Comparison of Stretching with Ice, Stretching with Heat, or Stretching Alone on Hamstring Flexibility

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Objective: To investigate the efficacy of stretching with ice for increasing hamstring flexibility.

Design and Setting: Supine hamstring flexibility was measured before and after subjects accomplished a 20-minute hamstring stretching routine. Two groups of eight subjects accomplished the routine using one of two modalities. A control group (n = 8) accomplished the routine without a modality. The measurements were compared.

Subjects: Twenty-four male collegiate baseball players.

Measurements: Heat or ice applied to the hamstring.

Results: We found differences in the responses among subject groups. Supine hamstring flexibility after stretching with ice was greater than both stretching with heat and stretching alone. Scores after stretching with heat and stretching alone were not different.

Conclusions: The results of our investigation suggest that the application of ice may provide enhanced short-term improvements in hamstring flexibility over heat or stretching alone. Further research is necessary to investigate the possible mechanisms for these improvements and to determine whether similar results can be obtained with other muscle groups.

Key words: cryotherapy, stretching, flexibility

Adequate flexibility is an important characteristic of physical fitness. Many athletic teams devote attention to the development or maintenance of flexibility, mainly through the use of various stretching exercises. There continues to be debate regarding the optimal technique(s) for stretching and flexibility training.

Numerous researchers have attempted to determine how temperature influences range of motion,[2,3,4,6,10,11,13,16,17] but it appears that there are no clear answers. The purpose of this study was to investigate the efficacy of cryostretching for increasing supine hamstring flexibility. We compared stretching with ice, stretching with heat, and stretching alone.

METHODS

Subjects

A convenience sample of 24 healthy male college baseball players (age = 20.7 ± 1.2 yr, ht = 73.0 ± 2.6 in, wt = 192.1 ± 16.4 lb) agreed to participate in the study. The University of Portland subcommittee on research involving human subjects granted approval for the study. All subjects gave voluntary written informed consent before participation. Subjects were involved in daily baseball training sessions and weight resistance exercise training 3 days per week. We verbally screened all subjects to ensure that none suffered from injuries or disabilities involving the hamstring muscle group.

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Equipment

A Leighton flexometer[9] (Fig 1) was used to assess hamstring flexibility for the pretest and posttest. We performed pilot tests using 12 subjects (18 to 41 years) to compare the Leighton flexometer with a standard goniometer in the measurement of supine hamstring flexibility. The measurements made with the Leighton flexometer appeared to be more consistent, and the flexometer was easier to use than a double-arm goniometer.

We applied standard hot packs (110°F to 115°F), secured with an elastic wrap, to the posterior thigh in subjects who stretched with heat. Subjects who stretched with ice used bags filled with crushed ice held in place over the hamstring muscle group with an elastic wrap. The area covered by the hot packs or crushed ice was approximately 10 inches by 19 inches and included the central portion of the hamstring muscle group.

Procedures

Each subject performed a supine hamstring flexibility pretest between 1:00 P.M. and 2:00 P.M. on the test day. We positioned each subject supine and securely strapped a Leighton flexometer to the lateral aspect of the right mid-calf (Fig 2). To stabilize the pelvis and contralateral leg, the test administrator secured the contralateral leg at the knee and secured both hips at the anterior superior iliac spine. After the flexometer was zeroed, the athlete was asked to raise his leg as far as possible without bending the knee. Subjects kept the ankle in a neutral position (90°) in an attempt to reduce the variability caused by dorsiflexion and plantar flexion. The test administrator did not assist the subject and gave only verbal encouragement, locking the flexometer at the terminal position of hip flexion. Three trials were administered, with a 20-second rest between trials. We tested the subject's left leg using the same protocol. The

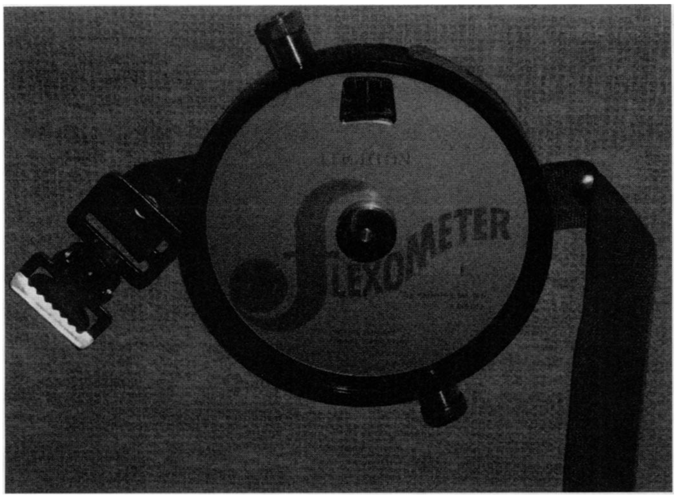

Fig 1. Leighton flexometer.

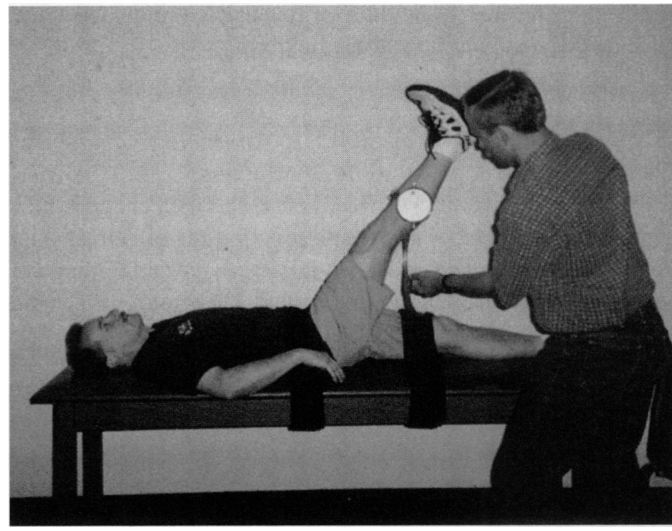

Fig 2. Subject performing supine hamstring flexibility test.

average of three trials was used as the supine hamstring flexibility score for each leg, with the sum of the scores for the two legs used as the dependent variable.

We randomly assigned subjects to treatment groups. The group that stretched with heat (n = 8) performed a 20-minute stretching routine with hot packs secured to the posterior thigh of each leg; the group that stretched with ice (n = 8) performed the same stretching procedures with ice bags secured to the posterior thigh of each leg; the group that only stretched (n = 8) performed the stretching routine without a modality. Stretching consisted of 2 single- and 2 double-leg static stretches (modified hurdler's stretch and sit-and-reach) held for 3 minutes each. Total stretching time was 20 minutes.

A posttest supine hamstring flexibility test was conducted by the same test administrator immediately after the experimental treatment in the same manner as the pretest.

Statistical Analysis

Simple descriptive statistics summarized the physical characteristics of each subject. The dependent variable (supine hamstring flexibility score) was the sum of the mean scores for the right and left leg. To examine effects on supine hamstring flexibility, we used a 2-way group-by-time repeated measures analysis of variance (ANOVA) with modality (stretch with heat, stretch with ice, and stretch only) as the grouping factor and trial (pretest, posttest) as the repeated measures factor. Tests of simple main effects were performed with ANOVA followed by Newman-Keuls multiple comparison procedure to identify different means. We used paired t tests to evaluate the differences between pretest and posttest means for each treatment group. Statistical significance was accepted at $p \leq .05$.

RESULTS

Group means for the pretest and posttest supine hamstring flexibility scores are presented in the Table. ANOVA indicated a main effect for modality ($F(2,21) = 3.77$; $p < .05$), trial ($F(1,21) = 63.14$; $p < .05$), and modality by trial interaction ($F(2,21) = 6.83$; $p < .05$). Tests of simple main effects (1-way ANOVAs performed on pretest group means and on posttest group means) demonstrated no difference between the pretest scores for the three groups ($F(2,21) = 1.54$; $p = .24$). Posttest means were found to be different ($F(2,21) = 6.66$; $p < .05$). The Newman-Keuls multiple comparison procedure revealed that the mean for the group that stretched with ice was greater than the means for both the group that stretched with heat and the group that only stretched. There was no difference between the means for the group that stretched with heat and the group that only stretched.

The treatment-by-trial interaction indicated that there were differences between the groups in their responses to the various

Pretest and Posttest Supine Hamstring Flexibility Scores

Group	Pretest*			Posttest*		
	Right	Left	Sum	Right	Left	Sum
Stretch + heat	84.6 (7.7)	87.4 (8.2)	172.0 (14.4)	88.8 (5.7)	90.9 (3.9)	179.6 (8.3)
Stretch + ice	86.5 (5.6)	90.5 (6.9)	177.0 (9.2)	95.1 (8.3)	99.8 (7.6)	194.9† (11.6)
Stretch only	83.9 (8.0)	81.5 (8.1)	165.4 (15.4)	85.9 (8.7)	86.4 (8.1)	172.3 (16.6)

* Given in degrees and standard error of the mean.
† Greater than stretch + heat and stretch only ($p < .05$).

treatments. Paired *t* tests showed that each group made improvements in supine hamstring flexibility.

DISCUSSION

Our results are contrary to those of others.[3,5,11,14,16] Differences in protocols, subjects, treatments, and data analysis may be partly responsible. A study investigating the effects of mild activity, heat, cold, and heat with mild activity on the range of motion at the wrist, elbow, ankle, and knee found that cold application (immersion in 10°C water for 10 minutes) was inferior to all other treatments, with the exception of the knee.[16] The investigation of different joints hampers comparisons with the present study.

Another study investigated the effects of static stretching, sauna warm-up, cold applications, and exercise warm-up on flexibility at the hip joint and found that ice application had no effect on straight leg flexion in 70 male students.[5] The duration of cold application (2.5 minutes) may have limited any hypothesized beneficial effects of the treatment.

Superficial heat followed by a 1-minute stretch and superficial cold followed by a 1-minute stretch were compared with stretching alone using 12 males and 12 females aged 18 to 39 as subjects.[17] A significant increase in hamstring length was noted regardless of the treatment used, with no significant differences detected between treatments. This experiment was different from ours in that thermal treatments were followed by stretching; our subjects performed stretching with heat or ice. Also, the stretching consisted of a single 1-minute stretch whereas our subjects performed several 3-minute stretches.

Flexion, abduction, and external rotation in the right hip were measured in a study that compared the combination of heat and stretching with heat alone and stretching alone.[6] Heat followed by stretching increased hip flexion range of motion immediately after and 30 minutes after the treatment, but the increase was not significantly greater than stretching alone. Heat alone did not increase range of motion at the hip joint. This study again differed from ours in that the stretch was performed after the 20-minute heat treatment and the passive stretch was held for only 7 seconds.

A study similar to ours found that both cryotherapy (ice) and thermotherapy (hydrocollators) improved immediate hip range of motion (measured with a goniometer) but detected no difference between the treatments.[11] The methodology of our study differed in several respects. We chose to measure hamstring flexibility with a Leighton flexometer instead of a goniometer. We also selected as our dependent variable the sum of the flexion scores (mean of 3 trials) for both legs. Our study design included a control group (stretch only) that allowed us to investigate the efficacy of temperature manipulations during a stretching protocol. It is unknown to what extent the use of athletes as subjects contributed to the difference in conclusions. The primary difference in our study is that we chose to examine the combined effect of static stretching and temperature manipulations on range of motion. An important limitation of our study is that the small convenience sample (n = 8 per group) limited our ability to detect any statistically significant difference between the means of the group that stretched with ice and the group that stretched with heat.

One study that investigated the effect of brief cold application on passive hip flexion was performed on 40 college-age volunteers.[12] Fluori-Methane spray (Gebauer Co., Cleveland, OH) (6 applications of 5 seconds each) in combination with stretching increased passive hip flexion 8.78°, but it was concluded that there was no significant improvement in passive hip flexion. Unlike our investigation, the total duration of cold application was only about 30 seconds, limiting any meaningful comparison to our results.

What are possible mechanisms for the cold-induced facilitation of flexibility in this study? A diminished proprioceptive feedback after stretching with ice may somehow act to increase range of motion. A review of several studies revealed that short-term cold application has little affect on proprioception.[8]

Another plausible mechanism relates to the effects of cooling on the stretch reflex. One study demonstrated that cooling a stretched muscle caused a depression of the stretch reflex.[7] In theory, this effect could have allowed our subjects to stretch further during the leg flexion test. The activation of the stretch reflex in our subjects was minimized because of the slow, controlled stretch performed during the stretching protocol and the leg flexion test.

The beneficial effects of cold application during stretching may be related to effects on muscle spasm or pain sensation.[1] The use of ice and low-load prolonged stretch may be useful for increasing the range of motion where inflammation or painful factors contribute to reduced function in patient populations.[10] Our study included only healthy athletes who were free from any known injuries or disabilities to the hamstrings, so it is unlikely that leg flexion was limited by abnormal pain or spasm. On the other hand, when ice treatment is combined with static stretching, the athlete may find it easier to endure the mild discomfort commonly felt at the terminal position of the stretch. One study reviewed evidence suggesting that stretching combined with cold application for the purpose of increasing range of motion should be used only in certain situations.[15] These include 1) when it is desired to tear connective tissue, 2) instances where intense pain warrants the use of cold-induced analgesia, and 3) muscle spasticity.[15] We interpret our results as supporting the use of ice during stretching, but we advise that caution be used in its practical application. We agree that after cooling it would be prudent to warm up properly to minimize stress-induced muscle tears.[8]

In conclusion, the results of this investigation suggest that the application of ice while stretching may provide enhanced short-term improvements in flexibility over heat or stretching alone. Further research must be performed to uncover the mechanism(s) involved.

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