

5-2012

## Duration of the Effects of Three Static Stretching Conditions With or Without a Dynamic Warm-Up in College Age Adults

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<http://dx.doi.org/10.34917/3105903>

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DURATION OF THE EFFECTS OF 3 STATIC STRETCHING CONDITIONS WITH  
OR WITH OUT A DYNAMIC WARM-UP IN COLLEGE AGE ADULTS

By

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A doctoral project submitted in partial fulfillment  
of the requirements for the

Doctorate of Physical Therapy

Department of Physical Therapy

School of Allied Health

The Graduate College

University of Nevada, Las Vegas

May 2012



## **Doctoral Project Approval**

The Graduate College  
The University Of Nevada, Las Vegas  
May 11, 2012

This doctoral project prepared by

**Spencer Blackwell, Andrew Blomberg, Jonathan Griffith**

entitled

**Duration of the effects of 3 static stretching conditions with or without a dynamic warm-up in college age adults**

is approved in partial fulfillment of the requirements for the degree of

**Doctor of Physical Therapy**

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## Abstract

**Purpose.** The purpose of this study was to determine the stretching duration (15, 30, 60 seconds) with or without a dynamic warm-up that resulted in the longest lasting acute effects in hamstring flexibility. **Subjects.** Forty subjects (17 male, 23 female) (age: 20-35 years) were selected to participate in this study using a sample of convenience from university graduate students. **Methods.** This study contained 7 treatment conditions in which each subject completed in random order. Three groups consisted of a 5-minute treadmill warm-up at a self-selected velocity (SSV) followed by one of three stretching durations (15, 30, or 60 sec). Three other groups consisted of only one of the three stretching conditions without the treadmill warm-up. The final group consisted of only walking for 5 min on the treadmill at SSV without receiving a static stretch. A baseline passive knee extension range of motion (ROM) was taken in supine followed by the stretching/treadmill intervention. Subsequent knee ROM measurements were taken each minute until knee ROM returned to baseline. **Results.** The presence of treadmill warm-up resulted in significantly greater duration of increased hamstring ROM ( $p \leq 0.0005$ ). Within the four treadmill conditions, there was no significant difference in duration of increased hamstring ROM. There was no observed statistically significant difference among the three static stretch groups with no treadmill warm-up as well. **Conclusion.** The results suggest that a dynamic warm-up with or without a static stretch led to the longest duration of acute increase in hamstring ROM.

## **Introduction**

Hamstring strains are a frequent occurrence in sporting activities and have been shown to result in variable but potentially lengthy recovery times and be highly recurrent.<sup>1-3</sup> The most common mechanism of injury for the hamstring muscles is a combination of extensive hip flexion and knee extension with the injury occurring close to the ischial tuberosity in the posterior thigh.<sup>2</sup> Lack of flexibility in the hamstrings appears to be a predisposing factor for injury.<sup>4</sup> Consequently, flexibility may be an important factor in the prevention of hamstring injury and may even aid in affecting athletic performance.<sup>4</sup> The previous statements are the current dogma, yet there is little evidence to support these claims.

Although the general consensus within the literature is that stretching in addition to warm-up does not reduce the incidence of muscle strains, some researchers still argue that stretching or warm-up reduces injury.<sup>5</sup> Safran et al.<sup>6</sup> suggests that warm-up stretches the musculotendinous junction (MTJ) and results in an increased length at a given load, putting less tension on the MTJ and resulting in a reduced incidence of injury.<sup>6</sup> At a physiological level it is thought that a warm-up may result in increased blood flow, elevation of baseline oxygen consumption, post-activation potentiation (transient increase in muscle contractile performance following previous conditioning), psychological effects and increased preparedness.<sup>7</sup> Research supporting a warm-up or stretching is not clear due to inconclusive data and therefore there is not sufficient evidence to endorse or discontinue routine stretching before exercise to prevent injury.<sup>8</sup>

At any sporting event it is common to see the participants engaging in a dynamic warm-up, such as jogging, as well as stretching before activity. However, there does not

seem to be consistency in the literature regarding the factors that could influence hamstring flexibility and stretching/warm-up effectiveness. These factors include how long each stretch should be held in order to achieve increased hamstring flexibility, how long this increased hamstring flexibility lasts, and whether a dynamic warm-up may replace or further enhance the flexibility gains of a static stretch. Prior to a sporting event, after stretching and warm-ups, players may have to sit through team meetings or on the sidelines waiting for their chance to participate. This idle time after stretching may diminish the temporary effects of stretching and/or dynamic warm up prior to the start of practice or the sporting event indicating another factor to consider in the evaluation of stretching or warm-up on hamstring flexibility. Previous research that has investigated the optimal length of stretch, duration of acute ROM gains following stretch, and the effect of dynamic warm-up on flexibility will be discussed in the upcoming paragraphs.

Previous research has provided suggestions regarding the duration of static stretch that results in maximal hamstring flexibility. A study done by Bandy et al.<sup>9</sup> suggests that a static stretch of 30 seconds in duration is an effective amount of time to achieve acute ROM increases in the hamstrings. The authors further elaborate that no increase in flexibility occurred when the static stretch duration was increased from 30 seconds to 60 seconds. A separate study done by Ford et al.<sup>10</sup> also suggested that clinicians need not perform static hamstring stretches of durations longer than 30 seconds.

To the best of our knowledge, research regarding the duration of acute effects following a hamstring stretch exists but is limited and inconsistent. A study conducted by Whatman et al.<sup>11</sup>, utilizing a series of static stretches (4 holds x 20 sec duration),

concluded there was no clear evidence that the ROM increase that resulted from the stretch lasts longer than 5 minutes. A separate study done by Spornoga et al.<sup>12</sup>, using proprioceptive neuromuscular facilitation (PNF) stretching techniques (5 modified hold relax stretches), concluded that immediate increases in hamstring ROM lasted for 6 minutes after the stretching protocol ended. Another study done by Ford et al.<sup>13</sup> found that increases in hamstring flexibility lasted 25 minutes following a single bout of stretching.

Current research has failed to demonstrate an increase in effectiveness of static stretching when preceded by a dynamic warm-up. However, coupling a dynamic warm-up with a static stretch has been shown to be more effective in increasing flexibility than dynamic warm-up alone. A study done by McNair and Stanley<sup>14</sup> has shown that a group that received a combination of a dynamic warm-up and a series of static plantar flexor stretches significantly improved plantar flexor ROM similarly to a group that only received a series of static stretches. There was no significant difference between these groups indicating that the addition of a dynamic warm-up did not further increase the flexibility of the plantar flexors. However, these 2 protocols did result in significantly greater plantar flexor ROM when compared to a group that only received a dynamic warm-up. De Weijer et al.<sup>15</sup>, found similar results in their study using the hamstring muscle group.

The research regarding stretch duration has evidence to suggest that utilizing a hamstring stretch of 30 second duration provides the optimal acute increase in hamstring flexibility.<sup>9,10</sup> Research that has investigated the duration of the effects of stretching has turned up mixed results with durations reported anywhere from 5 minutes up to 25

minutes post-stretch. In addition, many studies utilized a series of static stretches over duration of weeks rather than after a single bout of stretching. Furthermore, there has not been any evidence to compare the effects of a dynamic warm-up with a single bout static stretch.

Therefore, the purpose of this study was to determine the stretching duration (15, 30, 60 seconds) with or without a dynamic warm-up that resulted in the longest lasting acute effects in hamstring flexibility. We hypothesized that there would be no difference between groups receiving a combination of dynamic warm-up and static stretch compared to those who only received a static stretch of the same duration. We also hypothesize that combining a dynamic warm-up with a static stretch would result in greater duration of increased hamstring ROM when compared to dynamic warm-up alone. In addition, we believed there would be a significantly longer duration of increased hamstring ROM in those receiving a 30 or 60 second stretch compared to those receiving a 15 second stretch, with or without a dynamic warm-up. However, there would be no difference between those receiving a 30 or 60 second duration static stretch signifying that there would be no need to stretch longer than 30-second bouts.

## **Methods**

### *Subjects*

40 subjects (17 male, 23 female) (age: 20-35 years) were selected to participate in this study using a sample of convenience from university graduate students. All subjects were free from hamstring injury in the previous 6 months and were not currently



pregnant. All subjects read and signed an informed consent form approved by the institutional review board of the University of Nevada Las Vegas.

### *Reliability*

A pilot measurement of knee goniometric ROM of 8 subjects per investigator was conducted to establish intra-rater reliability prior to starting the study. All measurements were taken on the subjects' right knee. Subjects were positioned supine with right hip positioned at 90 degrees of flexion with a bolster (height=16 in.) placed against posterior thigh to ensure the hip maintained 90 degrees of flexion with a lumbar roll in place to eliminate compensation using a posterior pelvic tilt. The subjects left knee was bent during measuring to decrease strain on the subjects' lower back. This position will be referred to as the "measurement position"(figure 2). Right passive knee extension was measured using a universal goniometer with the axis at the lateral condyle of the femur and the arms aligned with greater trochanter and bisection of lateral malleolus while maintaining the hip at 90 degrees of flexion. The investigator taking the measurement was blinded to the results of the measurement, which was read by a fellow researcher. For each subject, 3-blinded measurements were taken on three separate days. Intra-rater reliability was established using Intra-class Correlation Coefficients (ICCs). The 2 researchers who obtained the highest reliability measure (ICCs(3,3) > 0.88) were selected to be the measurers of passive knee extension throughout the study.

### *Groups*

This study contained 7 treatment conditions in which each subject completed in random order. Three groups consisted of a 5-minute treadmill warm-up at a self-selected

velocity (SSV) followed by one of three stretching durations (15, 30, or 60 sec). These groups will be referred as treadmill+15, treadmill +30 and treadmill +60 second stretch for the remainder of the paper. Three other groups consisted of only one of the three stretching conditions without the treadmill warm-up. These groups will be referred as no treadmill+15, no treadmill+30 and no treadmill+60 second stretch for the remainder of the paper. The final group consisted of only walking for 5 min on the treadmill at SSV without receiving a static stretch. This group will be referred as treadmill only. (Figure 1)

## **Procedure**

Treatment order was randomly determined for each subject using a random number generator. After completing the screening questionnaire and informed consent, the protocol began with the participant sitting for 5 minutes. This was followed by a pre-test measure of passive knee extension of the right knee using a universal goniometer with the subject in the measurement position (Figure 2a and b).

For each of the three stretching conditions (15, 30, or 60 sec) associated with the treadmill warm-up, the subjects walked on a treadmill at SSV (figure 3) for 5 min which was immediately followed by a second measurement of passive knee extension in the measurement position. Next, the subject was stretched for 15, 30, or 60 sec. The researcher conducting the passive stretch extended the subjects right knee while the left knee and hip were positioned flat against the table until the subject verbally stated they felt a moderate stretch without pain in the hamstrings (Figure 4). The left knee was placed flat on the table to prevent posterior pelvic tilt during stretching. This position

will be referred to as the “stretching position”. After stretching, measurements of passive knee extension were taken with the subject in the measurement position every minute until passive knee extension ROM returned to within 3 degrees of baseline measurement for two consecutive measurements. Three degrees was used as the “cutoff” as the standard error of measurement for goniometric measurement of knee extension is 2.3 degrees<sup>16</sup>.

For each of the three conditions associated with stretching without a treadmill warm-up, each participant also sat for 5 min and then had a baseline measurement taken in the measurement position. Following baseline measurement, the subject was then stretched using the stretching position for 15, 30, or 60 sec. Following the stretching treatment, passive knee extension measurements were taken every minute until measurements returned to within 3 degrees of baseline for two consecutive measurements.

For the final condition, the subject sat for 5 min and then had a baseline measurement taken in the measurement position. Next, the subject completed the warm-up on the treadmill for 5 minutes at a SSV. Immediately following warm-up, the subject was placed in the measurement position and passive knee extension was measured every minute until measurements returned to within 3 degrees of baseline for two consecutive measurements.

Participants were given at least one day of rest in between stretching sessions to eliminate any previous effects from the intervention. Subjects were also questioned regarding any hamstring soreness at the start of each subsequent visit.

### *Data Management and statistical analyses*

All research data was analyzed using SPSS Version 18. The duration of increased hamstring ROM following intervention was determined to be the number of minutes before ROM returned within 3 degrees or less of the initial baseline measurement for two consecutive measurements.

To assess the relationship between duration of increased hamstring ROM and treatment, a 3-by-2 (time [15, 30, or 60 seconds] by warm-up[treadmill or no treadmill]) analyses of variance (ANOVA) was conducted. Furthermore, to compare the duration of increased hamstring ROM across all treatment groups a repeated measures ANOVA was conducted.

### **Results**

Figure 5 displays the descriptive statistics (means and standard deviations) of the 7 treatment conditions. The treatment condition of treadmill+60 second stretch had the longest lasting duration of increased hamstring ROM lasting  $4.58 \pm 3.522$  min (mean $\pm$ SD). Also, no treadmill+30 second stretch showed the shortest duration of increased hamstring ROM lasting  $2.70 \pm 1.265$  min. There was no interaction observed between time of stretching and presence of a dynamic treadmill warm-up for duration of increased hamstring ROM following intervention,  $F(1,2)=0.216$ ,  $p=0.806$ . Similarly, there was no statistically significant difference observed in the main effect of time (15, 30 or 60 second stretch),  $F(2)=0.305$ ,  $p=0.738$ . However, the presence of treadmill warm up resulted in significantly greater duration of increased hamstring ROM,  $F(1)=17.178$ ,  $p \leq 0.0005$  when compared to static stretch and no treadmill warm-up. Within the four treadmill conditions, there was no significant difference in duration of increased

hamstring ROM,  $F(3)=1.719$ ,  $p=0.167$ . There was no statistically significant difference among the three static stretch groups with no treadmill warm-up,  $F(2)=0.204$ ,  $p=.816$ .

## **Discussion**

The purpose of this study was to determine the stretching duration (15, 30, 60 seconds) with or without a dynamic warm-up that resulted in the longest lasting effects in acute hamstring flexibility. The findings of this study reject our original hypothesis stating there would be no difference between groups receiving a combination of dynamic warm-up and static stretch compared to those who only received a static stretch of the same duration. Our original hypothesis was constructed around the study done by McNair and Stanley<sup>14</sup> that showed a group that received a combination of a dynamic warm-up and a series of static plantar flexor stretches significantly improved plantar flexor ROM similarly to a group that only received a series of static stretches. Our results showed that combining a dynamic warm-up with a static stretch resulted in greater duration of improved hamstring ROM as compared to just receiving a single bout of static stretch. A possible explanation for this finding could be the increased blood flow into the muscle which is thought to result from physical activity that increases the extensibility of the muscle being used.<sup>7</sup> Since the static stretch without treadmill condition did not include a dynamic activity, it is thought that increase in blood flow to the hamstrings was not as great as the conditions which included a dynamic warm-up. Therefore, it is thought that due to the lesser blood flow, the hamstring muscles will not be as elastic and would subsequently display a lesser duration of increased ROM.

The results of this study also reject our second hypothesis that stated there would be a significantly longer duration of increased hamstring ROM in those receiving a 30 or 60 second stretch compared to those receiving a 15 second stretch, with or without a dynamic warm-up. The results demonstrated that static stretching 15, 30, or 60 seconds did not result in any greater ROM when compared to each other. These findings are inconsistent with previous literature which suggest there is a difference in improved hamstring ROM between 15 and 30 second stretch.<sup>9,10</sup> A majority of previously reviewed literature used a protocol of a series of static stretches whereas our study examined the effects of a single bout of static stretching.<sup>11,12</sup> Studies which did utilize a single bout of stretching may have used a higher intensity stretch compared to this study that could have resulted in greater duration of increased hamstring ROM. By having participants verbally state when they felt a “moderate stretch with no pain” may have been a suggestive instruction and may have been interpreted differently by participants. An alternative measure of stretch intensity could have been a Visual Analog Scale as this would have been a more objective measure and may have made it easier for participants to gauge the intensity of their stretch.

Results from this study help support the validity of our final hypothesis by demonstrating participants who stretched 30 or 60 seconds without participating in a dynamic warm-up displayed similar durations of increased hamstring ROM. This finding is consistent with previous literature stating that no increase in flexibility occurred when the static stretch duration was increased from 30 seconds to 60 seconds.<sup>9</sup> A separate study done by Ford et al.<sup>10</sup> also suggested that clinicians need not perform static hamstring stretches of durations longer than 30 seconds. However, as previously

mentioned, duration of increased hamstring ROM following a 15 second static stretch was similar to those following a 30 and 60 second stretch. Our results suggest that a single 15-second stretch with no treadmill warm-up may be equally as effective as a single 30 second or 60 second stretch with no treadmill warm-up. The reason for the disparity between this study and previous research may be the intensity of stretch or the stretching technique that was used. As mentioned before, the instructions regarding the desired intensity of hamstring stretch may have been unclear to the research subject. Furthermore, many of these previous studies had the subjects perform a self-stretch in comparison to our study, which utilized a stretch induced by a researcher.

Additional findings that were not originally hypothesized demonstrate that individuals may receive equal benefit from doing a 5 minute dynamic warm-up at a self-selected velocity when compared to doing a combination of dynamic warm-up and static stretch for 15, 30, or 60 seconds. This implies that individuals who participate in physical activity may not have to spend time stretching when they can get the same benefits, in terms of duration of increased hamstring ROM, by doing a simple dynamic warm-up.

These results are clinically important for health care providers who are trying to achieve an acute increase in hamstring length for their patients prior to activity. These results suggest that for patients needing an acute increase in hamstring length, health care providers should put them on a treadmill for five minutes at a self-selected velocity to get a greater increase in ROM as opposed to performing a manual static stretch. In addition, individuals who are participating in physical activity and using a dynamic warm-up

should do so within 3.67 minutes of activity or the effect of the warm-up may be washed out.

This study was limited by a small sample size of convenience. All subjects enrolled in this study were current members of the Doctor of Physical Therapy program at the University of Nevada Las Vegas and were between the ages of 22-34 years old. This hampers our generalizability of the study to other populations. Future research in this area should consider using a higher gait speed during the dynamic warm up. A higher intensity warm-up would more accurately represent a warm-up that would take place prior to exercise or a sporting event.

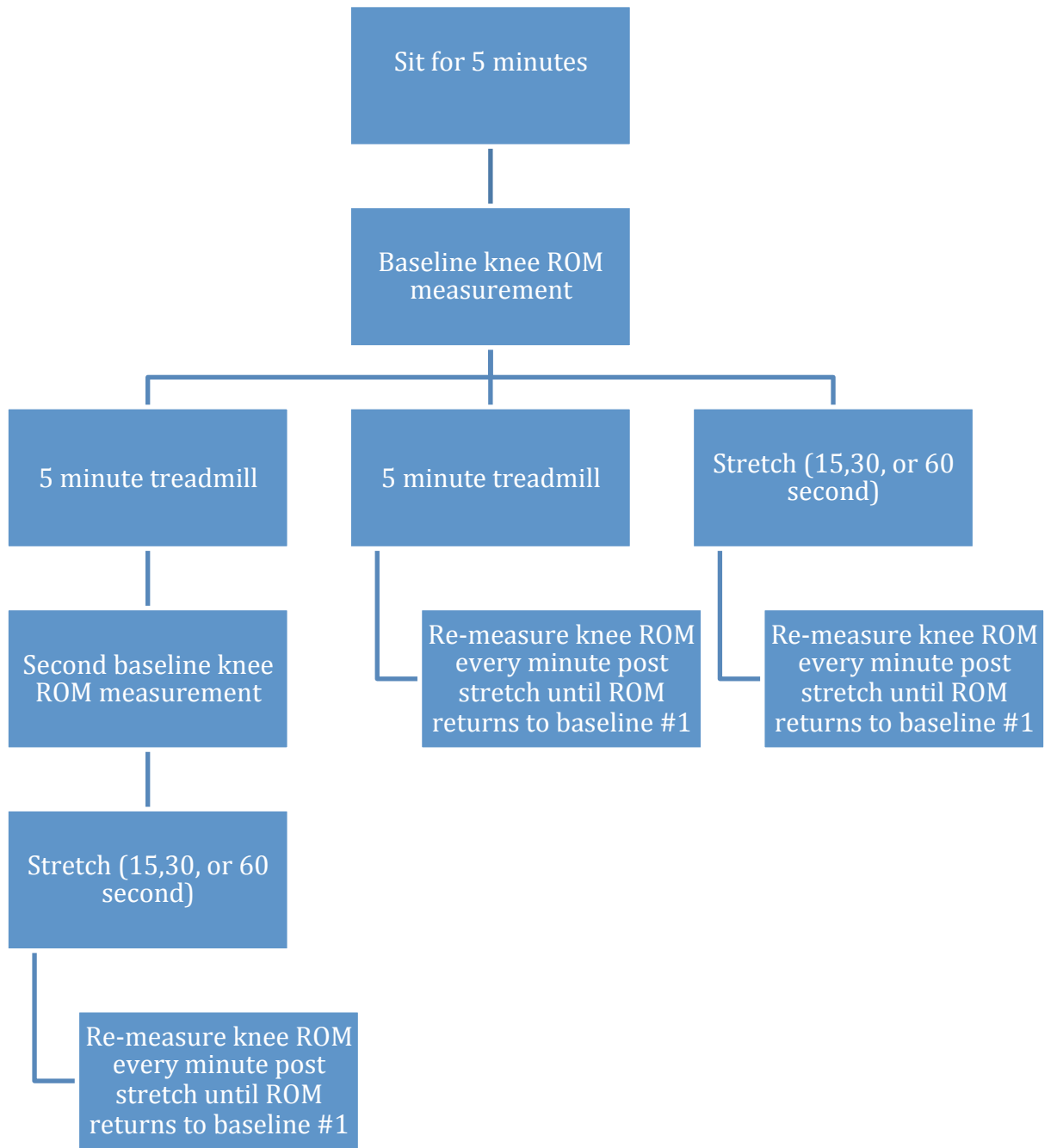
## **Conclusion**

The results suggest static stretching may not be as effective as the current dogma suggests. In fact, a dynamic warm-up with or without a static stretch led to the longest duration of acute increase in hamstring ROM. The clinical implications of this study suggest that health care providers, when looking to provide an acute increase in the length of the hamstring muscles, should have their patients perform a dynamic warm-up prior to activity.



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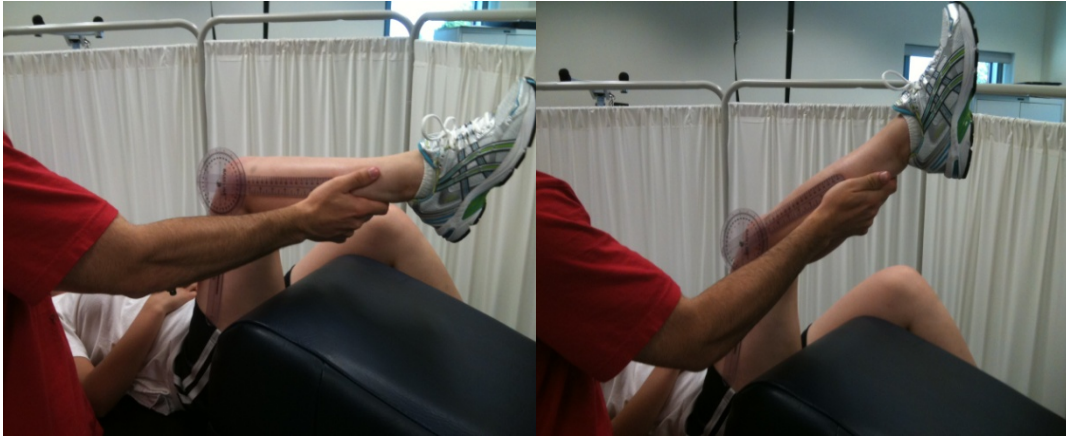
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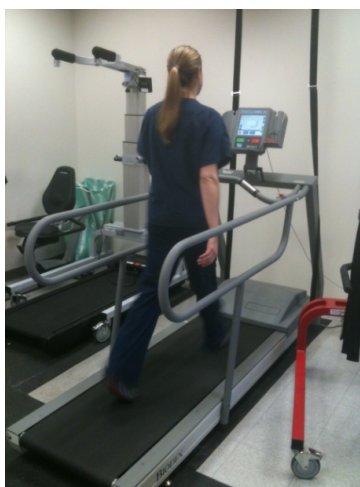
**Figure 1.** Schematic of 7 treatment conditions in which all subjects completed

a.

b.



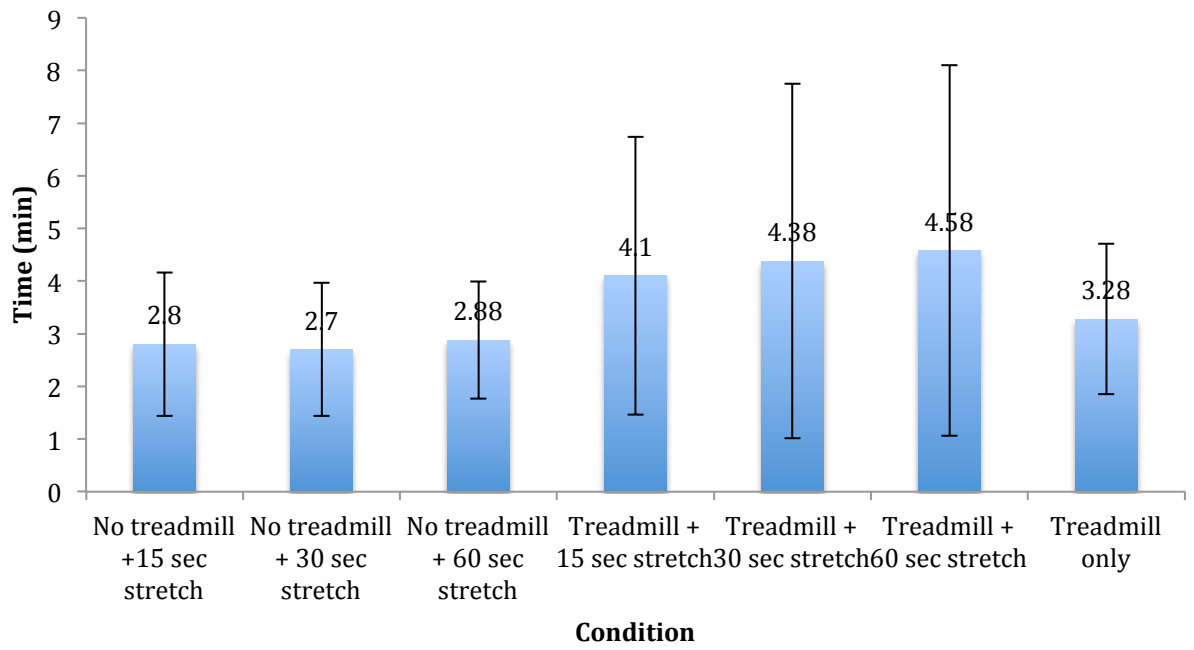
**Figure 2.** Technique of measuring subject knee extension ROM while in “measurement position” with universal goniometer. a. pre-measurement position with hip and knee flexed to 90 degrees. b. measurement of knee extension ROM taken when researcher feels resistance from subject’s hamstring when extending subject’s knee in “measurement position”.



**Figure 3.** Treadmill utilized for 5-minute warm-up at SSV



**Figure 4.** Method of stretching with patient in “stretching position”. Intensity of stretch determined by patient report.



**Figure 5.** Bar graph representing mean and standard deviation of each treatment condition

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- Kelley Physical Therapy Hawkins- Pahrump, NV - June 21-July 30 2010 (6 weeks)
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**RESEARCH**

- Thesis: Duration of effects of 3 static hamstring stretching conditions with or without a dynamic warm-up in college age adults
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  - Rehab physical therapy with emphasis on CVA and traumatic brain injury  
recovery
- Logan Regional Hospital – Logan, UT - July 11- September 23 2011 (11 weeks)
  - Inpatient acute care with emphasis on postoperative orthopedic knee and  
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- Mountain West Physical Therapy- Tremonton, UT - June 21-July 30 2010 (6  
weeks)
  - Outpatient orthopedic physical therapy with emphasis on post surgical  
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## **RESEARCH**

- Thesis: Duration of the effects of 3 static hamstring stretching conditions with or  
without a dynamic warm-up in college age adults
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