Effect of superficial pre-cooling on stretching effectiveness

Melissa Geller
Medical College of Ohio

Follow this and additional works at: http://utdr.utoledo.edu/graduate-projects
Graduate School

FINAL APPROVAL OF SCHOLARLY PROJECT

Master of Science in Biomedical Sciences
Concentration in Physical Therapy

Effect of Superficial Pre-cooling on Stretching Effectiveness

Submitted by

Melissa Geller

In partial fulfillment of the requirements for the degree of
Master of Science in Biomedical Sciences

Academic Major Advisor

Daniel J. Cipriani, III, Ph.D., P.T.

Chairperson

Clayton Holmes, Ed.D., P.T.

Dean, School of Allied Health

Christopher E. Bork, Ph.D.

Dean, Graduate School

Keith K. Schlender, Ph.D.

Date of Presentation: June 22, 2004

Date of Approval: 12-14-04
Effect of Superficial Pre-Cooling on Stretching Effectiveness

Melissa Geller
December 10, 2004

Conducted in Cooperation with
Medical College of Ohio
Department of Physical Therapy
3000 Arlington Ave.
Toledo, OH 43614

To meet the requirements of
Master of Science in Biomedical Sciences with a concentration in
Physical Therapy

Advisor: Daniel Ciprani PhD., P.T.
Acknowledgments

I would like to thank Daniel Cipriani, PhD., P.T. for all of his insight and statistical calculations he provided. Steve Benesh and Pam Spradlin for all of their time and support with the measurements throughout this study. Accurate Therapeutic Supply, Swansea, S.C. for donating the 12 comfort gel packs we used in the study. The Medical College of Ohio Nursing School and School of Allied Health awarding us the $130.00 Research Award Grant, which enabled us to order more gel packs to continue the study. And finally I would like to thank, Koroshi, Inc. in Toledo, OH for the generous $6,000 Grant they funded to provide one-month free training memberships for each subject who completed the study.
Abstract

According to past statistics, only approximately 35% of patients fully adhere to their home exercise programs. Due to the importance of gaining and maintaining range of motion in order to return to functional activities after an injury, and the low rate of adherence to home programs, it is important to know how long the effects of static stretching exercises will last if stretching is ceased. The purpose of this study was to compare the gains and retention of range of motion achieved by static stretching versus superficial cooling before static stretching. Subjects were randomly assigned into the standard stretching or the pre-cool group. Each group performed standing single leg hamstring stretches two times for 30 seconds, twice a day to each leg. The pre-cool group placed a cold gel pack on their hamstring for 10 minutes prior to performing the stretches. Subjects followed this protocol for four weeks everyday and then stopped stretching for the next four weeks. Hip flexion range of motion on each subject was measured each week for 9 consecutive weeks. All subjects made significant gains over the first four weeks of stretching, however there was not a significant difference between the standard and pre-cool groups at week four, (p>.10). However, at week eight the two groups were significantly different (p< .10). Therefore using a cold gel pack prior to stretching will improve range of motion at the same rate as stretching alone, but will retain more range of motion over time if the stretching is stopped. These findings are important for clinicians to implement into their treatment plans in order for their patients to retain the most range of motion possible once their treatment and home exercise program has been stopped.
Geller, Melissa

**Introduction**

Stretching is used and executed by, amateur and professional athletes, exercise enthusiasts and rehab specialists. One reason stretching is so popular among this diverse population is that it can provide many physical benefits to both healthy and injured individuals. Stretching is used to increase the length of a muscle across a joint in order to reinstate function, allow more functional movement and possibly to prevent injury.³

Research supports that stretching produces an increased range of motion/flexibility at a joint, by either increasing stretch tolerance or by increasing the length of the musculotendinous component.¹⁶ Most studies like Magnusson et al. and Gleim and McHugh, agree an increase in range of motion from a single session of stretching is due to lengthening of the musculotendinous junction. Long-term gains in range of motion however, are attributed to an increase in stretch tolerance versus an increase in actual muscle length.⁶,⁸,¹¹,¹² Feland et al. notes that connective tissue plays a large factor in flexibility. According to Feland et al., plastic deformation of tissue rather than elastic deformation, needs to be achieved in order for a prolonged increase in range of motion to take place.⁵ Plastic deformation occurs with an increase in tissue extensibility.¹⁰ Hardy and Woodall agreed with Feland et al and affirmed that in order for a permanent change in range of motion to take place the tissues have to be biologically adjusted.⁷

Superficial modalities such as ice and heat are also used throughout the general population, typically to decrease pain. In a rehabilitation setting specifically, cryotherapy is used to help alleviate musculoskeletal problems by decreasing pain, swelling, and/or muscle spasms.¹⁰
Geller, Melissa

Therapeutically, cryotherapy may be used in conjunction with stretching so that the cold impulses override the pain impulses being sent to the central nervous system allowing the patient to theoretically stretch to a greater degree without feeling an increase in pain. Cryotherapy applied before a stretch was found to decrease sensory input, pain and stretch reflex allowing patients to increase the range of motion at a joint.  

Cryotherapy has been found to decrease muscle spindle activity in a number of studies. This phenomenon assists patient to attain an enhanced stretch by decreasing muscle spasms. With a decrease in muscle spasms, a patient feels less discomfort and is able to attain a better stretch to the muscle with less pain. This decrease in muscle activity has been proven by electromyograhical studies that have recorded a decrease in muscle tension.

Cryotherapy can decrease muscle tension in order to improve flexibility of the muscle and increase the range of motion at the joint. Hardy and Woodall quoted in their study that cold followed by stretch was found to decrease muscle tension. Lentell et al also found that shoulder range of motion was increased further by using ice during a static stretch, than just stretching alone.

In a therapeutic setting ice and stretching could be combined in order to decrease a patient’s pain and muscle spasms allowing them to attain a better stretch and increase their range of motion. However, after a patient is discharged from therapy, only 35% of patients fully comply with their home exercise program. Therefore using cryotherapy with stretching
Geller, Melissa

may not only help to increase the range of motion gained at a joint, but also to retain the range of motion after the cessation of stretching.

To date, three studies have assessed the retention of range of motion after a stretching program.\textsuperscript{15,16,17} However, not one of these studies considered retention after using cryotherapy and static stretching together. Theoretically, because cold can inhibit pain and spasms a patient can stretch farther allowing for a plastic or more permanent deformation to take place in a muscle rather than an elastic or temporary change. Therefore, the purpose of this study was to assess the effects of superficial cooling when combined with static stretching. We assessed the rate change in range of motion during and after a stretching program of a cryotherapy and stretch group compared to a stretch only group. We had two hypotheses. Our first hypothesis was that the pre-cool group would gain more range of motion than the stretch group during a four-week stretching program. The second hypothesis, was that the pre-cool group would retain a greater amount of range of motion than the stretch group after four weeks of no stretching.

**Methods**

**Subjects**

Fourteen healthy subjects including staff, students, and friends of students from the Medical College of Ohio volunteered to participate in this study. The right and left legs of each subject were considered separately for a total of 28 legs. Subjects were between the ages of 18 and 45 in order to study the effects of ice and static stretching on healthy adults. Subjects were excluded from the study if they had any injury to their back, hip or knee with in the past
Geller, Melissa

year, or if they currently participated in a hamstring-stretching program. Prior to beginning
the study all participants signed an approved informed consent form for the Medical College
of Ohio’s Institutional Review Board.

**Stretching Protocol**

Subjects were educated on the proper stretching technique using a standing, single leg stretch
illustrated in Figure 1. The subjects were instructed to stretch to the point where moderate
discomfort was felt in the posterior thigh. If the
discomfort reduced during the 30 seconds, the
subjects were instructed to reach forward further
until moderate discomfort was felt again. The
stretch was repeated on each leg twice with the
subject taking a short five second rest in between
stretches. Stretching was repeated then twice a day
for a total of two minutes of stretching per day to
each hamstring muscle group.

All subjects were randomly assigned to either the standard stretching group or the pre-cool
group by the toss of a coin. Subjects in both groups followed the hamstring stretching
protocol described above however, the subjects in the pre-cool group used a 6”x 8” gel pack
placed directly on their skin in the middle of their hamstrings for ten minutes prior to
performing the stretch. Pre-cool subjects were instructed that a light towel or t-shirt could be
placed in between the gel pack and their skin if skin irritation was experienced. Ten minutes
of icing was used in order to cool the superficial layers of the skin but not induce a stiffening
of the muscle tissue itself. All subjects stretched seven days a week for four weeks. After four weeks of stretching, subjects in both groups ceased stretching for the next four weeks. A summary of the standard and pre-cool group protocols is listed in Table 1.

In addition to following the protocols, subjects were given a monthly calendar to log their stretching each day. This was used as a way to assess each subject’s adherence to the daily stretching.

Table 1. Stretching protocols for each group

<table>
<thead>
<tr>
<th>Standard Stretching Group</th>
<th>Pre-cool Stretching Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretch for 30 seconds</td>
<td>Place cold gel pack in the middle of posterior thigh for 10 minutes</td>
</tr>
<tr>
<td>Repeat stretch twice on each leg</td>
<td>Stretch for 30 seconds</td>
</tr>
<tr>
<td>Relax for a few seconds in between each stretch</td>
<td>Repeat stretch twice on each leg</td>
</tr>
<tr>
<td>Repeat this protocol twice a day</td>
<td>Relax for a few seconds in between each stretch</td>
</tr>
<tr>
<td>Repeat all steps every day for four weeks</td>
<td>Repeat this protocol twice a day</td>
</tr>
<tr>
<td>Do not perform any stretching during weeks 5-8</td>
<td>Repeat all steps every day for four weeks</td>
</tr>
<tr>
<td></td>
<td>Do not perform any stretching during weeks 5-8</td>
</tr>
</tbody>
</table>

Measurements

Hamstring range of motion was measured in a straight leg raise position (Figure 2). Subjects were initially measured for a pre-test measurement before they began stretching and then again once a week for 8 consecutive weeks. Past research has suggested that the time of day can effect muscle length, so the range of motion measurements were taken on the same day of the week, and at approximately the same time of day.3, 5
A Medical College of Ohio physical therapy student performed all measurements using a 12-inch goniometer. Prior to the beginning this study the physical therapy student was instructed on how to correctly perform the measurements by a licensed physical therapist. The subject’s leg being measured was raised and held in position by another physical therapy student. The same student held down the leg not being tested on the table in order to assure proper positioning of the hips and legs. The subject’s leg being measured was raised to the point a firm end feel was reached or the subject stated to stop.

**Statistical Analysis**

The reliability of the goniometer measurements performed by the physical therapy student was calculated by the intraclass correlation coefficient (ICC) using the pretest measurements. The ICC was found to be 0.96, with a 95% confidence interval (.88, .98).

The standard stretch group served as the control group in this study. A two factor ANOVA was used to search for interactions between the pre-cool group and the standard group over time. Two more two factor ANOVAs were used to look for specific interactions during the stretching period (weeks 1-4) and the cessation period (weeks 4-8). Independent t-tests were also used to analyze the means of the two groups at specific weeks throughout the study.
Results

Table 2 displays the mean values for both individual stretch methods at each week (1-8) and for the pre-stretch measurement. There was a significant interaction between time and stretch method (F = 5.69, df = 8, 19, p = .001). On examining the values of hamstring range of motion from the pre-stretching measurement to the end of the stretching protocol (week four), the standard group increased from $81.57^\circ$ to $102.50^\circ$ for a mean difference of $20.93^\circ$, while the pre-cool group increased from $82.57^\circ$ to $106.50^\circ$ for a difference of $23.92^\circ$. From week four to week eight when all subjects ceased the stretching protocol for four weeks, the standard group declined from $102.50^\circ$ to $93.79^\circ$ for a difference of $8.71^\circ$, while the pre-cool group decreased from $106.50^\circ$ to $102.57^\circ$ yielding a difference of $3.93^\circ$. To further analyze this significant interaction stretch method was compared to the pre-stretch measurement, week four and week eight, which also yielded a significant interaction (F= 2.833, df = 2.00, p = .078). Upon further examination, the two stretch methods were compared at pre-stretch measurement and week four yielding no significant interaction (F = .524, df = 1.00, p = .476). Stretch methods compared to week four and week eight also did not yield a significant difference, (F = 2.761, df = 1.00, p = .109), but possible

<table>
<thead>
<tr>
<th>Type of stretch</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE Standard</td>
<td>81.57</td>
<td>10.92</td>
<td>14</td>
</tr>
<tr>
<td>PRE-cool</td>
<td>82.57</td>
<td>14.91</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>82.07</td>
<td>12.84</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 1 Standard</td>
<td>87.50</td>
<td>10.37</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 1 Pre-cool</td>
<td>93.64</td>
<td>12.59</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>90.57</td>
<td>11.74</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 2 Standard</td>
<td>94.42</td>
<td>10.00</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 2 Pre-cool</td>
<td>95.57</td>
<td>14.05</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>95.00</td>
<td>11.98</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 3 Standard</td>
<td>97.00</td>
<td>10.09</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 3 Pre-cool</td>
<td>105.50</td>
<td>9.06</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>101.25</td>
<td>10.35</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 4 Standard</td>
<td>102.50</td>
<td>9.59</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 4 Pre-cool</td>
<td>106.50</td>
<td>9.49</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>104.50</td>
<td>9.69</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 5 Standard</td>
<td>100.35</td>
<td>10.83</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 5 Pre-cool</td>
<td>100.35</td>
<td>7.64</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>100.35</td>
<td>9.08</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 6 Standard</td>
<td>95.35</td>
<td>10.00</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 6 Pre-cool</td>
<td>100.92</td>
<td>9.45</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>98.14</td>
<td>9.96</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 7 Standard</td>
<td>94.35</td>
<td>11.11</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 7 Pre-cool</td>
<td>100.78</td>
<td>10.86</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>97.57</td>
<td>11.26</td>
<td>28</td>
</tr>
<tr>
<td>WEEK 8 Standard</td>
<td>93.78</td>
<td>11.30</td>
<td>14</td>
</tr>
<tr>
<td>WEEK 8 Pre-cool</td>
<td>102.57</td>
<td>10.23</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>98.17</td>
<td>11.48</td>
<td>28</td>
</tr>
</tbody>
</table>
clinical relevance. The power for the two-way ANOVAs representing pre-stretch and week four as well as week four and week eight respectively were .11 and .36. Figure 3 displays the comparison of measurements taken each week between the pre-cool and standard stretch group. From this information three independent t-tests were calculated, one for each of the individual time periods (pre, week four and week eight) compared to the two stretch method groups. The groups were equivalent at the pre-stretch measurement ($p = .841$) and at week four ($p = .230$), but were significantly different at week eight ($p = .041$). The power at week four was calculated to be .22.

**Figure 3.** Weekly ROM measurements
Discussion

This study continues to support the finding that static stretching can increase range of motion at a moveable joint, in particular motion at the hip joint. The pre test measurements from the two groups were not significantly different, which is what we expected with a randomized study. However, when reviewing the independent t-test at week four, the results were also not significantly different. This reinforces that static stretching increases range of motion at a moveable joint, but declined our hypothesis that superficial cooling would increase the effectiveness of a stretching program. These findings agree with the work of Taylor, Waring and Brashear. In their study, superficial pre-cooling did not significantly increase the range of motion gained by static stretching.  

Although there was not a significant difference between groups after the four week stretching protocol, this study, unlike any demonstrated that superficial cooling prior to stretching may aid in prolonging the ROM gained with a stretching program. The independent t-test at week eight presented a significant difference between the two groups. This data supports our hypothesis that pre-cooling will slow the loss of range of motion in the hamstrings.

Retention of the range of motion with the pre-cool group may be explained by the theory that deep tissues cool in order to heat superficial tissues when a superficial cooling agent is removed. A study performed by Enwemeka et al studied the temperature of tissues at different depths before and after the application of a cold pack. They concluded that after the removal of the superficial cold pack, temperatures at 2.0cm and 3.0cm lost heat equal to the amount of heat that was gained by the superficial tissues. Even 40 minutes after the cold
Geller, Melissa

pack was removed, the deeper tissues were still cooler than the superficial tissues. Enwemeka uses this phenomenon to explain why there is a reduction of pain, muscle spasms and edema with cryotherapy and why it is used in the clinical setting. This research was also supported by Swenson et al stating that the intramuscular temperature continues to decrease after the superficial cold agent is removed for several hours.

With this cooling phenomenon, the hamstring muscle tissue would cool after the cold gel pack was removed and continue cooling while the subject performed the static stretch. Subjects would have an increase in pain tolerance and stretch tolerance and a decrease in muscle spasms. This theoretically would allow them to stretch to a greater degree and reach a level of plastic deformation of the musculotendinous unit.

Another idea comes from Lin et al, that cryotherapy is more helpful to stabilize the extensibility of the muscle by stiffening the stretched fibers. This would aid in maintaining the length reached through the static stretch. When combining these two theories together one can see that by using a superficial cooling agent, one cools the superficial tissues. Once the agent is removed, the deep muscle tissue begins to cool, reheating the superficial tissues. If subjects stretch immediately after removing the cold gel pack, the muscle is cooling at the same time the stretch is occurring. This cooling would allow a decrease in pain sensation and an increase in stretch tolerance, eventually leading to tightening of the muscle tissue at the new lengthened position.
Further research focusing on the actual musculotendinous unit length and adaptations with cryotherapy is needed to support these theories. Willy et al proposed that the increase in range of motion after several weeks of stretching was due to a change in the musculotendinous unit length, but, there has not been any solid evidence to support this.\textsuperscript{16} Expanding the number of subjects in this study can also secure confidence behind these theories. Although our results at week four comparing the standard stretch method with the pre-cool stretch method were not significant (p > .10), the power of this test was very low (P = .11). This could be due to the small number of subjects that participated in the study. The pre-cool group did gain a greater degree of range of motion (23.92\textdegree{}), than the standard group (20.93\textdegree{}) and with more subjects a significant difference between the two groups could be found. Our results comparing week four to week eight were also not significant (p = .109), but were very close to being significant with p < .10. Again, with this analysis the power was very low (.36), and could be higher with more participating subjects. The rate of decline was markedly slower in the pre-cool group, (3.93\textdegree{}) than in the standard group, 8.71\textdegree{}. Therefore, by increasing the number of subjects in this study, can help support the theory that superficial cooling prior to stretching helps to retain range of motion gained from a stretching program.

**Conclusion**

Overall cryotherapy and static stretching alone or used in conjunction with one another does help to increase range of motion at a moveable joint. In the clinical setting cryotherapy can be effective with acute and chronic conditions.\textsuperscript{7} It is recognized that not all patients can tolerate cryotherapy. However, when patients present with muscle soreness and/ or spasms
the clinician should consider using a cold pack prior to stretching to decrease pain and help the patient retain the range of motion they would gain. This research is very important as well, considering only 35% of patients continue their home exercise programs.\textsuperscript{16} If patients can tolerate a cold pack prior to stretching, the overall range they will retain after they stop stretching will be greater than if they only stretched.
References


