Effect of intermittent stretching on the maintenance of flexibility in the hamstrings

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FINAL APPROVAL OF SCHOLARLY PROJECT
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Concentration in Physical Therapy

Effect of Intermittent Stretching on the Maintenance of Flexibility in the Hamstrings

Submitted by

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Effect of Intermittent Stretching on the Maintenance of Flexibility in the Hamstrings

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Medical College of Ohio Institutional Review Board for Human Subjects
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Koroshi Inc. - Toledo, OH

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Abstract

Study Design: Two-factor analysis of variance (2-way ANOVA)

Objectives: To determine the effects of intermittent stretching on the maintenance of flexibility in the hamstrings.

Background: Stretching is an accepted method to increase ROM. The research has shown that longer stretching durations provide more ROM benefits than short stretch durations. The ability to maintain ROM with intermittent stretching is not well – known.

Methods and Measures: 13 healthy subjects were randomly assigned into a control or intermittent group. Hip flexion ROM was measured passively. Each subject was measured at pre-test and at the end of each week for 8 weeks

Results: There was no difference in ROM between the control and intermittent stretching groups rate of gain. After week 5 the intermittent group maintained greater ROM than the control group. The control group lost 9 degrees of hip flexion from week 4 to week 8 and the intermittent group lost 3 degrees.

Conclusion: The control group lost ROM gains after cessation of stretching. The intermittent group maintained ROM gains with stretching 1-2 times per week. The results of this study indicate that stretching 1-2 times per week is enough to maintain ROM gains.
**Introduction**
There is controversy in the literature regarding improvement of flexibility. What is the appropriate way to stretch? How long should an individual stretch to increase flexibility? How long after stretching cessation are ROM gains maintained? These are all questions long discussed.\textsuperscript{1-7, 9, 11, 12} Research at times appears contradictory.\textsuperscript{1-7, 9, 11, 12} The purpose of this study was to investigate the effects of intermittent stretching on the maintenance of flexibility in the hamstrings. Research hypotheses included that there would be no difference between the control and intermittent stretching groups range of motion (ROM) during the first 4 weeks and that the intermittent group would maintain greater ROM than the control group during the last 4 weeks.

**Literature Review**
Numerous researchers have found that stretching increases ROM over a body segment. Bandy and Irion found that stretching for 30 seconds daily was effective in increasing ROM at the hip joint by 10 degrees over a six-week period. Harvey et.al. found that regular stretching increases the mean ROM 8 degrees at a joint. Some studies have looked at the specific physiological changes or adaptations that allow for the increases in ROM. Magnisson et.al. increased ROM due to a single bout of stretching is a change in the mechanical or viscoelastic properties of the muscle. Furthermore, Kubo et.al. concluded that stretch training increased the viscosity of musculotendinous, but not the elasticity of the musculotendinous unit.

Stretching can be applied in many different forms, including variations in technique, frequency, and duration. The three common types of stretching are: ballistic stretching, proprioceptive neuromuscular facilitation (PNF) technique, and static stretching. All three methods of stretching have been supported in the literature with regard to
improvement of joint ROM. The most commonly utilized stretch method to increase ROM is static stretching.

The length of time that a stretch should be maintained varies considerably within the research. Gajdosik found that high repetitions for short durations were the most effective in increasing ROM. In an earlier study by Madding et.al. a 15-second stretch produced similar increases in joint ROM as a 45-second and a 2-minute stretch. Others had research conflicting the results of the previous studies. Bandy and Irion found that 30-second and 60-second stretch were equally effective and increased ROM greater than stretching for 15 seconds. Bandy et.al. concluded that a 30-second stretch and 60-second stretch was equally effective. These two studies demonstrate that there will not be a greater increase in ROM with a long duration stretch than a short duration stretch, but the gains will be the same. Feland et.al. used subjects > 65 years old and showed that stretching for 60 seconds resulted in greater ROM gains compared to stretching for 30 seconds. The 30-second stretch was more effective than a 15-second stretch. This study included the residual effects of weekly measurements for 10 weeks. One study looked at the total daily stretch time compared to single bout time of stretching. Cipriani et.al. concluded that the single stretch duration did not make a difference in the ROM gains, but the total daily stretch time was the key to improved ROM.

Three studies have looked at the lasting effects of ROM increases after a stretching program. DePino et.al. looked at the duration of maintained hamstring flexibility after cessation of an acute static stretch. DePino et.al. found that four consecutive 30-second static stretches enhanced hamstring flexibility, but the improved hamstring flexibility only lasted for 3 minutes after cessation of the stretching protocol.
Willy et.al. conducted a study looking at the effect of cessation and resumption of static hamstring stretching on ROM. Willy et.al. concluded that after the initial stretching period knee ROM increased. After cessation of the initial stretching period knee ROM decreased to baseline. ROM increased again upon resumption of stretching, but the gains were not different from the initial gains. The study did not look at the rate at which the decline occurred in the termination stage of the study.

Harvey et.al. performed a systematic review and found that regular stretching increases joint ROM for more than one day after cessation of stretching. Harvey and colleagues found that possibly the effects of stretching are greater in muscle groups with limited extensibility.

One study has assessed frequency of stretch required per week in order to maintain ROM gained from initial stretch program. Wallin et.al. looked at ROM retention, but did not completely cease stretching. In this study the subjects intermittently stretched one, three, or five times per week, and found that stretching one time a week was enough to maintain improved ROM. While stretching three and five times per week increased ROM gains further.

Currently there is limited research on minimal frequency required to maintain ROM. The purpose of this study was to investigate the effects of intermittent stretching on the maintenance of flexibility in the hamstrings. We had 2 hypotheses. Our first hypothesis was that there would be no difference between the control and intermittent stretching groups ROM during the first 4 weeks. We further hypothesized that the intermittent group would maintain greater ROM than the control group during the last 4 weeks.

**Methods**
Subjects
15 healthy subjects volunteered to participate in the study. After the study was initiated one subject was excused from the study secondary to participating in other hamstring flexibility programs. Group 1 the control (standard) stretching group had fourteen subjects and group 2 the intermittent stretching group had fourteen subjects. Subjects consisted of students and staff members of the Medical College of Ohio. All subjects were free from low back and lower extremity injuries. At the time of the study twenty-eight subjects participated in the study, the control (standard) group with twelve females and 2 males (mean age = 25.7 years, SD ± 6.7, range 21-41 years of age, height 171.63 cm, SD ± 13.28, weight 79.36 kg, SD ± 18.18) and the intermittent group with twelve females and 2 males (mean age = 27.85 years, SD ± 9.6, range 22-43 years of age, height 171.99 cm, SD ± 4.39, weight 67.5 kg, SD ± 8.82). All subjects signed an approved informed consent form for the Medical College of Ohio’s Institutional Review board for Human Subjects.

Stretching Protocol
Subjects performed stretching exercise to the hamstring muscles of the thigh. The subjects were instructed to perform the stretch by doing a standing 1-legged stretch of the hamstring. Figure 1 illustrates the stretching position. The subjects pushed into the position until experiencing a moderate discomfort in the posterior thigh. Once the subject experienced moderate discomfort the subjects held that position for 30-seconds. The stretch was then repeated on the same leg for another 30 seconds and then also, done 2 times for 30 seconds on the opposite leg. The stretching protocol instructions given to the subjects are in Table 1.
Figure 1:

Total stretching time per session was 2 minutes and was done 2 times a day. The total stretching time each day was 4 minutes. The standard group stretched twice a day for 2 minutes for the first 4 weeks. Then weeks 5-8 the standard group did not stretch at all. The intermittent group used the same protocol that the standard group used and then after the first 4 weeks decreased to stretching 1-2 times per week for 4 additional weeks using the same protocol as the first 4 weeks. The subjects completed a daily log of their stretching. The log included on the day performed the time the stretching was performed or if the subject missed stretching for that day.
Table 1: Instructions to the subjects for the stretching protocol.

<table>
<thead>
<tr>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push into the stretching position until a moderate discomfort is felt in the posterior thigh.</td>
</tr>
<tr>
<td>Once the moderate discomfort is experienced then hold the stretch for a count of 30 seconds.</td>
</tr>
<tr>
<td>Repeat the stretch 2 times in the same session.</td>
</tr>
<tr>
<td>Relax for a count of 10 seconds between each stretch.</td>
</tr>
<tr>
<td>Repeat this procedure once a day with a minimum of 3 hours between sessions.</td>
</tr>
<tr>
<td>Repeat this procedure on the opposite leg.</td>
</tr>
<tr>
<td>Repeat this procedure every day for 4 weeks. Starting week 5 the control group stops stretching and the intermittent group only stretches 1-2 times per week.</td>
</tr>
</tbody>
</table>

Subjects were randomly assigned by a coin toss. Heads was the intermittent group and tails was the standard group. This process allowed for the subjects to be randomly assigned to a stretching group. All subjects stretched both legs. It was left to the subject’s discretion as to which leg to start each stretching session with.

**Measurement**
Figure 2 illustrates the position for measuring hip flexion. We measured hip flexion bilaterally with a straight leg raise. Hip flexion was measured with a standard 12-inch goniometer (McCoy, Chicago, IL). The same individual, a physical therapy 2nd year student, performed all measurements. The student took the measurements on 9 occasions: pretest, and at the end of each week for 8 weeks.
Data Analysis
We calculated the reliability of the goniometry measurements, with a single physical
therapy student, using the intraclass correlation coefficient (ICC). The ICC was 0.96 at a
95% confidence interval.

To analyze the data we used SPSS (New York City, NY). A two factor analysis of
variance (2-way ANOVA) with repeated measures on the within factor design was used.
The between factor has two levels control vs. intermittent. The control group was the
standard group that stretched everyday for the first 4 weeks and then weeks 5-8 did not
stretch. The independent variable was the stretching protocol and the dependent variable
was hip flexion. Next we examined for potential interactions between the rate of change
between the two groups. We used multivariate tests for the rate of decline between the
two groups. Lastly, we used independent t-tests to test if the groups started off equivalent
and different at week 8.

We had two hypotheses. Our first hypothesis was that there would be no difference
between the control and intermittent stretching groups range of motion. Our second
hypothesis was that at least one mean would be different from the other means for a
week.
Results
Means for hip range of motion for both protocols across 3 times were 82.58° (SD = 13.18, range = 52-109°); 104.71° (SD = 12.16, range = 90-135°); 98.83° (SD = 12.27, range = 83-123°) for the pretest, week 4, and week 8 measures, respectively. The interaction between time and groups was statistically significant with F = 4.274; df = 8, 15; and p = 0.008. Table 2 contains the mean values for each group and the overall mean for each time period (e.g. pretest, week 4, and week 8).

Table 2: Mean values of hip range of motion over 3 measurement time periods.

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th></th>
<th>Week 4</th>
<th></th>
<th>Week 8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Standard Group</td>
<td>81.17</td>
<td>11.80</td>
<td>103.58</td>
<td>9.66</td>
<td>94.97</td>
<td>11.81</td>
</tr>
<tr>
<td>Intermittent Group</td>
<td>84.00</td>
<td>14.83</td>
<td>105.83</td>
<td>14.6</td>
<td>103.00</td>
<td>11.72</td>
</tr>
<tr>
<td>Combined Groups</td>
<td>82.58</td>
<td>13.18</td>
<td>104.71</td>
<td>12.16</td>
<td>98.83</td>
<td>12.27</td>
</tr>
</tbody>
</table>

Group outcomes were significantly different (p< .10) each time period.

Figure 3 shows a plot of the mean ROM between the two groups from pretest to week 8.

![Figure 3: Mean hip flexion ROM from pretest to week 8.](image-url)
We tested different interactions to find out where the rate of gain/decline was significantly different between the two groups. We tested the pretest to week 1, pretest to week 2, etc… testing all time periods. There was no significant difference in the rate of gain between the standard and intermittent groups at any point during the first four weeks of stretching. After the control group stopped stretching, the intermittent group began to look different. The control group began to lose hip flexion ROM at a faster rate than the intermittent group. The control and the intermittent group both lost hip flexion ROM, but the control group lost at a faster rate and more hip flexion ROM. There was a significantly faster decline from week 4 to week 6 with F = 6.019; df = 1, 24; and p = 0.022 (p< .10). The mean hip flexion ROM for weeks 4 and 6 are in Table 3.

**Table 3:** Mean hip flexion ROM between two groups at week 4 and 6.

<table>
<thead>
<tr>
<th>Type of stretch</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 4</td>
<td>Control</td>
<td>102.500</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>105.833</td>
</tr>
<tr>
<td>Week 6</td>
<td>Control</td>
<td>95.357</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>105.250</td>
</tr>
</tbody>
</table>

There was a significant difference in the rate of decline from week 4 to week 7 between the two groups with F = 3.254; df = 1, 24; and p = 0.084 (p< .10). The mean hip flexion ROM for weeks 4 and 7 can be seen in Table 4.

**Table 4:** Mean hip flexion ROM between two groups at week 4 and 7.

<table>
<thead>
<tr>
<th>Type of stretch</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 4</td>
<td>Control</td>
<td>102.500</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>105.833</td>
</tr>
<tr>
<td>Week 7</td>
<td>Control</td>
<td>94.357</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>102.417</td>
</tr>
</tbody>
</table>

The rate of decline from week 4 to week 8 was significant with F = 6.38; df = 1, 24; and p = .019 (p < .10). In Table 5 are the mean hip flexion ROM for weeks 4 and 8.
Table 4: Mean hip flexion ROM between two groups at week 4 and 8.

<table>
<thead>
<tr>
<th>Type of stretch</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>102.500</td>
<td>9.597</td>
</tr>
<tr>
<td>Intermittent</td>
<td>105.833</td>
<td>14.602</td>
</tr>
<tr>
<td>Week 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>93.786</td>
<td>11.301</td>
</tr>
<tr>
<td>Intermittent</td>
<td>103.000</td>
<td>11.724</td>
</tr>
</tbody>
</table>

The first hypothesis that there would be no difference between the control and intermittent stretching groups ROM during the first 4 weeks was accepted. The two groups were equivalent at pretest with \( t = -1.18, p > .10 \) and stayed equivalent for the first 4 weeks of stretching with \( t = -0.697, p > .10 \) at week 4. The second hypothesis that the intermittent group would maintain greater ROM that the control group during the last 4 weeks was accepted. At week 8 the intermittent group maintained significantly greater ROM than the control group with \( t = -2.037, p < .10 \).

Discussion

Stretching is used as a method of increasing range of motion (ROM). The literature supports stretching as a method of enhancing ROM at a joint.\(^1,7\) Research is currently conflicting on stretching durations. Stretching durations vary from 10 seconds to 2 minutes being effective. The research supports 30 seconds or longer to be the most effective duration instead of short duration stretching.\(^1,2,5,6,9\) Cipriani et.al. found that the total stretch time is more important than the actual stretch duration. The research does not demonstrate a consensus with regard to how long after cessation of stretching the gains are maintained. Wallin et.al. found that in order to maintain ROM gains, stretching 1 time per week was enough. While stretching 1 time per week maintained ROM, stretching 3-5 times per week increased ROM gains. Once ROM is enhanced stretching at least one time per week will maintain the gains in ROM. In this investigation, subjects stretched 1-2 times per week. The ROM gains were not different...
for the two groups. The intermittent group maintained ROM gains where the control group did not maintain ROM gains.

Over the course of this investigation, the control group rate of gain over time declined after cessation of stretching. The intermittent group maintained rate of gain stretching 1-2 times per week. This is evident by looking at pretest measures to week 4 measures and week 5 measures to week 8 measures. The first hypothesis that there would be no difference between the control and intermittent stretching groups ROM during the first 4 weeks was accepted. Approximately 22 degrees of hip flexion ROM was gained from pretest to week 4 for both groups. The second hypothesis that the intermittent group would maintain greater ROM than the control group during the last 4 weeks was accepted. From week 4 to week 8 the control group lost approximately 9 degrees of hip flexion ROM, whereas the intermittent group lost approximately 3 degrees. Further research using a larger sample size is needed to demonstrate that intermittent stretching maintains ROM.

The results of this investigation may be useful for clinicians when developing a stretching protocol for a patient or client. The clinician can design the stretching program so that the patient or client will enhance ROM initially. Then once the ROM goal has been achieved the clinician can provide information to the patient to continue stretching 1-2 times per week to maintain enhanced ROM.

**Conclusion**

The purpose of this study was to test whether intermittent stretching would maintain ROM gains. We used a control group who stretched for 4 weeks and then stopped stretching after week 4 and an intermittent group who stretched for 4 weeks then at week 5 stretched 1-2 times per week. The control group lost ROM gains after cessation of stretching. The
intermittent group maintained ROM gains with stretching 1-2 times per week. The results of this study indicate that stretching 1-2 times per week is enough to maintain ROM gains.

**Clinical Application**
Clinicians are encouraged to have patients or clients to stretch initially everyday to gain ROM. Clinicians are also encouraged to have patients or clients continue stretching to maintain ROM gains, clinicians may also encourage a shorter stretching effort of 1-2 times a week after discharge versus everyday.

**References**


