Journal of Orthopaedic & Sports Physical Therapy
Official Publication of the Orthopaedic and Sports Physical Therapy Sections of the American Physical Therapy Association

RESEARCH STUDY

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

Brent F. Taylor, CPT, MPT[1]
Christopher A. Waring, CPT, MPT[2]
Teresa A. Brashear, 1LT, RPT[3]

Hamstring stretching is an important part of treatment programs aimed at decreasing the likelihood of hamstring injury. Few studies have examined the use of superficial thermal modalities in conjunction with hamstring stretching. The purpose of this study was to determine if the application of a superficial heating or cooling modality, followed by static stretch, increased the efficacy of static stretching of the hamstring muscles. This study examined 12 male and 12 female subjects, ages 18–38. All subjects received each of the following treatments: heat followed by static stretch, cold followed by static stretch, and static stretch alone. Each treatment was separated by at least 1 week. Pre- and post-treatment measurements of hamstring length were obtained using the Active-Knee-Extension (AKE) test. The data were analyzed via a 2 × 3 analysis of variance experimental design. Results indicated that there was an increase in hamstring length regardless of stretch treatment used, with $F(1,23) = 35.49$, $p < .001$. However, no significant differences were detected among stretch treatments, $F < 1.0$, nor among interaction effects, $F < 1.0$. The results of this study suggest that adequate hamstring stretching can occur without the use of a superficial thermal modality.

Key Words: *hamstring muscles, stretching, thermal*

[1] *Captain, U.S. Army, Fort Knox, KY. This study was conducted in partial fulfillment of the requirements for Captain Taylor's master of physical therapy degree from the United States Army-Baylor University Graduate Program in Physical Therapy.*
[2] *Captain, U.S. Army, Fort Leavenworth, KS. Address for correspondence: 1607 Klemp St., Leavenworth, KS 66048. This study was conducted in partial fulfillment of the requirements for Captain Waring's master of physical therapy degree from the United States Army-Baylor University Graduate Program in Physical Therapy.*
[3] *First Lieutenant, U.S. Army, Fort Sill, OK. This study was conducted in partial fulfillment of the requirements for First Lieutenant Brashear's master of physical therapy degree from the United States Army-Baylor University Graduate Program in Physical Therapy.*

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 static 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 (3,4,7,9,10,11,14,17,22,23).

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 dorsiflexion) 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 tonus (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). Henricson 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.

Acting as a "counterirritant," heat may allow one to tolerate stretching better.

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 (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. Knuttsson and Mattsson suggest that superficial cooling can cause reduction in gamma motor neuron activity through the stimulation of skin receptors (10).

	Range	Average
Age (years)	18–39	25.46
Weight (kg)	48.2–87.7	68.9
Height (m)	1.55–1.87	1.71

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

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).

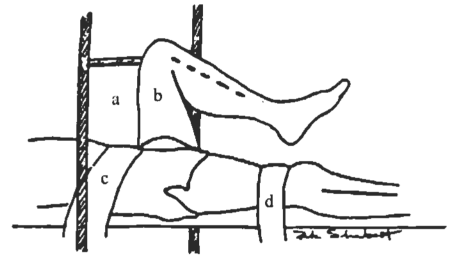

FIGURE 1. *Subject is supine with untreated thigh (d) and pelvis (c) stabilized to the table. Hip of treated thigh (b) is flexed to 90°. Treated thigh is held in contact with crossbar (a).*

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 midthigh 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

Group	Week 1	Week 2	Week 3
1 (2M, 2F)	Heat and stretch	Stretch only	Cold and stretch
2 (1M, 2F)	Heat and stretch	Cold and stretch	Stretch only
3 (2M, 2F)	Cold and stretch	Heat and stretch	Stretch only
4 (3M, 2F)	Cold and stretch	Stretch only	Heat and stretch
5 (2M, 2F)	Stretch only	Heat and stretch	Cold and stretch
6 (2M, 2F)	Stretch only	Cold and stretch	Heat and stretch

M = Male subjects.
F = Female subjects.

TABLE 2. *Treatment sequences (N = 24 subjects).*

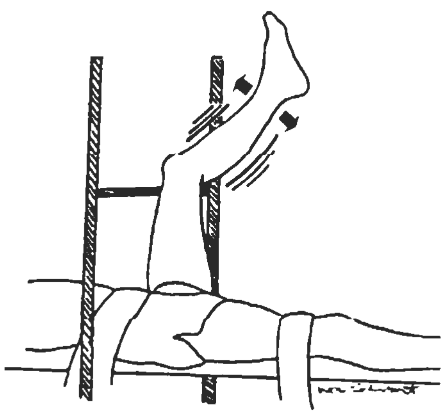

FIGURE 2. *Subject is asked to extend knee to mild resistance point. Data readings are taken below tibial tubercle with an inclinometer.*

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

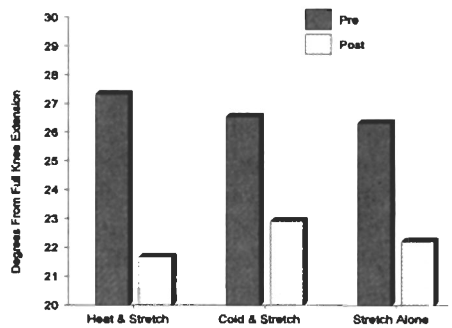

FIGURE 3. *Pretreatment and posttreatment measurements of active knee extension for heat and stretch, cold and stretch, and stretch alone. Measured in degrees lacking from full knee extension.*

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-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

Results do not indicate that the use of superficial thermal modalities significantly increases the efficacy of static stretching.

Source	SS	df	MS	F	p
Total	12082.00	143			
Subjects	8678.00	23			
Treatments	5.04	2	2.52	0.08	NS
Pre/post	720.36	1	720.03	35.49	<0.001
Interaction	27.18	2	13.59	0.97	NS
Residual treatment	1537.96	46	33.43		
Residual pre, post	466.64	23	20.29		
Residual interaction	647.15	46	14.07		

NS = Not significant.

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

Treatment	Preexercise		Postexercise	
	$\bar{X}$	SD	$\bar{X}$	SD
Cold and stretch	26.54	8.89	22.92	8.77
Heat and stretch	27.33	10.59	21.67	10.78
Stretch alone	26.33	7.81	22.21	6.89

All measurements in degrees from full knee extension.

TABLE 4. *Means and standard deviations for treatments.*

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 adults (15). Cold may also be used in conjunction with static stretch in an attempt to reduce the muscle stretch reflex by reducing muscle spindle activity (10,18). The results of the current study do not support the use of superficial cooling as a means to increase the efficacy of static stretch.

CONCLUSION

This study does not provide the clinician with evidence that a specific superficial thermal modality is effective in conjunction with static stretch for all people. However, the effects of static stretching in association with thermal modalities may be highly individualized. Although some people may respond favorably to a static stretch combined with a particular modality, this study suggests it would be wrong to prescribe thermal modalities to all patients on a static stretching program. JOSPT

ACKNOWLEDGMENTS

The authors acknowledge James R. Cropper, MAJ, MPT; Ada Kelly, PhD; and Kenn Finstuen, MS, MEd, PhD for their assistance in refining the experimental design and help with manuscript preparation. We also thank Rosendo T. Gutierrez, LTC, MPT and Eric Cipriano, CPT, MSW for their assistance in recruiting subjects.

REFERENCES

1. *Abramson DI, Mitchell R, Tuck S, Bell Y, Zayas A: Changes in blood flow, oxygen uptake and tissue temperatures produced by the topical application of wet heat. Arch Phys Med Rehabil 42: 305–318, 1961*
2. *Bruning JL, Kintz BL: Computational Handbook of Statistics, Glenview, IL: Scott Foresman, 1968*
3. *Fischer E, Solomon S: Physiological responses to heat and cold. In: Licht S (ed), Therapeutic Heat and Cold (2nd Ed), pp 126–169. Baltimore, MD: Waverly Press, 1965*
4. *Fruhstorfer H, Hermanns M, Latzke L: The effects of thermal stimulation on clinical and experimental itch. Pain 24: 259–269, 1986*
5. *Gajdosik RL: Effects of static stretching on the maximal length and resistance to passive stretch of short hamstring muscles. J Orthop Sports Phys Ther 14:250–255, 1991*
6. *Gajdosik R, Lusin G: Hamstring muscle tightness. Phys Ther 63:1086–1090, 1983*
7. *Gammon GD, Starr I: Studies on the relief of pain by counterirritation. J Clin Invest 20:13–20, 1941*
8. *Garrett W, Califf J, Bassett F: Histochemical correlates of hamstring injuries. Am J Sports Med 12:98–103, 1984*
9. *Henricson AS, Fredriksson K, Persson I, Pereira R, Rostedt Y, Westlin N: The effect of heat and stretching on the range of hip motion. J Orthop Sports Phys Ther 13:110–115, 1984*
10. *Knuttsson E, Mattsson I: Effects of local cooling on monosynaptic reflexes in man. Scand J Rehabil Med 1:126–132, 1969*
11. *Lehmann JF, De Lateur BJ: Therapeutic heat. In: Lehmann JF (ed), Therapeutic Heat and Cold (4th Ed), Baltimore, MD: Williams & Wilkins, 1990*
12. *Lehmann JF, Masock AJ, Warren CG, Koblanski J: Effect of therapeutic temperatures on tendon extensibility. Arch Phys Med Rehabil 51:481–485, 1970*
13. *Liemohn W: Factors related to hamstring strains. J Sports Med 18:71–75, 1978*
14. *Melzack R, Wall PD: Pain mechanisms: A new theory. Science 150:971–979, 1965*
15. *Newton RA: Effects of vapocoolants on passive hip flexion in healthy subjects. Phys Ther 65:1034–1036, 1985*
16. *Noonan TJ, Best TM, Seaber AV, Garrett WE: Thermal effects on skeletal muscle tensile behavior. Am J Sports Med 21:517–522, 1993*
17. *Parsons CM, Goetzl FR: Effect of induced pain on pain threshold. Proc Soc Exp Biol Med 60:327–329, 1945*
18. *Petajan JH, Watts N: Effects of cooling on the triceps surae reflex. Am J Phys Med 41:240–251, 1962*
19. *Stanish WD, Hubley-Kozey CL: Neurophysiology of stretching. In: D' Ambrosia R, Drez D (eds), Prevention and Treatment of Running Injuries, Thorofare, NJ: Slack, 1989*
20. *Strickler T, Malone T, Garrett WE: The effects of passive warming on muscle injury. Am J Sports Med 18:141–145, 1990*
21. *van Mechelen W, Hlobil H, Kemper HCG, Voorn WJ, de Jongh HR: Prevention of running injuries by warm-up, cool-down, and stretching exercises. Am J Sports Med 21:711–719, 1993*
22. *Warren CG, Lehmann JF, Koblanski JN: Elongation of rat tail tendon: Effect of load and temperature. Arch Phys Med Rehabil 52:465–472, 1971*
23. *Wessling D, DeVane D, Hylton C: Effects of static stretch versus static stretch and ultrasound combined on triceps surae muscle extensibility in healthy women. Phys Ther 67:674–679, 1987*