was randomized using a Latin Square crossover design. 20 healthy subjects were included (age 31.1±8.2 yr)

Setup

All strength testing and stretching were performed on an isokinetic dynamometer (Biodex System 2, Shirley, NY, USA). See figure 1.

Flexibility

Hamstring flexibility was assessed prior to strength testing and stretching. While seated in the dynamometer in the test position, maximum range of motion (ROM) was assessed by passively extending the knee joint from 100˚ of knee flexion to maximal stretch tolerance. Subjects were asked to grade their stretch discomfort on a Visual Analog Scale (VAS) from 0-10, where 0='no stretch discomfort at all' and 10='the maximal imaginable stretch discomfort'.

Figure 1: All strength testing and stretching were performed on an isokinetic dynamometer. The subjects were seated with seat back at 90° to the horizontal, test thigh flexed 45° above the horizontal while the opposite thigh rested horizontally on the chair.

METHODS - *Continued*

Isometric knee flexion strength

Maximum isometric knee flexion contractions were measured at 90°, 70°, 50°, 30° of knee flexion before (pre) and after (post) stretching. Subjects were verbally encouraged to give maximal efforts during two 4-s isometric knee flexion contractions at each joint angle. At each angle the initial torque prior to isometric contraction was recorded, and subsequently subtracted from the torque during maximum contractions. This torque represented the combination of limb mass and passive resistance to stretch. The corrected torque value for maximum contractions represents the contractile force production.

Stretching procedures

Static stretching: the knee was passively extended from start position (100˚) to subject's maximum ROM and held at that angle for 60 s with 6 repetitions and 15 s between stretches.

Contract-relax stretching: the knee was passively extended to subject's maximum ROM, and subjects were then asked to do a 10 s submaximal isometric knee flexion contraction (70% of maximal effort), followed by 50 s with the leg maintained in the stretched position with 6 repetitions and 15 s between stretches.

Data processing and statistic analysis

Differences in stretching intensity (VAS score), maximum ROM and percent decline in resistance to stretch were compared between static and contract-relax stretching using paired t-tests. The muscle length-dependent effect of stretch technique on the stretch-induced strength loss (absolute torque in N·m) was assessed using a Stretch Technique (Static vs. Contract-Relax) by Time (pre vs. post stretching) by Angle (90°, 70°, 50°, 30°) repeated measures analysis of variance (ANOVA). Relative strength loss (percent decline in torque from pre to post stretching) was compared between stretch techniques using a Stretch Technique by Angle repeated measures ANOVA. The relative shift in the angle-torque relationship (length-tension curve) was assessed by first expressing knee flexion torque at each joint angle as a percentage of the torque at the angle of peak torque. Then a Stretch Technique by Time by Angle repeated measures ANOVA was performed on the relative torque values. By expressing torque relative to the angle of peak torque, any shift in the length-tension curve can be assessed independently of the stretch-induced strength loss. Effect of Stretch Technique on the stretch-induced strength loss was assessed using a Stretch Technique by Time repeated measures ANOVA. Mean±SD is reported in the text and table, and mean±SE is displayed in the figures.

RESULTS

Stretching effects

Stretch discomfort (VAS) and decline in passive resistance to stretch at maximum ROM after stretching were similar for static versus contract-relax stretching (Table 1). Max ROM was slightly greater on the leg that subsequently underwent contract-relax stretching (Table 1). Torque during the 10 s contraction of the contract-relax stretching averaged 74.5±26.2% of MVC.

Table 1	Contract-relax Stretching	Static Stretching	P-value
Maximum ROM	19±7.8°	16.9±7.8°	0.04
VAS at maximum ROM	7.3±1.2	7.3±1.3	0.60
Decrease in passive tension	9.7±4.7%	10.7±7.7%	0.59

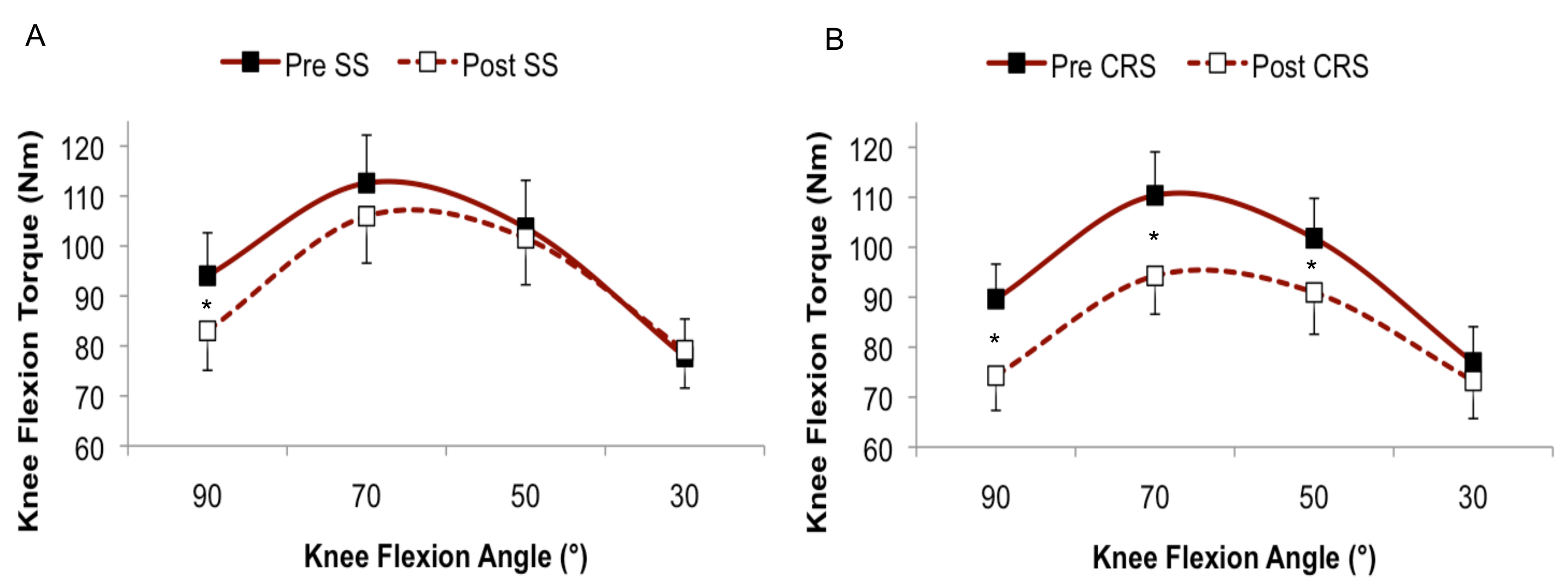

Figure 2: Isometric knee flexion torque before (pre) and after (post) static stretching (SS) (A) and contract-relax stretching (CRS) (B). Torque was measured at four different knee flexion angles from short (90°) to long (30°) muscle length. There was a significant stretch-induced strength loss after both static stretching ($P = 0.025$) and contract-relax stretching ($P < 0.0001$), which for both stretching interventions were most apparent at short versus long muscle length (Angle by Stretching $P < 0.0001$). Mean±SE displayed. * $P < 0.01$

RESULTS - *Continued*

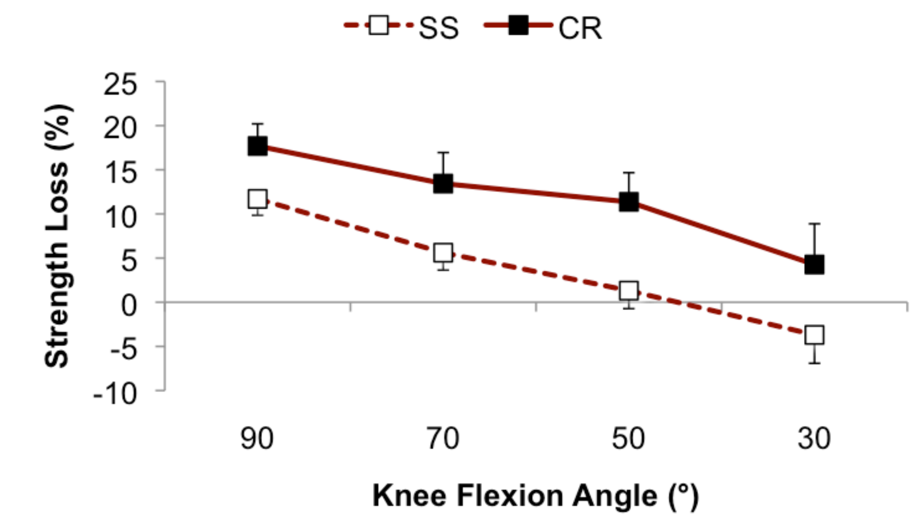

Figure 3: The stretch-induced strength loss after static stretching (SS) and contract relax stretching (CRS) at four knee flexion angles. Strength loss (averaged across all angles) was greater (Effect of Stretching Technique $P = 0.032$) after contract-relax stretching (11.7%) versus static stretching (3.7%). Strength loss was progressively less at longer muscle lengths (Angle effect $P < 0.0001$) with no difference in Angle effect between Stretch Techniques (Stretching Technique by Angle $P = 0.85$). Mean±SE displayed.

Stretch-induced strength loss

Static stretching resulted in a significant strength loss (P=0.025),which was more apparent at short versus long muscle length (Time by Angle $P < 0.0001$; Fig. 1a). Contract-relax stretching also resulted in significant strength loss ($P < 0.0001$), which was also more apparent at short versus long muscle length (Time by Angle $P < 0.0001$) (Fig. 1b). The average strength loss across all knee flexion angles was greater after contract-relax stretching (11.7%) versus static stretching (3.7%) ($P = 0.032$) (Fig 3). The muscle length effect on strength loss (angle-torque relationship) was not different between contract-relax stretching and static stretching (Time by Angle by Stretch Technique $P = 0.88$) (Fig. 4).

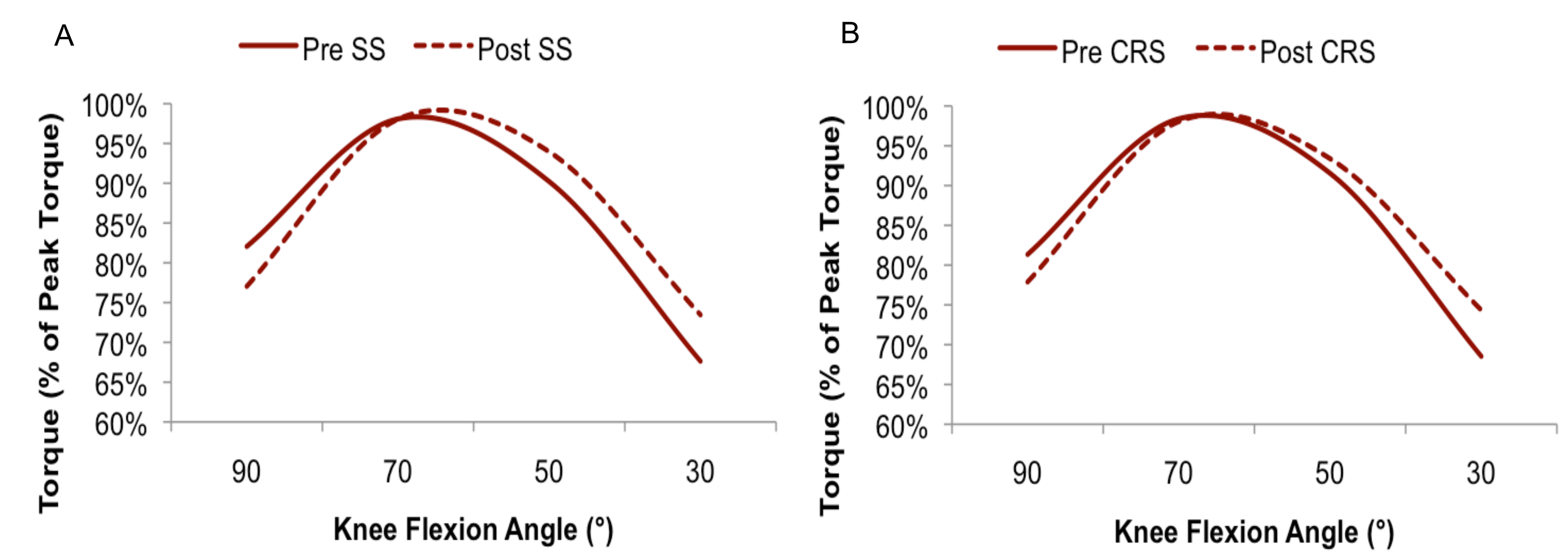

Figure 4: The angle-torque relationship for maximum isometric knee flexion contractions expressed relative to torque at the angle of peak torque before (pre) and after (post) static stretching (SS) (A) and contract-relax stretching (CRS) (B). Time by Angle ($P < 0.0001$) indicates a rightward shift in the angle-torque relationship. This shift was not different between stretch techniques (Time by Angle by Stretch Technique $P = 0.88$).

CONCLUSION

Stretch-induced strength loss after static stretching and contract-relax stretching was most apparent at short muscle lengths, however the average strength loss across all muscle lengths was greater after contract-relax stretching. Contrary to the hypothesis, there was no difference in the stretch-induced shift in the length-tension relationship between static and contract-relax stretching.

Practical Relevance

Since contract-relax stretching resulted in greater strength loss than static stretching without any greater benefit in terms of alteration in the length-tension relationship, it would be appropriate to use static hamstring stretching in preference to contract-relax stretching.

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