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The Rate of Decline in Hip Range of Motion Following the Cessation of a Static Hamstring Stretching Program

Submitted by

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The Rate of Decline in Hip Range of Motion Following the Cessation of a Four Week Static Stretching Program

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For the consideration of the degree Master of Science in Biomedical Sciences with a concentration in Physical Therapy

Medical University of Ohio at Toledo
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ABSTRACT

Study Design: Prospective Test Retest Design.

Objectives: To document the rate of decline in hip range of motion (ROM) following the cessation of a long-term static hamstring stretching program.

Background: Static stretching programs are an integral component of rehabilitation programs, as well as an important part of sports conditioning programs. Benefits of stretching may include increased flexibility, muscular performance, and speed of the rehabilitation process, along with decreased risk of injuries and muscular soreness. Currently, the effect that cessation of stretching has on ROM has not been extensively studied. There is also a lack of consensus as to how long ROM benefits actually last following the conclusion of a stretching program.

Methods and Measures: 15 subjects (10 women, 5 men) volunteered to participate in four weeks of daily static hamstring stretching, followed by four weeks of cessation from stretching. One subject was unable to complete the study due to non-compliance. The mean age for these subjects was 24.6 yrs. (SD= 5.4, range 21-41yrs.) The static stretching program consisted of two 30 second hamstring stretches, performed two times daily, for a total stretching time of two minutes per leg, per day (for the initial four weeks of the study). A Pre-test hip ROM measurement, using a passive straight leg raise (SLR), was taken prior to the start of the study. Hip ROM measurements, thereafter, were recorded at the end of each week, over the course of this eight week study.
**Results:** This study utilized a simple, repeated measures analysis of variance in order to demonstrate the change in each subject’s hip ROM over the course of the study. Mean hip ROM significantly increased (p<0.05) during the stretching period, from Pre-test to Week 4 (71.4° ± 18.5° to 90.6° ± 20.5°). Mean hip ROM then significantly decreased (p<0.05), during the cessation period, from Week 4 to Week 8 (90.6° ± 20.5° to 83.9° ± 20.3°). Overall, the subjects had a significant total gain (p<0.05) in mean hip ROM from the Pre-test measurement to Week 8 (71.4° ± 18.5° to 83.9° ± 20.3°).

**Conclusions:** Hip ROM significantly increases following four weeks of a static hamstring stretching program. Hip ROM is also partially maintained for at least four weeks following the cessation of a stretching program.

**Key Words:** hamstring flexibility, stretching, cessation
INTRODUCTION

Static stretching has been a staple in numerous Physical Therapy rehabilitation programs, as well as in programs for competitive athletes. Static stretching is defined as tension applied to a muscle group in a slow and controlled manner (1, 5, 14). Stretching has many benefits including increasing flexibility, improving muscular performance, and speeding up the rehabilitation process. Stretching has also proven useful at decreasing the risk of injuries, and decreasing muscular soreness (1, 2, 5, 7, 8, 9, 11, 13, 14, 15, 16).

According to Starring et al, the hamstring musculature is particularly susceptible to shortening when not stretched on a consistent basis. This may help to explain why hamstring injuries are among the most common injuries occurring in the lower extremities (5). Hamstring injuries, and re-injuries, also occur frequently during sport activities (4). Reasons for these injuries may include insufficient extensibility, inadequate warm-up, ballistic movements, and/or poor body mechanics (5). Acute and chronic injuries are also more likely to occur in those individuals with limited flexibility (13). Therefore, a static hamstring stretching program may help decrease the likelihood of sustaining a hamstring injury.

Athletics, in particular, place a high value on enhancing muscular performance. Worrell et al found that increased hamstring flexibility is directly correlated with increased hamstring muscle performance during selective, open chain, isokinetic activities. According to Worrell, as the length of the muscle increases, so does the amount of energy that the muscle is capable of absorbing. This energy can then be used to generate a more forceful contraction. Thus, a more forceful contraction could potentially mean an increase in muscular performance.
Frequent static hamstring stretching has also been shown to shorten the rehabilitation process following a second degree hamstring strain (9). This is of clinical importance, particularly when dealing with athletes. If a static hamstring stretching program is initiated early on in the rehabilitation process, then the athlete has an increased likelihood of returning to his/her sport in a more timely fashion.

Clinicians and athletes may also be using several other modes of stretching, besides static stretching. Other stretching techniques such as ballistic stretching, proprioceptive neuromuscular facilitation (PNF), and dynamic range of motion (DROM) have been utilized to increase ROM (with varying results). According to current literature, static stretching has proven to be one of the most effective methods for increasing ROM, as compared with ballistic stretching, PNF, and DROM techniques (1, 3, 11, 16).

The duration a stretch is performed is another integral component of any stretching program. Cipriani et al focused on whether total stretch time was more important for increasing hip ROM than individual stretch durations throughout the day. Results demonstrated that a total stretch time of two minutes per day was sufficient to induce significant ROM increases. Doebler et al also found that a static stretch time of two minutes per day was far more effective at increasing hip ROM than stretch times of lesser duration. Thusly, current research has demonstrated that a daily static stretch time of two minutes is a sufficient duration to increase ROM.

Currently, there is a limited amount of research regarding the rate of change in ROM following the cessation of a stretching program. There are also conflicting results, among these studies, as to how long ROM gains last once stretching has ceased. Two
similar short-term stretching stretching studies by Starring et al, and Rubley et al examined the effects of an acute bout of static hamstring stretching on hip ROM. Starring et al found that an acute bout of stretching increased hip ROM for one week post-stretch, whereas Rubley et al found that an acute bout of stretching increased hip ROM for three weeks post-stretch. This demonstrates the present lack of consensus as to how long ROM gains last following the cessation of an acute static stretching program.

The aim of our study was to assess the lasting ROM effects of a chronic (i.e. long-term) static stretching program. There are presently only a few long-term studies, similar to this study, that have documented the lasting effects of ROM following the conclusion of a static stretching program. These studies also offer conflicting results as to how long ROM gains actually last following the cessation of a long-term stretching program.

One long-term study by Willy et al compared hip ROM measurements following the cessation and resumption of a static hamstring stretching program. The stretching program consisted of an initial six weeks of static hamstring stretching, followed by four weeks with cessation from stretching, and a final six weeks with resumption of the stretching program. The results demonstrated that ROM increased after the initial six weeks, decreased back to the original range following four weeks of non-stretching, and increased again following the resumption of the stretching program (with no significant change in ROM from the initial six weeks). The researchers concluded that ROM gains return to their baseline values four weeks following the cessation of a static stretching program.

A second long term stretching study by Guissard et al examined the effect of static stretching of the plantar-flexor muscles over the course of six weeks. Results
indicated that ROM was partially maintained for four weeks following the cessation of the stretching program.

A final long-term stretching study by Zebas et al documented the effects of six weeks of static stretching, followed by four weeks of cessation from stretching. This study also demonstrated that ROM gains are partially maintained for at least four weeks following the conclusion of a stretching program. In summary, the above studies offer conflicting results, demonstrating the general lack of consensus as to how long ROM gains actually last following the cessation of a long-term static stretching program.

To date, the effect that cessation of stretching has on ROM has not been extensively studied. There is also a lack of consensus, among current literature, as to how long ROM benefits will be maintained following the conclusion of a stretching program. Clinically, understanding these effects will help to increase the efficiency of rehabilitation programs by allowing clinicians to establish a stretching regimen, for their patients, with the intent of maximizing ROM gains. Knowledge of how long ROM will be maintained may also assist clinicians as they attempt to educate patients on how long ROM gains will last if a follow up home stretching program is not initiated upon discharge from therapy. The sports community may also benefit from the knowledge of how ROM increases and decreases over time. Understanding these effects may assist with the planning of on and off season training, in order to maximize the benefits derived from a stretching program.

Therefore, the purpose of this study was to document the rate of decline in hip ROM following the cessation of a long-term static hamstring stretching program. This may assist clinicians, patients, and athletes maximize the benefits derived from a
stretching program. It was hypothesized that hip ROM would increase significantly
during the first four weeks of the study (the stretching period), and that hip ROM would
decrease significantly during the final four weeks of the study (the cessation period). It
was also hypothesized that hip ROM would be partially maintained following four weeks
of cessation from a static hamstring stretching program.

METHODS

Subjects

Healthy adults between the ages of 18 and 50 were recruited for this study.
Selection of subjects consisted of using a sampling of convenience (i.e. Medical
University of Ohio students, employees, and relatives). All subjects signed an informed
consent form approved by The Medical University of Ohio Institutional Review Board.
All subjects also met the inclusion criteria of being 18-50 years old, and not currently
involved in a hamstring stretching program. Subjects were excluded from the study if
they were pregnant, had a current injury, and/or pain in their neck, trunk, lower back,
hips, thighs, knees, lower legs, and/or ankles. Subjects were not permitted to stretch their
hamstrings, except during specified times, throughout the course of the study. There
were no other restrictions placed on the subject’s activities of daily living or recreational
activities.

Design

This stretching study utilized a prospective test retest design. The study ran for a
total of eight weeks, with the initial four weeks of the study being the stretching period,
and the final four weeks of the study being the cessation period.
**Stretching Protocol**

A standing one-legged hamstring stretch was used for the purposes of this study (2). Subjects were instructed on the proper static stretching procedure prior to the start of the study. To start, each subject assumed an upright posture with both feet facing forward. The leg to be stretched was extended and placed on a surface at or slightly below hip level. Subjects then kept their back straight, while they hinged forward at their hips, until they felt slight to moderate discomfort in the back of their leg (i.e. the hamstrings). Subjects maintained this position of discomfort throughout the entirety of the stretch. Figure one illustrates the stretching position.

The initial stretch was held for a total of 30 seconds. This stretch was then followed by a 10-second rest, and a final 30-second stretch. The same procedure was then repeated for the contralateral leg. This stretching protocol was performed two times daily, with a minimum of four hours apart between protocols. For a total stretching time of two minutes per leg, per day. Stretching was performed seven days per week, for the initial four weeks of the study. The final four weeks of the study called for the cessation of all hamstring stretching. To ensure consistency and compliance, subjects kept a record of the time of day they performed each stretch.

**Measurement Procedure**

This study used a standard plinth to take the weekly hip ROM measurements. ROM was measured once each week using a 12 inch goniometer (Jamar, Miami, FL). An initial Pre-test measurement (of each subject) was taken just prior to the start of the study. Hip ROM, thereafter, was measured at the end of each week of this eight week study. To
start, each subject lay supine on a plinth with their knees bent over the side. One investigator positioned each subject’s leg (one at a time) in a passive straight leg raise (SLR). This same investigator applied a passive range of motion force, to each leg, until the subject felt slight to moderate discomfort in the hamstrings. This position was held while a second investigator used a goniometer to take the hip ROM measurements (Figure two). Although right and left lower extremity measurements were taken for each subject, only measurements of each subject’s right leg were analyzed for the purposes of this study.

This measuring investigator then read the ROM measurement aloud, and the results were recorded by a third and final investigator. The third investigator kept documentation of all the ROM measurements, and had sole access to these records. All three investigators performed the same duties for the entirety of the study.

Prior to the start of the study, the measuring investigator took two separate ROM measurements of each subject’s right leg (on two separate occasions) in order to determine intrarater reliability. Intraclass Correlation Coefficients (2,1) were determined and demonstrated that the investigator had a high intrarater reliability of 0.95 (CI<sub>95</sub> = 0.91, 0.97).

**Statistical Analysis**

This study utilized a simple, repeated measures analysis of variance in order to demonstrate the change in each subject’s hip ROM over the course of the study. Planned repeated contrasts were used to test for weekly changes over time. In addition, pairwise
post hoc tests were used to test the Pre-test and Week 4, Week 4 and Week 8, and Week 8 with the Pre-test.

RESULTS

15 subjects (10 women, 5 men) volunteered to participate in four weeks of daily static hamstring stretching, followed by four weeks of cessation from stretching. One subject was unable to complete the study due to non-compliance. The mean age for these subjects was 24.6 yrs. (SD= 5.4, range 21-41yrs.) Subject demographics of height, weight, and age are depicted in Table 1.

The simple, repeated measures analysis of variance showed that there was a significant change in hip ROM over time (Table 2). With a significant increase in hip ROM occurring each week, during the initial four weeks of the study (the stretching period). The greatest hip ROM losses occurred during the final four weeks of the study (the cessation period); however, losses between weeks were not significant (Figure 3). Pairwise comparisons demonstrated that there was a significant increase (P< 0.05) in hip ROM between the Pre-test measurement and the measurement taken during Week 4 (the stretching period) (71.4° ± 18.5° to 90.6° ± 20.5°) (Figure 4). Pairwise comparisons also revealed that hip ROM significantly decreased (P<0.05) from Week 5 to Week 8 (the cessation period) (90.6° ± 20.5° to 83.9° ± 20.3°) (Figure 5). Paired Samples T-Tests were then performed in order to compare each subject’s ROM at initial and at the conclusion of the study. Overall, the subjects had a significant total gain in mean hip ROM from the Pre-test measurement to Week 8 (71.4° ± 18.5° to 83.9° ± 20.3°) (Figure 6).
DISCUSSION

We reject the null hypothesis for the first hypothesis because hip ROM did increase significantly during the initial four weeks of the study, and hip ROM did significantly decrease during the final four weeks of the study. We also reject the null hypothesis for the second hypothesis because hip ROM was partially maintained for four weeks following the cessation of the stretching program. While there is a significant loss in hip ROM following four weeks of cessation, final hip ROM measurements were still significantly higher than those of the initial ROM measurements. These finding are consistent with those of several other studies (7, 16).

The results of this study conflict with those of Willy et al who found that hip ROM returned to baseline following four weeks of cessation from a static hamstring stretching program. This could be due to several key factors. Willy et al chose to use only those individuals who were defined as having operationally short hamstrings. Using only individuals with tight hamstrings could have affected the outcome of the study because it is unknown whether there is a different rate of decline in ROM among those individuals with tight hamstrings, and those individuals without tight hamstrings. In addition, the stretching protocol that Willy et al chose to use called for subjects to stretch their hamstrings for only one minute per day. Current literature suggests that a stretching time of two minutes per day is ideal for significantly increasing ROM (2,6). Therefore, this stretching protocol may have not been extensive enough to produce any significant results. Finally, Willy et al chose to have their subject’s stretch only five days per week, as compared to our seven days of stretching per week. This too could explain the difference in results.
The results of this study also demonstrated roughly double the ROM gains as compared with other similar studies. The aforementioned long-term studies by Willy et al, and Guissard et al reported mean ROM gains around ten degrees. In addition, the majority of published stretching studies also report a mean gain in ROM of approximately ten degrees (3). Our study found a mean gain of approximately 20 degrees. This could be due to the more aggressive stretching protocol that had subjects maintain the feeling of discomfort throughout the entirety of the stretch. Our study also required subjects to stretch their hamstrings for the aforementioned seven days per week. This approach may have contributed to the significantly higher results, of this study, as compared with other similar studies. In summary, this study’s significantly larger ROM gains may be attributable to the increased stretching intensity, and the aggressive seven days per week stretching program.

From a clinical perspective, the results of this study may further assist clinicians as they attempt to educate their patients on the importance of compliance with home exercise programs (HEP). The clinician may now be better equipped to educate their patients on how quickly ROM will increase or decrease (based on the level of compliance with a home stretching program). Clinicians may also be better able to illustrate how quickly ROM gains will be lost if a maintenance HEP is not initiated upon discharge from therapy.

Athletes, and their coaches, could also benefit from the findings of this study. The knowledge of how ROM increases and decreases over time may assist with the planning of on and off season training, in order to maximize the benefits derived from a stretching program.
This study had several limitations associated with it. First, this study used a sampling of convenience. Future studies may chose to broaden the sampling size in order to add more diversity to the subject pool. A second limitation was that the majority of subjects were physical therapists, or physical therapy students. Having a background in physical therapy may have influenced the measurements because of the subject’s potential preconceived notions of how ROM would increase or decrease over time.

Future studies may choose to look at changes in ROM beyond four weeks of cessation in order to determine how long it takes for ROM to return to baseline. Future studies may also choose to keep subjects blinded to their weekly ROM measurements, to avoid influencing subjects in one form or another. Different muscle groups could be looked at to see if there are different rates of decline among the different muscles. Finally, our study chose to use healthy individuals, aged 18-50 years old. Future may assess the younger, older, and injured populations as well.

**CONCLUSION**

The results of this study indicate that engaging in a four week static hamstring stretching program will significantly increase hip ROM. This study also found that there is a significant loss in hip ROM following four weeks of cessation from stretching. Lastly, that hip ROM is partially maintained following four weeks of cessation from a stretching program.

Consequently, clinicians can use this knowledge as they attempt to educate their patients on the importance of compliance with HEP’s. This is of particular importance upon discharge from therapy since patients must initiate a maintenance HEP, in order for
ROM gains to be maintained. Furthermore, athletes and coaches may now be better able to design on and off season training. Training can now be designed around how ROM increases and decreases over time, in order to fully maximize the benefits derived from a stretching program.
REFERENCES


16. Zebas, CJ, Rivera ML. Retention of flexibility in selected joints after cessation of a
stretching exercise program. *Exercise Physiology: Current Selected Research.*
Appendix A

Figure 1. The standing one-legged hamstring stretch.
Figure 2. Position and SLR technique for measuring hip ROM.
Table 1. Descriptions of subject’s height, weight, and age.

<table>
<thead>
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<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
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<tr>
<td>Valid N (listwise)</td>
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Appendix D

Table 2. Mean hip ROM, Standard Deviation, and Number of subjects from the Pre-test measurement through Week 8.

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<td>14</td>
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<td>85.9286</td>
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<td>WEEK8</td>
<td>83.9286</td>
<td>20.30333</td>
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</table>
Figure 3. Mean hip ROM from Pre-test through Week 8
* Significant change at p < 0.05.
Figure 4. Mean hip ROM comparing the Pre-test measurement with Week 4 (values significantly different at $p < 0.05$).
Appendix G

Figure 5. Mean hip ROM comparing Week 4 with Week 8. (values significantly different at $p < 0.05$).
Appendix H

Figure 6. Mean hip ROM comparing the Pre-test measurement with Week 8. (values significantly different at p <0.05).