

[Sports Physical Therapy]

Superficial Precooling on a 4-Week Static Stretching Regimen: A Randomized Trial

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Background: The influence of superficial precooling on range of motion (ROM) as part of a stretching program has not been extensively studied. It is not clear if the analgesic effect can benefit a stretching program.

Hypotheses: Superficial precooling will result in greater gains in ROM as part of a stretching program, compared with stretching without a precooling intervention. Superficial precooling will also result in greater retention in ROM gains following cessation of stretching, compared with stretching without a precooling intervention.

Study Design: Prospective randomized single-blind test-retest design.

Methods: Twenty-nine participants were randomly assigned to 1 of 2 static stretching protocols: a standard protocol (n, 14; age, 24.6 ± 5.4 years) or a precool protocol (n, 15; age, 25.1 ± 7.3 years). These samples allowed for 80% power for statistical significance testing. Both groups performed static hamstring stretching daily for 4 weeks. The precool group applied ice to the hamstring for 10 minutes before stretching. Both groups stretched for 4 weeks and then stopped stretching for the last 4 weeks. Hip ROM measures were obtained each week for 8 weeks.

Results: For the standard group, mean hip ROM increased from 71.4° ± 18.5° to 90.6° ± 20.5° and for the precool group, 71.5° ± 22.3° to 91.8° ± 20.9°. For the standard group, mean hip ROM decreased from 90.6° ± 20.5° to 83.9° ± 20.3° and for the precool group, 91.8° ± 20.9 to 85.0° ± 19.4°. There were no differences between groups at any time in the study ($P > .05$).

Conclusions: Precooling had no beneficial effects on ROM or on retention of ROM.

Clinical Relevance: Cold application, before stretching, does not provide any benefit to a stretching program.

Keywords: ice; hamstring stretching; cessation

Static stretching is an integral component of rehabilitation programs, as well as an important part of sports conditioning. Numerous therapeutic cooling and heating modalities have also become a staple in physical therapy and are used by competitive athletes. Superficial thermal modalities before stretching may increase muscle extensibility and tolerance to stretch.

The majority of research to date has focused on the use of heat combined with stretching.^{1,5,7,9-14} Single applications of ice may have a complementary effect when used with a therapeutic exercise program.⁸ Therapeutically, cold decreases muscle excitability and muscle spindle depolarization.⁶ Cold also raises

the pain threshold, whereas heat tends to lower it, making it easier for muscle spindles to fire.¹² Cold therapy, used with static stretching, may help reduce muscle spasms better than heat.⁹

Cold is highly beneficial largely because of its analgesic effects.⁶ Cold may elicit range of motion (ROM) gains given that stretching usually produces discomfort.¹ Superficial precooling before stretching may increase adherence to home exercise programs and decrease the risk of reinjury following discharge from therapy.

To date, there is a continuing debate on which techniques can optimally enhance the effectiveness of a stretch. Thus far, few studies have examined the use of ice when used with a

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therapeutic stretching program.^{1,9,12,13} Even fewer studies have examined the effects of precooling the musculature before stretching.¹³ There are conflicting results on the effectiveness that these superficial thermal modalities provide to a stretching program.^{9,12,13} The documented effects have followed a single 1-day stretch.^{1,12,13} The accumulated effects of superficial thermal modalities in conjunction with a static stretching program are not known, nor is the outcome following the cessation of a stretching program.

Taylor et al¹³ examined the acute effect of a single 1-day stretch coupled with a thermal agent. Treatment consisted of 20 minutes of heat, ice, or no modality applied to the hamstrings, followed by a 1-minute static hamstring stretch. Hip ROM increased for all 3 groups with no statistically significant difference among them. The researchers concluded that static stretching with a superficial modality provides no additional benefits.

This study had several potential weaknesses. First Taylor et al¹³ took hip ROM measurements after only a 1-minute single stretch. Current research suggests that a 2-minute stretch per day may increase ROM more so than a 1-minute stretch.²⁻⁴ Lin¹⁰ sought to determine the acute effect of a single 1-day stretch applying a hot pack to the knee before stretching, as followed by a 10-minute static stretch with either a hot or cold pack. Knee ROM increased for both groups, with cold therapy resulting in significant ROM gains. The researcher concluded that cold, combined with passive stretching, may increase ROM.¹³

Finally, Brodowicz et al¹ examined the acute effect of a single 3-minute hamstring stretch with heat, ice, or no modality. The mean flexibility gains with ice were higher than those with heat or without a modality. The researchers concluded that short-term applications of ice during a static stretch may increase ROM more so than heat or stretching alone.¹

Consequently, there is a lack of consensus regarding which modalities optimally enhance a static stretching program. What is not known is the cumulative effect of cold with a lengthy stretching protocol (ie, weeks rather than a single day). The lasting effects on ROM are not known, namely because the prior studies evaluated a single 1-day stretch with superficial thermal modalities.

Finally, because cold was simultaneously applied with the stretch time, it is likely that the analgesic effect may not have had sufficient time to influence the stretch action. Rather, it is reasonable to think that the cold should be applied in advance of the stretching, to improve the chance of an analgesic benefit.

The hypothesis for this study was that superficial precooling, combined with a static stretching program, will significantly increase ROM more so than static stretching alone over a 4-week stretching program. The second hypothesis was that superficial precooling will allow greater ROM retention following the cessation of static stretching, compared with static stretching alone.

METHODS

Participants

The study and consent form were approved by our institution's Research and Ethics Institutional Review Board. Participants were healthy 18- to 50-year-olds not currently in a hamstring stretching program. Participants were excluded if they were pregnant, currently injured, or experiencing general body pain. Finally, participants were instructed to stretch their hamstrings only during the designated times for the study.

Design

A minimum sample size of 10 participants per group was determined on the basis of the expected gain in ROM of at least 5.0° (with a standard error of the measure of 2.5°) over the course of 4 weeks. This anticipated effect size would yield a significant finding at a power of greater than 80%. Similarly, to detect a clinically meaningful difference of at least 5° between groups required a sample size of at least 12 per group, for a power of 80%.

A prospective randomized single-blind test-retest design was used for this study. Participants were randomly assigned to 1 of 2 static stretching protocols: a standard protocol or a protocol that included precooling with ice for 10 minutes. Both groups performed the same stretching. All volunteers participated in daily hamstring stretching for the initial 4 weeks, followed by no stretching for the final 4 weeks.

Stretching Protocol

Before the study, participants were instructed on the standing one-legged hamstring stretch (Figure 1).² They stood upright with their head, hips, and feet facing forward. The leg to be stretched was extended and placed on an elevated surface at or slightly below hip level. They were instructed to keep their backs straight as they hinged forward at their hips, until they felt slight to moderate discomfort in the posterior thighs (ie, hamstrings), maintaining this position for 30 seconds, followed by a 10-second rest and then a final 30-second stretch. Volunteers were instructed to count at a pace of "one-one-thousand, two-one-thousand, three-one-thousand . . ." for 30 counts to ensure a full 30-second stretch time. This same protocol was then repeated for the contralateral leg. This protocol was performed 2 times daily, with a minimum of 4 hours between protocols. Participants were instructed to keep a log of the times that they performed the stretches, to help ensure consistency and adherence.

Measurement Procedure

A standard plinth was used for weekly hip ROM measurements, with a standard 12-in. (30-cm) double-arm goniometer (Jamar, Miami, Florida). Before the study, an initial pretest hip ROM measurement was obtained. The remaining hip ROM measurements were taken at the end



Figure 1. The standing one-legged hamstring stretch.

of each week of this 8-week study. Before the study and to determine intrarater reliability, the measuring investigator took 2 separate hip ROM measurements of each participant's right leg. Intraclass correlation coefficients_{1,1} were determined and thus demonstrated that the data were reliable ($ICC_{1,1} = .95$; confidence interval, 95%: 0.91-0.97).

A passive straight leg raise was used to measure hip flexion.² Volunteers lay supine on a plinth with their knees bent over the side. One investigator passively raised the measured leg, with the contralateral leg stationary. A passive ROM was applied until the participant felt slight to moderate discomfort in the posterior thigh or requested that the passive ROM cease. A second investigator used a standard goniometer to measure hip ROM (Figure 2). The bony landmarks used to measure hip ROM were the trunk as the stationary arm, the greater trochanter as the axis, and the lateral epicondyle of the knee as the moveable arm.¹⁴ The investigators were blinded to the groupings.

Statistical Analysis

Descriptive statistics were generated for participant details. The 2 groups were compared on baseline values, using paired *t* tests. To test for the possible interaction between stretching protocol and time, a 2-factor analysis of variance was used. In the absence of any interaction, the main effects were then tested with analysis of variance. A *P* value of .05 was established as the criterion for statistical significance.

RESULTS

A total of 33 participants started this study; 4 did not complete the study, owing to class schedule conflicts, prior injury unrelated to the study, and involvement in a hamstring



Figure 2. Position and straight leg raise technique for measuring hip range of motion.

stretching program. Twenty-nine participants (average age, 24.9 ± 5.9 years) completed the study: 14 in the standard group (9 women, 5 men) and 15 in the precool group (8 women, 7 men). Participants in the 2 groups did not differ on height, weight, and age. Pretest measures of hip ROM were similar between the 2 groups. Mean hip ROM significantly increased for both groups from pretest to week 4 (mean gain, 19.8° ; minimum-maximum gain, 0.0 - 57.0° ; $P < .01$). Mean hip ROM significantly decreased for both groups following the final 4 weeks of the study (mean loss, 6.7° ; minimum-maximum change of 14° of gain and 21° of loss; $P < .01$). During the first 4 weeks, the mean hip ROM of the standard stretch group increased from $71.4^\circ \pm 18.5^\circ$ to $90.6^\circ \pm 20.5^\circ$; the mean hip ROM of the precool stretch group increased at a similar rate, from $71.5^\circ \pm 22.3^\circ$ to $91.8^\circ \pm 20.9^\circ$. During the cessation period, the mean hip ROM of the standard stretch group decreased from $90.6^\circ \pm 20.5^\circ$ to $83.9^\circ \pm 20.3^\circ$, whereas the mean hip ROM of the precool stretch group decreased at a similar rate, from $91.8^\circ \pm 20.9^\circ$ to $85.0^\circ \pm 19.4^\circ$ (Figure 3). Finally, the mean hip ROM was significantly greater overall for both groups when compared to that of the pretest measurement to the end of the study, at week 8 (mean gain, 13.1° ; minimum-maximum change, 18° of loss and 39° of gain, $P < .001$). At no time during the study was there a significant difference between groups on hip ROM ($P = .960$) (Table 1).

DISCUSSION

The results demonstrate that superficial precooling before stretching does not produce any greater gains in ROM or assist with the maintenance of ROM any more than static stretching alone. Participants in both groups gained ROM at a similar rate during the stretching phase of this study and lost ROM at a similar rate during the cessation phase of this study.

The results of this study conflict with those of Brodowicz et al¹ and Lin.¹⁰ These studies both found cold to be effective

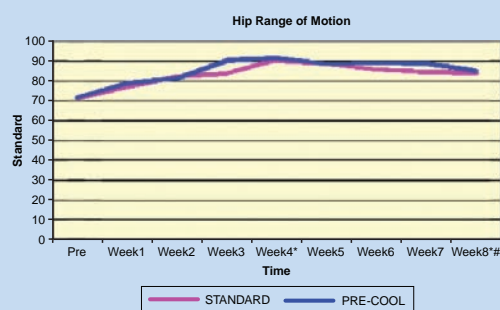


Figure 3. Mean hip range of motion from pretest through week 8.

*Significant difference when compared to pretest.

#Significant difference from week 4 to week 8.

at enhancing a single stretch. Reasons for these discrepancies may be that these researchers chose to evaluate a single 1-day stretch. They also applied the modality with the stretch, whereas in this study the modality was used before stretching. Lin used participants who had sustained a traumatic fracture of their lower extremities with secondary decreases in knee ROM. This study used only healthy individuals.

Clinically, the results of this study are relevant because icing the musculature during a treatment session may be an inefficient use of valuable treatment time. Precooling may still be beneficial when trying to increase the tolerance to stretch.

This study did have several limitations. First, it used a sample of convenience. The majority of participants were young and healthy physical therapy students. We cannot generalize these results to the elderly or to those with pathology or pain. Those with pain might respond differently to the analgesic effect of precooling. The activity level outside this study was not controlled; hence, it could be a confounding variable. In addition, compliance with the stretching protocol was not assessed. All participants were measured on a weekly basis, which may have improved compliance, although this was not measured. Another factor to consider is the large age range given the small sample size (18 to 48 years). Finally, this study examined only the effects of precooling on the hamstring muscle group. Most superficial muscle groups would likely yield similar results given the similar physiologic properties.

CLINICAL IMPLICATIONS

The results of this study indicate that superficial precooling before stretching does not produce greater gains in ROM or assist with the maintenance of ROM any more so than static stretching alone. Static stretching increases ROM regardless of whether the musculature is precooled. Superficial thermal modalities may increase one's comfort or tolerance to stretch, but they do not increase or maintain ROM.

Table 1. Mean hip range of motion (in degrees).

Week	Hip Range of Motion	
	Standard	Precool
Pretest ^a	71.4 ± 18.6	71.5 ± 22.7
Week 1	76.7 ± 17.1	78.8 ± 21.7
Week 2	82.4 ± 21.2	81.5 ± 22.1
Week 3	83.7 ± 19.1	90.5 ± 21.7
Week 4 ^{a,b}	90.6 ± 20.5	91.8 ± 21.0
Week 5	88.6 ± 20.5	88.8 ± 18.2
Week 6	85.9 ± 18.7	89.1 ± 19.9
Week 7	84.8 ± 19.0	88.9 ± 19.5
Week 8 ^{a,b,c}	83.9 ± 20.3	85.0 ± 19.4

^aNo significant difference between groups ($P > .05$).

^bGreater hip range of motion when compared to that of premeasure, $P < .05$.

^cLess hip range of motion when compared to that of week 4, $P < .05$.

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