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Standing and Supine Hamstring Stretching Are Equally Effective

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Objective: To evaluate the relative effectiveness of standing and supine hamstring stretching in increasing hamstring flexibility as measured by increasing range of motion at the knee.

Design and Setting: The trial was randomized, and the setting was local academic physical therapy and physical therapist assistant programs.

Subjects: Twenty-nine healthy subjects who exhibited limited hamstring muscle flexibility bilaterally (22 women, 7 men, 25.9 ± 6.13 years of age) volunteered to participate in this study. Subjects were randomly assigned a different stretch for each leg. Each leg was stretched 3 days per week for 3 weeks (3 × 30 seconds). Stretching sessions were supervised.

Measurements: We measured supine active knee extension. Measurements were taken before and after the 3-week stretching phase by the same investigator, who was blind to limb assignment. We calculated a 2-way mixed-design analysis of variance and Tukey Honestly Significant Difference post hoc tests to analyze data. An independent *t* test was performed to determine whether the change scores in the stretching groups differed by sex.

Results: Prestretching and poststretching measurements were significantly different for both the standing and supine stretch (<0.05). No significant difference ($P > .05$) in change score existed between the 2 stretches or between the sexes.

Conclusions: The standing and supine hamstring stretches were comparably effective in improving flexibility.

Key Words: flexibility, knee

The effects of stretching on flexibility have been well documented in the literature.[1–3] Zachezewski[4] defined muscle flexibility as "the ability of a muscle to lengthen, allowing one joint (or more than one joint in a series) to move through a range of motion." When a muscle loses or lacks flexibility, its ability to deform is decreased, resulting in decreased range of motion (ROM) around a joint. Restricted flexibility can be related to a number of variables, including joint capsule or other soft tissue restrictions.

Improving flexibility is postulated to prevent athletic injuries; however, data to support this suggestion are limited. A review of the literature by Smith[5] revealed that general stretching exercises can benefit athletes and social exercisers in numerous ways, including improving flexibility, reducing the incidence of injury, and enhancing athletic performance. However, the literature review was narrative in nature, and the methodologic quality of the studies reviewed was not addressed. Poor hamstring flexibility has often been associated with injuries to the low back and lower extremities.[6–8] Jonhagen et al[7] revealed a statistically significant difference in hamstring flexibility between injured and uninjured sprinters, but the authors noted that it was unclear whether the tight hamstrings caused the injury or were a result of the injury. Hartig and Henderson[6] demonstrated that a hamstring stretching regimen significantly increased flexibility and decreased the incidence of lower extremity injuries in a group of military basic trainees as compared with a control group. Clearly, further methodologically sound studies are necessary to fully understand the role of flexibility in sports performance and injury. Regardless of this paucity of evidence, stretching is widely accepted and recommended by coaches, athletes, athletic trainers, and physical therapists.[5,9–11]

A number of researchers[1,2,11–15] have focused on the technique, frequency, and duration of stretching necessary to achieve the greatest flexibility gains. Among the different stretching methods are ballistic, static, and proprioceptive neuromuscular facilitation techniques.[12] Various authors[2,11,12,14,15] have demonstrated the effectiveness of all 3 methods in increasing knee-extension ROM, an indirect measure of hamstring flexibility. Further, numerous investigators have demonstrated that no significant change in hamstring flexibility occurs between pretest and posttest measurements in control groups (no stretching).[1,2,11,12,16]

The standing hamstring stretch has been validated as an effective means of improving hamstring flexibility.[2,11,12,17–19] This stretch requires the individual to stand on one leg while placing the stretching leg forward on an elevated surface and simultaneously bending forward at the waist (without flexing the spine) to achieve an adequate stretch. However, the effectiveness of this stretch is significantly related to pelvic positioning[14]; therefore, proper performance is imperative. Sullivan et al[14] demonstrated that stretching in a position of anterior pelvic tilt results in a significantly greater increase in hamstring flexibility. Others have also noted the importance of pelvic position in hamstring flexibility measurement.[11,12]

Although static stretching of the hamstrings in the standing position has been investigated,[2,6,9,11,12,14,15,19] the supine static stretching technique commonly used in the clinical setting does not appear to have been investigated. The supine hamstring stretch is performed by lying supine in a doorway or at a corner, and placing the stretching leg on the wall while the contralateral leg rests flat on the floor. This stretch is also performed as a partner stretch in group athletic settings. It appears to be easier to teach and to require less supervision than the standing method, thereby making it a technique patients and athletes can successfully perform independently. Therefore, our purpose was to evaluate the relative effectiveness of standing and supine hamstring stretching in increasing hamstring flexibility, as measured by increasing ROM at the knee.

METHODS

Subjects

Thirty-nine subjects were initially recruited from local physical therapy and physical therapist assistant academic programs. All subjects signed informed consent forms approved by the Institutional Review Board at the University of New Hampshire, Durham, NH. Exclusion criteria included any lower extremity or back injury within the last year that required medical attention and any known condition that might affect flexibility. Only subjects who, in both limbs, lacked at least 25° of active knee extension with the hip flexed to 90° were included in the study. One of the original 39 subjects was excluded secondary to the presence of a central nervous system disorder known to affect flexibility, and 9 subjects failed to demonstrate restricted hamstring flexibility, leaving 29 healthy subjects (22 women, 7 men, 58 legs). Ages ranged from 18 to 43 years (mean = 25.9 ± 6.13 years). Subjects agreed to maintain their current activity regimen, including exercise levels, throughout the study.

Equipment

All measures of active knee extension were performed with a standard 18-in (45.72-cm) goniometer. A plastic ruler of the same width was attached to each end of the goniometer to add 6 in (15.24 cm) to the length of each arm. We did this to help maintain the distal ends of the goniometer in proper alignment with the bony landmarks and to increase the ease of measurement.

To ensure accuracy of measurement, the examination table used to collect data was modified in a manner similar to that used by Gajdosik et al.[20–23] Two vertical metal rods secured to C-clamps were attached to both sides of the examination table on opposite sides, at equal distance from the head of the table. Attachments were perpendicular to the table. Once the attachments were firmly secured, a piece of 1.5-in (3.81-cm) athletic tape was attached between the vertical uprights 1 ft (30.48 cm) above the table surface.

Procedure

We used a measurement of supine active knee extension as described by Gajdosik et al[21] as an indicator of hamstring flexibility. Subjects wore shorts to allow easy access to bony landmarks. Subjects were instructed to assume a supine position on the examination table and, with the hip and knee flexed to 90°, we made marks over the lateral malleolus, lateral femoral condyle, and greater trochanter of the femur. Subjects were then instructed to position themselves so that when the hip was at 90° of flexion, verified with goniometric measurements, the thigh was touching the nonadherent side of the tape. This provided both visual and tactile clues for subjects to consciously maintain 90° of flexion while performing active knee extension. One investigator (R.L.S.) also maintained hand contact with the thigh anteriorly and posteriorly to monitor hip angle. Each subject's pelvis was secured to the table with a strap over the anterior superior iliac spines. Another strap was placed over the midthigh of the contralateral limb to secure it to the table. While maintaining 90° of hip flexion, subjects were asked to actively extend the knee as far as possible. Once they could no longer extend the knee, or the hip began to lose the 90° angle as determined by the investigator, the angle of knee flexion was then obtained by another investigator (K.D.H.), who was blind to leg assignment. All measurements were performed in identical fashion both before and after the stretching phase, with no warm-up or stretching before measurement (Figure 1).

Figure 1. In 90° of hip flexion, subjects actively extended the knee until they could no longer extend and maintain contact with the tape. This position was monitored closely by the examiner on the right, while the other examiner obtained the knee measurement.

Thirty-eight subjects participated in the initial measurement of ROM. After the prestudy measurement, the 9 subjects (18 legs) who did not meet our restricted ROM inclusion criteria agreed to maintain their current flexibility and exercise regimens and allowed us to take a second set of measurements (3 weeks after the initial measurements) so we could assess intrarater reliability of the measurement techniques. Although 3 weeks may be longer than expected between the first and second measurements for determining intrarater reliability analysis, Bandy et al[2] compared their control group's pretest and posttest scores after 6 weeks.

On the day of their prestretching measurement, subjects were introduced to the stretches in a one-on-one session with an investigator. This investigator followed a script to ensure consistency. Each subject was also given a handout with a detailed description of both stretches and pictures of the stretches being performed in the appropriate manner. We used a computer-generated number table to randomly assign a stretching method to each leg; all subjects did both stretches. All subjects were instructed to push each stretch until they felt a comfortable stretching sensation in their hamstrings. For the standing stretch, subjects were instructed to face the table with

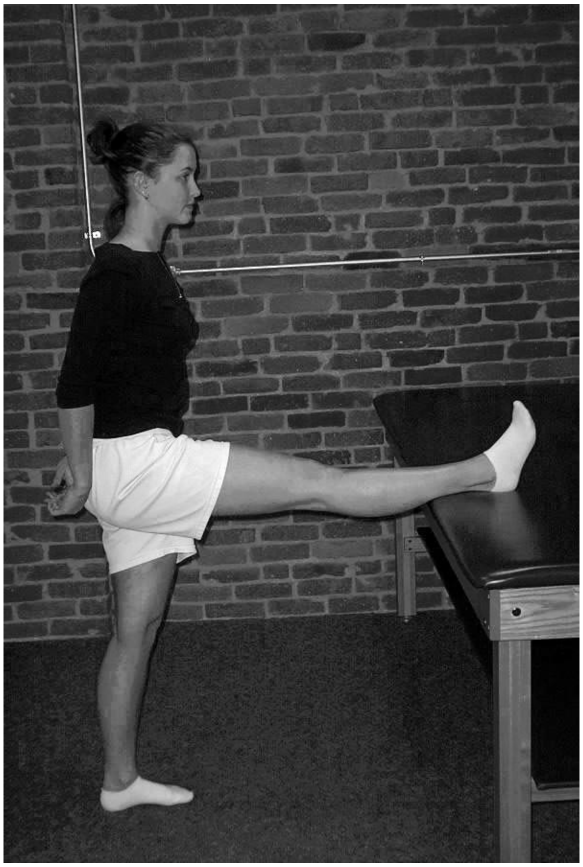

Figure 2. For the standing stretch, subjects faced the table with their hips square, maintained an erect torso, held their arms on their hips, looked straight ahead, and flexed forward at the waist until a hamstring stretch was perceived.

Figure 3. For the supine stretch, subjects lay supine on the floor with the stretching leg on the wall and the other leg flat on the floor, with distance from the wall adjusted so a hamstring stretch was perceived.

their hips square, maintain an erect torso, hold their arms out or on their hips, look straight ahead, and flex forward at the waist until a hamstring stretch was perceived (Figure 2). Subjects were cautioned against, and monitored to prevent, posteriorly tilting the pelvis or rounding the trunk forward, or both. Instructions for the supine stretch included lying supine on the floor with the stretching leg on the wall and the other leg flat on the floor, with the distance from the wall adjusted so that they felt a hamstring stretch (Figure 3). When the position no longer caused a stretching sensation to the hamstring, subjects were instructed to slide their bodies closer to the wall or to increase their trunk flexion for supine or standing stretching, respectively.

The stretching regimen was performed in a group setting 3 times per week, at the same time of day, for 3 weeks. Each stretching session consisted of performing the assigned stretches to each leg 3 times for 30 seconds each. Subjects rested for 15 seconds between stretches and during the rest period removed their leg from the wall or the table. Warm-up did not occur before stretching sessions. Also, subjects wore shorts and removed their shoes for each session. Stretching sessions were supervised by one of the investigators or by the subjects' physical therapy or physical therapy assistant instructor to ensure that stretches were being performed in a proper and consistent manner. An attendance sheet was used at each school, and subjects signed in for each stretching session to ensure compliance. If a subject missed a stretching session, he or she stretched later or the next day. A priori, it was determined that any subject who missed 2 stretching sessions would be excluded.

After 3 weeks of stretching, poststudy measurements were taken in the same manner as the prestretching measurements. This session took place within 2 days of the last stretching session. The 2 investigators taking the measurements did not review the previous flexibility measurement, thereby limiting bias in taking the new measurement.

Statistical Analysis

Our analysis of these data included descriptive analysis; intraclass correlation coefficient (ICC); and analysis of means via a 2-way mixed analysis of variance, post hoc tests, and independent *t* test. The ICC testing was performed to determine the reliability of ROM measurements using data from the 9 subjects not included in the main study. Means were analyzed to test our null hypothesis and to answer a secondary question about the effect of sex on the stretching outcome. All data analysis was performed using SPSS (version 10.1; SPSS Inc, Chicago, IL).

The means and standard deviations were calculated for all levels of the dependent variables for both groups. The 2-way mixed analysis-of-variance design was employed to examine the effects of the independent variable (stretching technique) as a function of group (between-subjects factor) and time (pretest to posttest, within-subjects factor). The primary dependent variable of interest in this study was the change in hamstring

Knee-Extension Measurements*

	Supine			Standing		
	Extension (°)†	95% Confidence Interval	Standard error of measurement‡	Extension (°)†	95% Confidence Interval	Standard error of measurement‡
Pretest	139.5 ± 9.68			138.3 ± 10.68		
Posttest	147.5 ± 8.25			147.4 ± 10.28		
Change	8.1 ± 8.4	5.4–10.8	2.7	9.4 ± 9.7	3.4–15.3	2.9

*Straight = 180°.
†mean ± SD.
‡SEM = $S_x(\sqrt{1-r_{xx}})$ where S_x is standard deviation and r_{xx} is reliability coefficient.[24]

flexibility, as measured by knee-extension ROM, between the prestretching and poststretching measurements. If significant effects were found, post hoc analysis was performed with the Tukey Honestly Significant Difference test to identify which group means differed. Results were considered significant at an alpha level of 0.05. In addition, we calculated an independent *t* test to determine whether the change scores (pretest subtracted from posttest knee extension) in the stretching groups differed by sex.

RESULTS

No subjects were lost due to missed stretching sessions, but 1 subject dropped out of the study after 1½ weeks citing personal reasons. The randomization placed 17 right legs (12 left) in the standing group and 12 right legs (17 left) in the supine group. In the ICC analysis, the mean value for degrees of knee extension was 159.2° (SD = 5.91) for the pretest measurements and 159.8° (SD = 7.54) for the posttest measurements. The ICC (3,1) value for intrarater reliability was 0.899.

The Table presents the mean values and SDs for prestretching and poststretching knee-extension measurements, change scores, standard error of measurement, and 95% confidence intervals for both the supine and standing stretching groups. The 2-way mixed-design analysis of variance revealed a significant main effect occurred in the within-group factor, time ($F_{1,56} = 53.5$, $P < .05$), but no statistical difference was recognized between groups ($F_{1,56} = .305$, $P = .585$). No significant interaction was noted ($F_{1,56} = 287$, $P = .59$). Post hoc analysis using the Tukey Honestly Significant Difference test revealed a significant difference ($P < .05$) between pretest and posttest measurements for both the supine and standing groups but no significant difference between the groups for either the pretest or posttest measurements. The effect size was 0.14, and the observed power was 0.88. An independent *t* test did not reveal any significant difference in change scores ($t = .367$, $P = .715$) between the sexes.

DISCUSSION

Although the standing hamstring stretch appears to be more commonly used, our results demonstrate that the supine stretch is comparably effective. Improvements in flexibility in our study are comparable with the results of Bandy et al.[2,11,12] The gains experienced by the subjects in our study were 9.4° for the standing hamstring stretch and 8.1° for the supine stretch.

No general consensus is apparent regarding the appropriate time frame for a stretching program. Time frames ranging from 2 weeks[14] to 8 weeks[1] of stretching have been used in published studies. The subjects in our study stretched 3 times a week for 3 weeks, which is within the range of duration and frequency studied by others.[1,2,11,12,22] In one study[12] on the effects of time and frequency during static stretching on flexibility of the hamstring muscles, after subjects stretched 3 times for 30 seconds, 5 days a week for 6 weeks, the mean gain was 10.1°. In other studies,[2,11] stretching for 30 seconds once per day, 5 days a week for 6 weeks, the subjects gained 12.5° and 11.42° of knee extension, respectively. Although our ROM gains were slightly lower, they were similar to studies with longer stretching regimens. This suggests that in only 3 weeks, people can make ROM gains similar to those gained over longer periods. However, how long the flexibility improvements will persist is uncertain.

The supine measurement of knee extension, both passively[2,11,12] and actively,[20,21] has been used by clinicians and researchers as an indirect indication of hamstring flexibility. In this study, we used methods similar to those of other studies,[14,20–22] and our high intratester reliability ($r = .899$) with the active knee-extension test is comparable with the findings of Gajdosik et al.[20,21]

In this study, pelvic position was intentionally controlled by instruction and supervision during the standing hamstring stretch. For the supine stretch, the pelvic position was intentionally not controlled. This allowed comparison of realistic (ie, self-selected) pelvic positioning in the supine stretch with the most effective standing stretch technique. Our results suggest that ''casual'' supine hamstring stretching was as effective as the rigidly controlled standing stretching. For this reason, it may be preferable to use the supine method in unsupervised settings, such as home exercise programs or with athletes. Further, supine stretching may better isolate the hamstrings, allow improved relaxation, and, in general, be safer and more comfortable for people with a history of low back pain.

This study had some limitations. First, the study group was selected from local physical therapy and physical therapy assistant programs, which may have created a selection bias. Also, the sex distribution was not equal. An interesting sex-related finding was that 4 of 11 men (36%) but only 5 of 27 (19%) women were too flexible to participate based on our inclusion criteria. The reader must carefully determine the appropriateness of generalizing these results to specific populations. Further, we did not employ a warm-up activity, which might have increased overall ROM gains. Also, we had no direct control over subjects' activities preceding the pretest or posttest measurement sessions, although we did request that subjects maintain their daily activities for the duration of the experiment. Finally, our lack of a control group might be considered a limitation; however, based on the existing literature,[1,2,11,12,16] we are quite confident that a control group would have experienced no change in available motion during this 3-week period.

CONCLUSIONS

Our results suggest that both standing and supine hamstring stretches are comparably effective in improving flexibility. We found no significant difference between the standing and supine hamstring stretches. With proper instruction and supervision, both stretches can be effective and may be used interchangeably. However, because the supine stretch does not require specific pelvic positioning and, therefore, requires less instruction and supervision, it may be more effective for independent programs.

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