Rate of decline of ROM following the cessation of a stretching program

Stephen Benesh
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

Rate of Decline Following the Cessation of a Stretching Program

Submitted by

Stephen Benesh

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:
RATE OF DECLINE OF ROM FOLLOWING THE CESSATION OF A STRETCHING PROGRAM

Stephen Benesh

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 Cipriani, Ph.D., P.T.
ABSTRACT

Study Design: Single-group repeated measures

Objectives: To determine the rate at which range of motion (ROM) declines will occur at the hip joint with the cessation of hamstring muscle stretching.

Background: Past studies have shown that stretching results in an increase in ROM about a joint. Similarly, when stretching exercises are ceased, decreases in ROM are the result. However, it has not been determined in the literature at what rate these declines occur.

Methods and Measures: Analyzed the effects of four weeks of static hamstring stretching and four weeks of cessation of flexibility exercises on hip ROM with the knee extended. Seven subjects, each contributing two lower extremities (14 measurements) participated in a stretching protocol. Subjects stretched both lower extremities, twice a day. Each session consisted of two 30-second stretches. Hip flexion ROM was measured before the stretching protocol and once a week during for eight weeks. There were nine measurements in total.

Results: Mean hip ROM increased 20.93 degrees from the pre-measurement to week four (stretching period). During the cessation period (week four to week eight) ROM decreased by 8.71 degrees. 7.14 degrees were lost between the first two weeks of the cessation phase (weeks four and six) and 1.57 degrees was lost during the final two weeks of this period (weeks six to eight)

Conclusion: When ceasing a stretching protocol, the greatest declines in ROM will occur in the first two weeks following the flexibility program.
Chapter I

Introduction

Muscle stretching is a common form of physical exercise. The main benefit of stretching is increased range of motion about a joint. Several studies have shown this. However, limited research exists pertaining to the rates at which ROM gains are made during a stretching program and lost when ending a stretching regimen. Studies are needed to determine these trends so stretching programs can be tailored to both maximize and maintain ROM gains.

The purpose of this study was to discover the rate at which ROM gains are made at the hip joint during a stretching program and the rate at which these gains are lost when ceasing flexibility exercises. During this study hip flexion ROM measurements, with the knee extended, were taken using a standard 12-inch, double arm goniometer. Seven participants enrolled in the study. They accounted for 14 lower extremities that were measured over an eight-week period. For the first four weeks, subjects completed a daily hamstring-stretching program. During the latter four weeks they postponed all hamstring stretching. A total of nine weekly measurements were taken and recorded during the course of the study.

The data collected was examined statistically using a simple repeated measures analysis of variance. It was hypothesized that the greatest ROM gains during the four week stretching period would be achieved in the first two weeks as compared to the last two weeks. Further, the greatest ROM declines made during the four-week cessation phase would happen in the first two weeks compared to the latter two weeks. Finally, it was hypothesized that the ROM gains made during the stretching phase would not be retained following a cessation period.
Chapter II

Literature Review

Muscle stretching is a fundamental part of therapeutic exercise. Athletes, recreational enthusiasts, and clinicians all utilize this practice. Primarily, stretching is used as a means to increase joint range of motion. Rehabilitation specialists use stretching in order restore a patient’s lost motion due to injury or immobility, while athletes engage in flexibility activities to increase performance.

Past research collectively supports that flexibility exercises enhance range of motion over a body segment. Bandy and Irion (1994) found that 30 seconds of daily stretching was effective in increasing ROM at the hip joint by 10 degrees over a six-week period. Other studies have investigated the specific physiological adaptations that allow for this increase. According to Magnusson et al. (1995) enhanced joint range, due to single bout stretching, is attributed to greater musculotendinous lengthening. Conversely, long-term gains from stretching were credited to an increase in stretch tolerance, with no adaptation in muscle length. Moreover, Kubo et al (2002) found that stretching the medial gastrocnemius muscle over eight weeks increased the viscosity of musculotendinous unit.

Anecdotally, stretching has been used as a means to prevent injury, improve athletic performance, and minimize muscle soreness. The literature is not as conclusive on these benefits, however. Orchard et al. (1997) found no relationship between hamstring flexibility and muscle injury in Australian Footballers. However, in a prospective study among 146 professional soccer players, Witvrouw et al. (2003) indicated that increased tightness of the hamstring and quadriceps was correlated with higher incidence of injury in both muscle groups.
Research supporting the efficacy of stretching for decreasing muscle soreness is the least definitive. Johansson et al. (1999) concluded that pre-exercise static stretching had no preventative effect on muscular soreness following heavy resistance exercise. However, evidence supporting the converse is also available.

The application of stretching is quite varied by technique, frequency, and duration. Three of the most common types of stretching exercises include: static, ballistic, and proprioceptive neuromuscular facilitation (PNF) techniques. Past research has demonstrated that all three methods are effective in increasing joint range of motion. Still, the ballistic technique is not widely supported in the literature because the dynamic movement used in this method may injure the skeletal muscle by exceeding its extensibility. PNF stretching uses an isometric contraction followed by a period of relaxation. Effective use of this technique requires an experienced clinician. Hence, static stretching is the most common method used by the general population.

Gajdosik (1991) study confirmed that high repetitions for short duration stretches are the most effective in increasing range of motion. Yet, the length of time specified for each repetition varies considerably in the research. Madding et al. (1987) concluded that a 15-second stretch produced similar increases in joint range of motion compared to both 45-second and two minute timed stretches. The results from Bandy and Irion (1994) conflicted with this data. They determined that 30-second and 60-second stretching lengths were equally effective and increased ROM greater than 15-second stretches. With subjects who were 65 years of age and older, Feland et al. (2001) concluded that a 60-second stretch resulted in greater gains in ROM compared to a 30-second stretch after adding the residual effects of weekly measurements for 10 weeks. The 30-second duration was more effective than a 15-second stretch. In all of these
Benesh, Steve

studies, the total daily stretch time varied and this inconsistency may have been the reason for conflicting outcomes. Cipriani et al. (2003) found that the time for a single stretch bout was not a major factor in increased ROM. Rather, the sum of daily stretching time played a key role in greater mobility about a body segment. All in all, no difference was found between six repetitions of 10-second stretches and two repetitions of 30-second stretches, as long as daily cumulative stretching totaled two minutes.

The literature supports that engaging in static stretching for a particular daily time period, over several weeks, will result in an enhanced range of motion due to greater stretch tolerance and increased tendon viscosity. These benefits are often sought in the rehabilitation setting. Typically, a patient who has a musculotendinous injury will undergo passive stretching exercises during therapy and will also receive home exercises, which include strength and flexibility training. Due to the limited number of physical therapy sessions covered by insurance, it is essential that patients adhere to home exercise programs in order to achieve the best possible recovery from a debilitating condition. According to Sluijs et al. (1993) only 35% of patients fully adhere to their exercise programs. If patients discontinue therapeutic exercises, then it is important to know how long the ROM gains made during therapy will last. The research on the retention of strength gains is rather comprehensive. Similar studies concerning stretching are not as numerous and detailed.

Three studies to date have questioned if ROM increases are retained after a stretching program. Wallin et al. (1985) used 47 male subjects to determine the amount of stretching that was needed to maintain ROM after an initial training program. Subjects were randomly assigned to four different groups: Groups A, B, and C trained using PNF stretching and Group D used ballistic stretching. The initial program lasted 30 days and subjects stretched three times per
week. The plantar flexors, adductors, and hamstrings were the muscles of interest. After 30 days of stretching, all four groups participated in another 30 days of stretching. Group A stretched once per week for 30 days. Group B and D continued at three times per week (group D crossed-over to PNF in the second 30 day session). Group C stretched for five days a week. All groups in the initial phase had significant improvements in joint range of motion among the three muscle groups. In the second phase, Group A (1x/week) showed no significant increase in ROM, but stretching gains were maintained. Group B (3x/week) and Group C (5x/week) had significant improvements in movement about the joint; with C’s increase being greater than B’s. Group D (3x/week, cross-over) demonstrated an increase similar to that of Group B. In short, stretching one day a week, after participating in an initial flexibility program, was enough to maintain gains in ROM made from the initial program. Additionally, stretching three and five times a week resulted in additional gains in ROM.17

Zebas and Rivera (1985) also looked at ROM retention, but completely ceased stretching activities after the initial training phase. Studying ROM about the ankle, hip, trunk, shoulder, and neck the investigators divided subjects into three stretching groups: ballistic, PNF, and static. Measurements were taken after the six-week training phase, and at two and four weeks during the cessation period. Following the opening stretching phase, all three groups made similar gains in ROM. After the cessation period, the static and PNF groups showed significant retention of ROM gains; however, the ballistic group returned to pre-training levels. Although this study did address the issue of cessation directly, the methods, especially for the stretching protocols were vague. No information was given concerning intensity, duration, and the technique for stretching. The standards used for measuring ROM were also unclear.21

6
Willy et al. (2001) conducted a similar study focusing on cessation after stretching. The study had 18 subjects, who each had one leg randomly assigned to the experimental group, while the contralateral limb served as the control. The duration of the study spanned 16 weeks. The first six weeks were the initial stretching stage, followed by a four-week cessation period. In the final six weeks, stretching was resumed. During the treatment stages, subjects performed upright hamstring stretches that consisted of two, 30-second stretches each day, five times per week. Joint motion about the knee was measured on both the treatment and control legs. Measurements were performed before and after the three phases. The results showed that knee ROM in the stretched leg increased significantly after the initial stretching phase. A decrease in ROM was recorded after the cessation period. The final measure was not statistically different than measure following the stretching phase. Therefore ROM gains made during the stretching program were lost. Following the resumption phase, knee ROM increased significantly, but was not statistically different from the measurements taken after the initial stretching period. Although Willy and colleagues found that ROM gains were not retained after a four-week cessation period, they did not study the rate at which the decline occurred during the termination stage.19

**Problem Statement**

If ROM gains are not sufficiently retained after four weeks of not stretching, then patients who fail to comply with a home exercise program may be susceptible to re-injury or long-lasting impairment. Similarly, athletes who stretch inconsistently may never achieve optimal flexibility for performance. Further investigation is needed to discover at what rate ROM gains are lost. The results can provide information on the degree of consistency that is needed for a stretching program to be maximally effective.
Benesh, Steve

Purpose

The purpose of the study was to examine the effects on hip ROM after postponing stretching. It was hypothesized that hip ROM will increase significantly during a four-week stretching phase and will decrease significantly during a four-week cessation period. After cessation, it is theorized that hip ROM will return to pre-measurement levels. In addition, subjects will display greater flexibility gains in the first two weeks of stretching when compared to the latter two weeks. Greater declines in the first two weeks of the cessation phase are also expected. If it is shown that ROM gains are not retained sufficiently following a cessation period and considerable flexibility is lost within the first few weeks of not stretching, then immediate and ongoing adherence to a home exercise program/stretching regimen is essential to both maximize and maintain ROM about a joint.

Chapter III

Methods

Design

Single group repeated measure design

Subjects

Seven healthy subjects (6 female, 1 male) were recruited as a sample of convenience from the Medical College of Ohio and University of Toledo (mean age = 25.7 years, SD = 6.7, range = 21-41 years of age). This resulted in 14 observations, with each subject contributing two lower extremities. Specifically participants were included if they had a no history of knee, hip, or low back injuries within the last year and were not currently participating in a lower extremity-stretching program. Written informed consent was obtained from all subjects. The
Instrumentation

The researcher used a standard 12-inch, double arm goniometer to measure range of motion about the hip joint. This device has been determined to be reliable according to past research. In order to measure hip ROM, the technique outlined by Norkin and White was used. Sufficient intra-rater reliability was obtained as demonstrated in Table 1.

Table 1. Intraclass Correlation Coefficient values with the 95% confidence interval

<table>
<thead>
<tr>
<th>Measure</th>
<th>ICC</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip ROM</td>
<td>.96</td>
<td>.88</td>
<td>.98</td>
</tr>
</tbody>
</table>

Procedures

Overview: The study lasted a total of eight weeks. For the first four weeks subjects participated in a hamstring stretching program. The next four weeks represented the cessation period. Range of motion of the hip joint was measured before the stretching program and after each subsequent week during the study. Likewise, in the cessation phase hip ROM was also measured once per week. This accounted for a total of nine measurements. For each subject, two measurements (both right and left legs) were taken during a session. All measurements took place on the same day and at the same time each week for a given subject.

Measurement Protocol: This study repeated the measurement technique used by Cipriani et al (2003). All ROM measurements were taken with the subject lying supine on a plinth. Two investigators were needed to complete the measurement. One made the goniometer reading while the other positioned the subject. The same two researchers performed their respective jobs through out the duration of the study. The contralateral leg that was not involved in the
measurement, laid flat on the plinth surface at the thigh and the knee was flexed at the edge of the plinth, allowing the lower leg to hang over the table. The investigator applied support to the upper thigh of this leg to ensure a neutral limb and stable pelvis. The measurement leg was extended to zero degrees at the knee and passively flexed at the hip until the investigator noted a firm end feel or when the subject requested to stop. A standard 12-inch goniometer was used to measure ROM. Body landmarks used to take the measurement were the greater trochanter serving as the axis, lateral epicondyle of the knee as the movable arm, and the midline of the pelvis as the stationary arm. Both the right and left legs of each subject were measured. All measurements were taken in the Physical Therapy Lab at the Medical College of Ohio.

**Stretching Protocol:** The stretching program described by Cipriani et al. (2003) was utilized in this study. Subjects were instructed to perform a hamstring stretch in a standing position with one leg raised forward and resting on an elevated surface (e.g., chair or cabinet). The leg was elevated approximately knee to waist high, with the knee fully extended, head forward, and the hip in zero degrees of rotation. Subjects were instructed to point the support foot forward and to raise their arms so they were parallel to the ground. Once this position is achieved, the subject flexed forward at the hip until they experienced moderate discomfort in the posterior thigh. A neutral spine was maintained throughout the exercise. The stretching protocol consisted of two minutes of daily stretching for seven days of the week. There were two sessions daily, separated by at least three hours. During each session, the subjects performed a 30-second stretch, followed by a one to two second rest period, and then another 30-second stretch. All subjects completed this protocol on both right and left legs. Participants were asked to write in a daily log to document their stretching times and return this form on the last day of the study. This instrument was used to increase adherence.
Data Analysis

The independent variable in the study was the type of stretching cessation. This variable had one level – standard stretching. The dependent variable was hip flexion range of motion measured at the angle formed by the hip and the pelvis, with the knee extended. The study consisted of a single group repeated measure design. No control group existed. The absence of a control group was justifiable since past research had shown that non-stretching periods resulted in no significant gains in ROM.$^{2,19}$ A simple repeated measures analysis of variance was used to determine the differences in hip range of motion within the group over time as well as the interaction effect of group and time. SPSS statistical software was used to conduct the analysis of the data. The p-value was set at .10 because the potential of rejecting a true null hypothesis would not place a subject at undue risk.

Chapter IV

Results

Each of the seven subjects that participated in the study accounted for two measurements – both right and left lower extremities (N=14). Females made up 85.7% of the measurements (n=12) while males totaled 14.3 % (n=2). General subject demographics concerning age, height, and weight are outlined in Table 2. The mean range of motion measurements, taken from fourteen lower extremities over nine weeks, and descriptive statistics are also included in the table.
Table 2  General Information

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>25.7143</td>
<td>6.71884</td>
<td>21</td>
<td>41</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.63</td>
<td>13.281</td>
<td>150</td>
<td>196</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>79.36</td>
<td>18.187</td>
<td>59</td>
<td>113</td>
</tr>
<tr>
<td>PRE (degrees)</td>
<td>81.5714</td>
<td>10.92432</td>
<td>60.00</td>
<td>100.00</td>
</tr>
<tr>
<td>WEEK 1</td>
<td>87.5</td>
<td>10.37564</td>
<td>65.00</td>
<td>101.00</td>
</tr>
<tr>
<td>WEEK 2</td>
<td>94.4286</td>
<td>10.00549</td>
<td>66.00</td>
<td>105.00</td>
</tr>
<tr>
<td>WEEK 3</td>
<td>97.0</td>
<td>10.09189</td>
<td>79.00</td>
<td>113.00</td>
</tr>
<tr>
<td>WEEK 4</td>
<td>102.50</td>
<td>9.59768</td>
<td>85.00</td>
<td>120.00</td>
</tr>
<tr>
<td>WEEK 5</td>
<td>101.1667</td>
<td>11.09327</td>
<td>82.00</td>
<td>115.00</td>
</tr>
<tr>
<td>WEEK 6</td>
<td>95.3571</td>
<td>10.00467</td>
<td>78.00</td>
<td>110.00</td>
</tr>
<tr>
<td>WEEK 7</td>
<td>94.3571</td>
<td>11.11207</td>
<td>70.00</td>
<td>110.00</td>
</tr>
<tr>
<td>WEEK 8</td>
<td>93.7857</td>
<td>11.30132</td>
<td>72.00</td>
<td>111.00</td>
</tr>
</tbody>
</table>

A simple repeated measures analysis of variance was performed on the data. Statistical analysis showed significant change of hip flexion ROM over time between at least two means (F=12.08, df=8, 6; p<.10). Individual paired t-tests were used to determine which specific means were statistically different. The analysis revealed significant (p<.10) ROM gains, during the stretching phase, between the compared measurements at weeks one and two, weeks three and four, and between the PRE measurement and week four. ROM measurements between the PRE measure and week 1, along with week two to week three were not statistically different. A significant (p<.10) decline in ROM was present between weeks five and six. The changes in
ROM between weeks four and five, six and seven, and seven and eight were not significantly different. Further analysis revealed a significant (p<.10) ROM decline between the means found at the end of week four and week eight. The pre measurement was significantly different than week eight. Figure 1 illustrates the mean values of hip flexion ROM during the nine measurement times.

**FIGURE 1**

![Estimated Marginal Means of MEASURE_1](image)

p<.10 for all the below results

- a: no significant difference between pre and week 1
- b: significant difference between week 1 and week 2
- c: no significant difference between week 2 and week 3
- d: significant difference between week 3 and week 4
- e: no significant difference between week 4 and week 5
- f: significant difference between week 5 and week 6
- g: no significant difference between week 6 and week 7
- h: no significant difference between week 7 and week 8
Chapter V
Discussion

Stretching is a widely practiced activity utilized in the athletic, recreational, and therapeutic settings. Flexibility exercises have been proven to increase ROM about a body segment, allowing for increased functional mobility. As hypothesized, the four-week stretching phase produced significant gains in hip flexion ROM. Moreover, the four-week cessation period resulted in a significant decline in flexibility of the hamstrings. These trends are consistent with the literature.\textsuperscript{6,17,19,21}

Past research, however, has not closely analyzed the rate at which flexibility increases and decreases. This present study attempted to discover the degree at which ROM is gained and lost at the hip joint. Subjects were measured once a week during the eight weeks of the study. To the knowledge of the investigators no studies to date have taken measurements on a weekly basis during both a stretching and cessation period. For the duration of the four-week stretching phase, the greatest gains in ROM occurred during the first two weeks, as hypothesized. Cipriani et al. (2003) determined that after a six-week stretching cycle, the greatest gains in hip flexion ROM were made during the initial three weeks when compared to the latter three weeks. Cipriani’s data represented a quadratic trend when placed in graphical form. This relationship was present over the six weeks and it depicted diminishing ROM gains over time. Similarly, the greatest declines in ROM occurred in the first two-weeks of the cessation phase.\textsuperscript{4} Zebas and Rivera (1985) found similar results during a four-week cessation phase following a six-week stretching program.\textsuperscript{21}

There was a significant difference between the means of the PRE measurement and week eight. The statistics showed that even after the cessation phase, ROM gains were retained.
Specifically, there was a mean retention of 12.214 degrees. This differs drastically from Willy et al who observed zero degrees of retention after a four-week cessation period. Several factors could have caused this dissimilarity. First, the stretching program used by Willy consisted of two 30-second stretches per day, for five days, totaling 60 seconds of stretching per day. The protocol in the present study required subjects to stretch twice per day, with each session made up of two-30 second stretches, every day of the week. The total daily stretching time equaled two minutes. The total weekly stretching time equaled 14 minutes compared to five minutes. Increased stretching time may have aided in retention. In other words, increased stretching time may have led to greater ROM gains, which would have taken more time to regress during a cessation period. Secondly, 12 men and six women participated in Willy’s study, while one male and six females completed the present experiment. It appears that females may retain flexibility better than men. A third possibility is that once a week measurements provided a stimulus to maintain a certain pain threshold, allowing for retention in ROM. Wallin et al. reported in their study that stretching once per week was sufficient to maintain improved joint mobility from a stretching program.

Nevertheless, these findings suggest that ROM gains decline significantly after ceasing stretching activities for four weeks, with the greatest reductions occurring in the first two weeks. These results have significant implications in therapeutic setting. Stretching treatments are often used in physical therapy to increase the patients ROM in order to restore functional mobility. Home exercise programs are typically given to a patient to complement in-the-clinic treatment and to promote maintenance or further progress post-discharge. If a patient stops exercising after discharge then ROM will be lost relatively quickly. This creates the potential environment for impairments to persist, function to regress, and injuries to reoccur. The therapist, who does not
inform his or her patient about the current evidence regarding stretching, may be contributing to non-adherence. Therefore it is incumbent on the clinician to educate the patient on the efficacy of stretching, as reported in the literature. Once the patient is adequately informed about a stretching program, this individual can make an educated decision about continuing their exercises.

Limitations of this study include issues surrounding the subjects. The number of participants totaled seven. Future studies should increase subject size to increase statistical significance. Of the seven subjects, six were female and one male. It is conceivable that flexibility adaptations in muscle may differ between the genders. This possibility would limit the investigator’s ability to generalize the results over a whole population. Further the subjects enrolled in the study were relatively young, with a mean age of 25.7 years. The results, therefore, could only be applied to those in the population of similar age. Any future reproduction of this research should investigate other muscles of the body and include a resumption phase similar to that used by Willy et al. 2001.

**Conclusion**

The purpose of this study was to determine the rate of range of motion decline following the cessation of a stretching program. A significant difference existed between ROM lost in the first two weeks of the cessation period compared to the amount lost in the latter two weeks (week 4 to week 6 = 7.14 degrees; week 6 to week 8 = 1.57 degrees. Therefore, after a stretching period, ROM gains will decline at the greatest rate within the first two weeks of not stretching. These results indicate that patients who are stretching must continue with their flexibility exercises post-discharge to maintain or improve their ROM. Clinicians should take an active role in sharing the current research on stretching with their patients.


