The Effects of Therapeutic Application of Heat or Cold Followed by Static Stretch on Hamstring Muscle Length

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Hamstring injuries are common among athletes performing high speed, high load activities (8). Inadequate warm-up, inflexibility, and poor stretching can predispose the athlete to a hamstring injury (13). Physical therapists and others often advocate the use of stretching techniques as a means of increasing hamstring length and hip joint range of motion, thus decreasing the likelihood of injury (19). However, the literature has not yet shown stretching to be effective in reducing the incidence of athletic injuries (21). Superficial heating and cooling modalities are often used in conjunction with static stretching in an attempt to increase the efficacy of stretching. The principal methods by which both superficial heat and cold may improve the efficacy of stretching are by reducing muscle pain and decreasing muscle guarding (3,4,7,9,10,11,12,22,23).

LITERATURE REVIEW

Historically, clinicians have prescribed different static stretching techniques as a means of increasing flexibility (19). Research has shown static stretch to be effective in increasing the length of connective tissue (22). Warren et al explored the effects of stretching on rat tail tendon (22). They found that low-load, long duration stretching of rat tail tendon was more effective in increasing rat tail tendon length than high-load, short duration stretching (22). Therapists often use deep heating modalities to increase tissue extensibility to allow for increased efficacy of stretching techniques. Wessling et al found that static stretch combined with ultrasound increased the extensibility of triceps surae muscle (measured by changes in dorsi-flexion) more than static stretch alone (23). Laboratory studies also indicate that passive warming of the musculotendinous unit increases its extensibility (16,20). Noonan et al and Strickler et al interpreted their research as evidence that passive warming may decrease the possibility of strain injury secondary to extensibility changes (16,20).

Superficial heating may improve the efficacy of stretching by reducing activity-induced increased muscle tension (muscle guarding) (9). Fischer
and Solomon suggest that heating of the skin reduces gamma motor neuron excitability (3). This would decrease the sensitivity of muscle spindles, which may decrease muscle guarding. Lehmann and De Lateur suggest that this mechanism may be effective in decreasing muscle spasms (11). Heat also may improve hamstring stretching by reducing pain (7,11,14). Acting as a "counterirritant," heat may allow one to tolerate stretching better, thus increasing the efficacy of stretching (7,11,14). Henrikson et al compared the effects of stretching the hamstrings alone, applying superficial heat alone, and stretching combined with the application of superficial heat on the range of hip flexion (9). Their results showed no changes in hip flexion in the heat only group. Both the stretching only and the stretching plus heat groups showed improvements in hip flexion. Although they reported that heat plus stretching increased hip flexion somewhat more than stretch alone, their results were not statistically significant.

The basis for using cold in combination with stretching, like heat, is pain reduction and decreased muscle guarding. Cold may relieve pain by acting as a "counterirritant," heat may allow one to tolerate stretching better, thus increasing the efficacy of stretching (4,7,17). Gammon and Starr suggest that cold is a more effective counterirritant than is heat (7). Cold may reduce muscle guarding by reducing the activity of the muscle spindles. Knutsson and Mattsson suggest that superficial cooling can cause reduction in gamma motor neuron activity through the stimulation of skin receptors (10).

Clinicians have advocated various tests as a means of indirectly measuring hamstring length. The test used in this study was the active-knee-extension (AKE) test as described by Gajdosik and Lusin (6). We chose this method for its ease of use in a clinical setting and its demonstrated reliability.

The purpose of our study was to determine if the application of a superficial heating or cooling modality, followed by a 1-minute static stretch to the hamstrings, increases the efficacy of the hamstring stretch alone, as measured by the AKE test.

**METHODS**

Twelve males and 12 females, ages 18–39 (Table 1) were selected from an active duty U.S. Army population. We prescreened subjects to establish eligibility for the study. Eligible persons reported no history of orthopaedic or cardiovascular disorders, hypermobility of the knee, or insensitivity or hypersensitivity to heat or cold. Subjects were specifically instructed not to initiate or change any current exercise program while participating in this study. Ongoing exercise programs were permitted to allow the subjects to continue to comply with the fitness standards of the U.S. Army. They were split into six treatment groups using a random numbers table. Six possible sequences were used to eliminate treatment bias (Table 2).

The three treatments used were a heat treatment followed by a static stretch, a cold treatment followed by a static stretch, and static stretch alone. A session consisted of a pretreatment measurement of knee extension using the AKE method, the administration of the treatment for 20 minutes, followed immediately by a posttreatment measurement using the AKE method. Each session was at least 1 week apart to eliminate the effects of carryover.

To perform the AKE test, subjects were supine with the contralateral lower extremity strapped at mid-thigh to the treatment table (Figures 1 and 2). A 15-cm strap was also placed over the anterior superior iliac spines for pelvic stabilization (6). The hip of the treated thigh was then flexed to 90°. A wooden crossbar was placed in contact with the anterior

<table>
<thead>
<tr>
<th>Group</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(2M, 2F)</td>
<td>Heat and stretch</td>
<td>Stretch only</td>
<td>Cold and stretch</td>
</tr>
<tr>
<td>2(1M, 2F)</td>
<td>Heat and stretch</td>
<td>Cold and stretch</td>
<td>Stretch only</td>
</tr>
<tr>
<td>3(2M, 2F)</td>
<td>Cold and stretch</td>
<td>Heat and stretch</td>
<td>Stretch only</td>
</tr>
<tr>
<td>4(3M, 2F)</td>
<td>Cold and stretch</td>
<td>Stretch only</td>
<td>Heat and stretch</td>
</tr>
<tr>
<td>5(2M, 2F)</td>
<td>Stretch only</td>
<td>Heat and stretch</td>
<td>Cold and stretch</td>
</tr>
<tr>
<td>6(2M, 2F)</td>
<td>Stretch only</td>
<td>Cold and stretch</td>
<td>Heat and stretch</td>
</tr>
</tbody>
</table>

M = Male subjects.  
F = Female subjects.

**TABLE 1.** Subject characteristics (N = 24; 12 males, 12 females).

<table>
<thead>
<tr>
<th>Range</th>
<th>Average</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>18–39</td>
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<tr>
<td>Weight (kg)</td>
<td>48.2–87.7</td>
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<tr>
<td>Height (m)</td>
<td>1.55–1.87</td>
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</tbody>
</table>

**TABLE 2.** Treatment sequences (N = 24 subjects).
thigh, and the subject was instructed to maintain contact with the rod as he/she actively extended his/her knee. The knee was extended as to the point of mild resistance or just below the threshold of myoclonus as described by Gajdosik and Lusin. An electronic inclinometer (Saunders Therapy Products, Bloomington, MN) was placed 7.6 cm below the tibial tubercle. Data readings were taken once the instrument was stabilized, and the average of three readings was recorded. The same researcher measured the knee angle (degrees from full extension) for all three sessions.

The heat treatment consisted of a 77°C hot pack wrapped in seven layers of dry terry cloth towels applied to the posterior thigh. The cold treatment consisted of a −18°C gel pack wrapped in one layer of a wet terry cloth towel applied to the posterior thigh. The stretch only group received no modality. All subjects were in a prone position for the duration of their treatments. At the end of 20 minutes, the hot or cold treatments were removed. All subjects then performed the static stretch to the hamstrings by the following method. In a long sitting position, each subject rested the heel of the untreated lower extremity along the medial surface of the treated thigh. The subject then reached forward to grasp the ankle of the treated lower extremity. Each subject then performed one continuous stretch to pain tolerance, without bouncing, for 1 minute.

RESULTS

Examination of the pre- and post-treatment mean values of knee extension reveal that the cold plus stretch treatment caused an increase in flexibility of 3.62° from a mean starting point of 26.54° to a mean end point of 22.92°; heat plus stretch caused an increase of 5.66° from a mean starting point of 27.33° to a mean end point of 21.67°; and stretch alone caused a mean increase of 4.12° from a mean starting point of 26.33° to a mean end point of 22.21°. Overall results are plotted in Figure 3. Interpretation of the F values obtained indicated that there was a significant increase in hamstring length regardless of treatment used with $F(1,23) = 35.49, p < 0.001$. However, a significant difference was not shown when comparing the efficacy of one treatment vs. another ($F < 1.0$). Additionally, there was no significant interaction demonstrated ($F < 1.0$).

Inferential analysis of the data obtained in this study was done via 2 × 3 analysis of variance experimental design for treatments-by-subjects (2). The results are reported in Tables 3 and 4.

DISCUSSION

The results of the current study support the findings of other studies that static stretching is effective in increasing hamstring length (5,9). The results do not indicate that the use of superficial thermal modalities significantly increases the efficacy of static stretching. Our results are similar to those found by Henricson et al who studied the effects of heat and stretching on hip range of motion (9). Both the current study and Henricson et al found that heat and stretching gave the greatest increases

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**TABLE 3. Analysis of variance source table and F ratios.**

<table>
<thead>
<tr>
<th>Source</th>
<th>S$S$</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
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<tbody>
<tr>
<td>Total</td>
<td>12082.00</td>
<td>143</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Subjects</td>
<td>8678.00</td>
<td>23</td>
<td></td>
<td></td>
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<tr>
<td>Treatments</td>
<td>5.04</td>
<td>2</td>
<td>2.52</td>
<td>0.08</td>
<td>NS</td>
</tr>
<tr>
<td>Prepost</td>
<td>720.36</td>
<td>1</td>
<td>720.03</td>
<td>35.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Interaction</td>
<td>27.18</td>
<td>2</td>
<td>13.59</td>
<td>0.97</td>
<td>NS</td>
</tr>
<tr>
<td>Residual treatment</td>
<td>1537.96</td>
<td>46</td>
<td>33.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual pre, post</td>
<td>466.64</td>
<td>23</td>
<td>20.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual interaction</td>
<td>647.15</td>
<td>46</td>
<td>14.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not significant.
in range of motion (ROM), but the increases in ROM of the heat plus stretching groups were not significantly greater than the stretch alone groups (9).

Wessling et al, in a study of the triceps surae muscle group, showed a significant increase in ankle dorsiflexion with the use of ultrasound combined with static stretch compared to static stretch alone (19). Ultrasound and other deep heating modalities are believed to cause collagen to become more extensible, thus increasing the efficacy of a stretch (12,19). Superficial heating modalities do not sufficiently raise the temperature of deeper muscle and tendon tissues, and thus, should not cause significant changes in tissue extensibility (1).

Our study supports the premise that superficial modalities do not significantly alter the extensibility of tissues being stretched by one prolonged static stretch of the hamstrings.

Cooling modalities, such as vapocoolant sprays, are frequently used to minimize stretch-induced pain by acting as a counterirritant (8,15). Newton found the use of vapocoolants, in a spray and stretch technique, did not increase passive hip flexion in healthy subjects. J Orthop Sports Phys Ther 13:110–115, 1984

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REFERENCES