

The Effect of Standing, Supine and Dynamic Stretching on Hamstring Muscles Flexibility

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ABSTRACT

The purpose of this study was to compare the effects of standing, supine and dynamic range of motion (DROM) stretch on hamstring flexibility.

Methods: Forty-five subjects, ranging in age from 18 to 32 years and with limited hamstring flexibility (defined as lacked at least 25° of active knee extension with the hip flexed to 90°) volunteer to participate in this study, were randomly assigned to one of three groups. One group performed 30 second standing static stretch, three days a week. The second group performed 30 second supine static stretch, three days a week. The third group performed DROM stretch three days a week by lying supine with the hip held in 90° of flexion. The subjects then actively moved the leg into knee extension (5 seconds), held the leg in end range knee extension for 5 seconds, and the slowly lowered the leg to initial position (5 seconds). These movements were performed six times per session (30 seconds of total actual stretching time). All previous procedure repeated three times per settings for the three types of stretch with resting period 15 seconds between every repetition (total duration of stretch at each session was 90 seconds). **Results:** Statistical analysis revealed significant difference in the range of motion of knee extension for the prestretch and poststretch measurements of standing, supine and DROM stretch. The standing and supine stretch were significantly higher than DROM stretching. No significant difference between standing and supine stretch. **Conclusions:** The standing and supine stretch are equally effective in improving the hamstring flexibility, and both of them are preferable than DROM stretch during hamstring flexibility training.

Key words: Flexibility, Hamstring, Stretch.

INTRODUCTION

Muscle flexibility exercises are among the exercise types most commonly used in rehabilitation and sports practice. Their aims usually include reducing the risks of injuries, minimizing late-occurring muscle pain and improving general muscle

performance¹. The muscle flexibility defined as "the ability of a muscle to lengthen, allowing one joint (or more than one joint in a series) to move through a range of motion". When a muscle loses or lacks flexibility, its ability to deform is decreased, resulting in decreased range of motion (ROM) around a joint. Restricted flexibility can be related to a number of variables, including joint capsule or other soft tissue restrictions².

Improvement of flexibility is postulated to prevent athletic injuries; however, data to support this suggestion are limited. Smith³ revealed that general stretching exercises can benefit athletes and social exercisers in numerous ways, including improving flexibility, reducing the incidence of injury, and enhancing athletic performance. Poor hamstring flexibility has often been associated with injuries to the low back and lower extremities^{4,5}. Jonhagen et al.,⁶ revealed a statistically significant difference in hamstring flexibility between injured and uninjured sprinters, but the authors noted that it was unclear whether the tight hamstrings caused the injury or were a result of the injury. Hartig and Henderson⁴ demonstrated that a hamstring stretching regimen significantly increased flexibility and decreased the incidence of lower extremity injuries in a group of military basic trainees as compared with a control group. Clearly, further methodologically sound studies are necessary to fully understand the role of flexibility in sports performance and injury. Regardless of this paucity of evidence, stretching is widely accepted and recommended by coaches, athletes, athletic trainers, and physical therapists^{3,7,8}.

Many researchers^{9,10,11,12,13,14} have focused on the technique, frequency, and duration of stretching necessary to achieve the greatest flexibility gains. Among the different stretching methods are ballistic, static, and proprioceptive neuromuscular facilitation techniques¹¹. Various authors^{10,11,12,13,14} have

demonstrated the effectiveness of all 3 methods in increasing knee-extension ROM, an indirect measure of hamstring flexibility.

Physical therapists routinely assess the flexibility of a patient's soft tissues to aid in clinical decisions regarding appropriate therapeutic interventions. Many treatments utilize static stretching maneuvers to maintain length or elongate connective tissue. The passive tension that develops in a noncontracting (passive) muscle when lengthened is thought to result from the series elastic and parallel elastic connective tissue elements of skeletal muscle¹⁵. These specific noncontractile components include the muscle tendon, crossbridge attachments, proteins within the myofibril, and the connective tissue harness of the muscle (epimysium, perimysium, and endomysium). Because these connective tissue elements are viscoelastic, stretching should induce time- and rate-dependent changes, provided the duration of the stretch is sufficient¹⁶.

The standing hamstring stretch has been validated as an effective means of improving hamstring flexibility^{8,10,11,17-19}. This stretch requires the individual to stand on one leg while placing the stretching leg forward on an elevated surface and simultaneously bending forward at the waist (without flexing the spine) to achieve an adequate stretch. However, the effectiveness of this stretch is significantly related to pelvic positioning¹³; therefore, proper performance is imperative. Sullivan et al¹³ demonstrated that stretching in a position of anterior pelvic tilt results in a significantly greater increase in hamstring flexibility. Others have also noted the importance of pelvic position in hamstring flexibility measurement^{8,11}.

Although static stretching of the hamstrings in the standing position has been investigated^{4,8,10,11,13,14,19,20}, the supine static stretching technique commonly used in the clinical setting does not appear to have been investigated. The supine hamstring stretch is performed by lying supine in a doorway or at a corner, and placing the stretching leg on the wall while the contralateral leg rests flat on the floor. This stretch is also performed as a partner stretch in group athletic settings. It appears to be easier to teach and to require less

supervision than the standing method, thereby making it a technique patients and athletes can successfully perform independently.

A relatively new method to lengthen muscles is called dynamic range of motion (DROM). This method is described by Murphy^{21,22} as an alternative to static stretching, who suggests that DROM is a better stretch for lengthening muscle than static stretching. During DROM, a contraction by the antagonist causes the joint crossed by the agonist (lengthening muscle) to move through the full ROM at a controlled, slow tempo. All movements are performed slowly and deliberately. If performed too quickly, a tendency to swing the extremity exists, causing the stretch reflex to be elicited at the endpoint of the movement in the lengthening muscle²².

Dynamic range of motion begins from a neutral position, followed by slow movement (4-5 seconds) of the limb to end range, a brief hold at end range (4-5 seconds), and, finally, slowly (4-5 seconds) moving the limb back to the original neutral position using an eccentric contraction²¹. This contraction by the antagonist causes the lengthening muscle to relax due to the principle of reciprocal inhibition. So, DROM is more natural way to elongate the muscle and does so in a relaxed state, since the muscle is reflexively inhibited, and the strength is promoted because the movement is being performed by the muscles that actively move the involved joint^{21,22}. Therefore, the purpose of the current study was to evaluate the relative effectiveness of standing, supine, and dynamic range of motion hamstring stretching in increasing hamstring flexibility, as measured by increasing ROM at the knee. The null hypothesis to be tested is that if standing, supine, and DROM stretch are compared no difference in knee extension ROM will occur following 4 weeks of training.

METHODS

Subjects

Forty five subjects each one agreed to volunteer and complete the 4 weeks of training. All subjects signed an institutionally approved informed consent statement prior to data collection. Exclusion criteria included any lower extremity or back injury within the last

year that required medical attention and any known condition that might affect flexibility. Only subjects who lacked at least 25° of active knee extension with the hip flexed to 90° were included in the study. Ages ranged from 18 to 32 years (mean = 24.68 ± 4.25 years). Subjects agreed to maintain their current activity regimen, including exercise levels, throughout the study.

Equipment

Measurements of active knee extension were performed with a standard 18-in (45.72-cm) goniometer, which is relatively long goniometer that help to maintain the distal ends of the goniometer in proper alignment with the bony landmarks and to increase the ease of measurement.

Procedure

The measurement of supine knee extension performed as described by Gajdosik et al.,²³ as an indicator of hamstring flexibility. Subjects wore shorts to allow easy access to bony landmarks. Subjects were instructed to assume a supine position on the examination table and, with the hip and knee flexed to 90°, we made marks over the lateral malleolus, lateral femoral condyle, and greater trochanter of the femur. Subjects were then instructed to position themselves so that when the hip was at 90° of flexion, verified with goniometric measurements, the thigh was touching the non adherent side of the tape. This provided both visual and tactile clues for subjects to consciously maintain 90° of flexion while performing active knee extension. One investigator also maintained hand contact with the thigh anteriorly and posteriorly to monitor hip angle. Each subject's pelvis was secured to the table with a strap over the anterior superior iliac spines. Another strap was placed over the mid thigh of the contralateral limb to secure it to the table. While maintaining 90° of hip flexion, subjects were asked to actively extend the knee as far as possible. Once they could no longer extend the knee, or the hip began to

lose the 90° angle as determined by the investigator, the angle of knee flexion was then obtained by another investigator, who was blind to leg assignment. All measurements were performed in identical fashion both before and after the stretching phase, with no warm-up or stretching before measurement.

Each subject was also given a handout with a detailed description of the three types of stretch and pictures of the stretches being performed in the appropriate manner. A computer-generated number table used to randomly assign a stretching method to each subject. For the standing stretch, subjects were instructed to face the table with their hips square, maintain an erect torso, hold their arms out or on their hips, look straight ahead, and flex forward at the waist until a hamstring stretch was perceived. Subjects were cautioned against, and monitored to prevent, posteriorly tilting the pelvis or rounding the trunk forward, or both as shown in figure (1). Instructions for the supine stretch included lying supine on the floor with the stretching leg on the wall and the other leg flat on the floor, with the distance from the wall adjusted so that they felt a hamstring stretch. When the position no longer caused a stretching sensation to the hamstring, subjects were instructed to slide their bodies closer to the wall as shown in figure (2) or to increase their trunk flexion for supine or standing stretching, respectively.

The third group performed DROM stretch by lying supine and holding their hip in 90° of flexion. The subjects then actively extended the leg (5 seconds), held the leg at the end of the knee extension for 5 seconds, and then slowly lowered the leg (5 seconds), which was considered one repetition. The DROM movement was repeated for six repetitions. Performing DROM stretch for six repetitions of 5 seconds each allowed 30 seconds of actual stretching time, which could then be later compared with the 30 second standing and supine stretches performed by the first and second groups.



Fig. (1): Standing stretching procedure for hamstring.



Fig. (2): Supine stretching procedure for hamstring.

The stretching regimen was performed in a group setting 3 times per week, at the same time of day, for 4 weeks. Each stretching session consisted of performing 3 times for 30 seconds each. Subjects rested for 15 seconds between stretches and during the rest period removed their leg from the wall (Supine stretch), the table (standing stretch) and take the sitting position for the DROM stretch. Warm-up did not occur before stretching

sessions. Also, subjects wore shorts and removed their shoes for each session. Stretching sessions were supervised by one of the investigators or by the subjects' physical therapy or physical therapy assistant instructor to ensure that stretches were being performed in a proper and consistent manner. If a subject missed a stretching session, he stretched later or the next day. A priori, it was determined that any subject who missed 2 stretching

sessions would be excluded. After 4 weeks of stretching, all subjects were retested using the same procedures described in the initial testing. Two days separate the last day of stretching and the final measurement. The two investigators taking the measurements did not review the previous flexibility measurement, thereby limiting bias in taking the new measurement.

Statistical analysis

The analysis of these data included descriptive analysis of means and standard deviation of pre stretch and post stretch values of the three groups. Means were analyzed to test our null hypothesis and to answer a secondary question about the effect of stretching type on the ROM. All data analysis was performed using SPSS (version 16).

Dependant t test was calculated on the pretest to post test change for each group (a total of three t tests was performed). To assess whether any significant differences existed in the pretest scores across the three groups, a one-way ANOVA was calculated. This analysis was performed to assess whether any significant difference existed between the

three groups prior to the initiation of the study. A one-way ANOVA was calculated across the posttest scores of the three groups to assess if any difference existed in the posttest scores. This analysis was performed to assess whether any difference existed between the three groups, if there is significant difference between the three groups use Tukey post hoc analysis to explain which group is significantly differed than the other groups. Significance for all statistical tests was accepted at the 0.05 level of probability.

RESULTS

The means values for the pretest and post test measurements of the supine stretch group were 139.67 ± 6.75 and 147.13 ± 6.79 , respectively, the values of standing stretch group were 138.40 ± 8.02 and 146.93 ± 7.39 , respectively, and the values of dynamic range of motion stretch group were 137.87 ± 6.65 and 140.40 ± 6.17 , respectively. Table (1) presents the means for pretest and posttest measurements and gain scores for each group.

Table (1): Knee-extension measurements pre and post stretch of the three groups.

	Supine Extension ROM	Standing Extension ROM	DROM Extension ROM
Pretest	139.67 ± 6.75	138.40 ± 8.02	137.87 ± 6.65
Posttest	147.13 ± 6.79	146.93 ± 7.39	140.40 ± 6.17
Gain (difference between pretest and posttest)	6.47 ± 1.30	8.53 ± 1.68	2.6 ± 1.12

The results of the paired t test of pre and post values for each group of the three groups revealed a significant difference between the pre stretch and post stretch values that mean the three types of stretching was effective in increasing the range of knee extension. The supine stretching group: $df = 14$, $t = 22.2$, $P < 0.05$; the standing stretch group: $df = 14$, $t = 19.6$, $P < 0.05$; the DROM stretch group: $df = 14$, $t = 9.25$, $P < 0.05$. The pre stretch and post stretch measurements of knee extension ROM of three groups illustrated in figure (3).

The one-way ANOVA calculated to assess whether any significant differences existed in the pretest scores across the three

groups indicated no significant difference ($df = 2$, $t = 0.25$, $P > 0.05$). The one-way ANOVA calculated to assess if any difference existed across the post stretch scores of the three groups indicated a significant difference ($df = 2$, $t = 4.76$, $P < 0.05$). Tukey post hoc analyses indicated significant differences between the standing and supine stretch groups and DROM stretch group without significant difference between the standing and supine stretch group (ie., the standing and supine stretch groups appeared to be equally effective in increasing the hamstring flexibility to a significantly greater extent than the DROM stretch group).

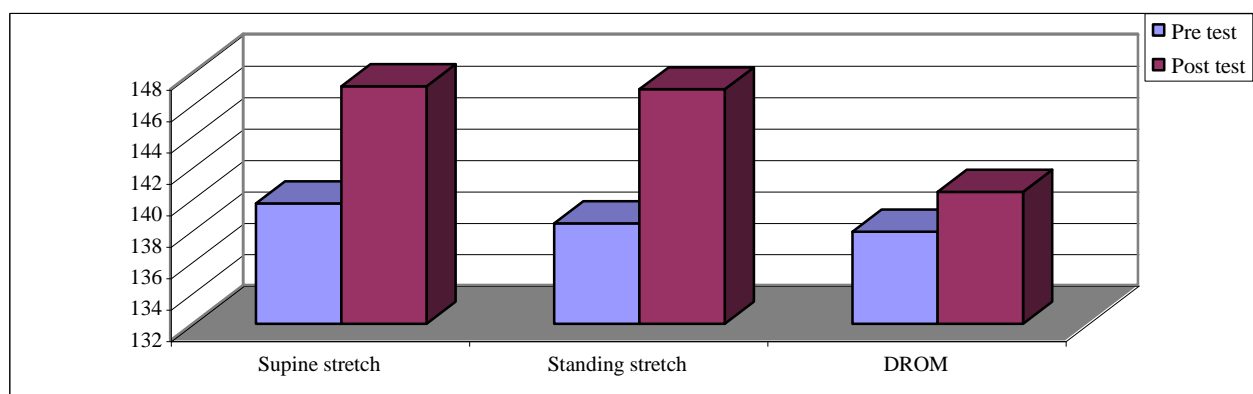


Fig. (3): The pre stretch and post stretch measurements of knee extension ROM of three groups.

Finally, in an attempt to summarize the data, an additional analysis using a one-way ANOVA on gain scores was calculated, revealing a significant difference between groups ($df = 2$, $t = 7.77$, $P < 0.05$). Post hoc analysis using a tukey test indicated a significant difference between the DROM stretch group (gain = 2.6 ± 1.12) and both the standing stretching group (gain = 6.47 ± 1.30) and supine stretch group (gain = 8.53 ± 1.68), as well as no significant difference in gain of the standing and supine stretch groups.

DISCUSSION

The musculotendinous units function in a viscoelastic manner, and therefore, have the properties of creep and stress relaxation. Creep is characterized by the lengthening of muscle tissue due to an applied fixed load. Stress relaxation is characterized by the decrease in force over time necessary to hold a tissue at a particular length²⁴. The musculotendinous unit deforms or lengthens as it is being stretched and goes through elastic and then plastic deformation before completely rupturing²⁵. The proprioceptors located within the muscle fibers and tendons relay information about muscular tension to the central nervous system. The two proprioceptors related to stretching are muscle spindles and golgi tendon organs. Muscle spindles are located in the intrafusal fiber of the muscle, and responds to any changes in length^{26,27}.

According to the results of the study the null hypothesis rejected that no difference would be seen in knee extension range of motion after 4 weeks of standing, supine

stretching and dynamic range of motion stretch. The groups that performed standing and supine stretch showed significantly greater gains in flexibility than the group performed dynamic range of motion stretching. This is consistent with the results of Bandy et al.,¹⁰ compared the effects of 30 seconds of static stretching with dynamic range of motion, the gain made with static stretch was 11.42° but the gain with dynamic stretching was only 4.26° , the gains of the current study were 6.47° for the supine hamstring stretching group, 8.53° for the standing hamstring group and 2.6° for the dynamic stretching group, these results appear to be less than that reported by Bandy et al.,¹⁰ the reason may be due to the short duration of the present study (4 weeks) in comparison to the study conducted by Bandy et al.,¹⁰ which conducted through 6 weeks of stretch training.

The time frames for a stretch program ranging from 2 weeks¹³ to 8 weeks⁹ of stretching have been used in the published studies. The participant of the current study stretched 3 times a week for 4 weeks, which is within the range of duration and frequency studied by others^{8,9,10,11,28}. In spite of the results were slightly lower, they were similar to the results of other studies with longer stretching duration, so stretching for 4 weeks can make gains similar to those gained over longer periods. Moreover, stretching exercises performed three times a week were sufficient to improve flexibility and range of motion compared to subjects exercising once a week, with results similar to those of subjects who exercised five times a week²⁹.

The standing hamstring stretch is common and has been validated as an effective means of improving hamstring flexibility^{10,11,19}, the present study proved that supine stretching is equally effective as standing stretch. During standing stretch the subject must bend forward without flexing the spine to achieve an adequate stretch, so the pelvic position is very important during standing stretch^{8,11,13}. In contrast, during supine stretch the pelvic position was intentionally not controlled, for this reason it is preferable to use the supine stretch in unsupervised settings, such as group therapy, home exercise programs or during athletic training. Moreover, supine stretch isolates the hamstring muscles during stretching, so it is safer and more comfortable for people with a history of low back pain which will improve the relaxation during stretch. However, the supine stretching may be not preferable if the subject suffering from cardiovascular problems as hypertension.

The duration of static stretch (standing and supine) used during this study was 30 second as the previous studies^{8,11} indicated that a 30 second stretch duration was more effective than a 15 second stretch and equally as effective as a 60 second stretch. Moreover, the 30 second of stretch and the procedure of DROM stretch repeated for three times that was trial to overcome the problem facing Bandy et al.,¹⁰ during conduction of their study, as they stated that DROM group performed more stretching activities than the static stretching group. Despite of this increment in the total duration of stretch of the DROM group, the groups of standing and supine stretching for 30 seconds (3 repetitions) increased hamstring flexibility to a significantly greater than the DROM group (3 repetitions), that is coincident with the study conducted by Bandy et al.,¹⁰ proved that the standing static stretch is more effective in increasing hamstring flexibility than DROM.

However, Guissard and Duchateau³⁰ reported that active dynamic stretching results in length changes similar to passive static stretch, the major advantage to active dynamic stretching compared to passive static stretching is its effect on the nervous system, and elastic properties of the muscle during a

stretch. As stated earlier, the nervous system regulation of tension and length is performed by a golgi tendon organ and muscle spindle, respectively. When a muscle is repeatedly stretched, a muscle spindle records the change in length, thus activating the stretch reflex and causing a change of muscle length through a muscle contraction. As a direct result of an increase in muscle spindle activity, a fast, dynamic stretch will increase a stretch reflex response causing an agonist muscle to contract with greater force. So, the dynamic range of motion stretch is more effective in increasing the muscle power and performance which did not evaluated during this study.

This study was limited by the following: First, the study was restricted for the male subjects and female subjects not represented in this study. So, the reader must be careful during generalization of the results of this study on all population. Second, this study utilized a relatively young sample. Therefore, the results of the present study will be more suitable for similar age group and further research evaluate the effects of the three methods of stretching in individuals in other age groups would be interested. Third, no warm up activity applied before stretching which may increase the over all ROM gains, that is in agreement with the findings of O'Sullivan et al.,³¹ the warm-up significantly increased hamstring flexibility, static stretching also increased hamstring flexibility, whereas dynamic stretching did not (i.e; the effect of warm-up and static stretching on flexibility was greater in those with reduced hamstring flexibility). Finally, there is no control group in the design of the present study because all the previous literature^{8,9,10,11,32} proved that no changes will occur in the knee extension ROM of the control group as they did not perform any type of stretch.

Conclusion

The results of the study proved that the standing, supine and DROM stretching increased the hamstring flexibility (the three types of stretch led to increased knee extension ROM). Moreover, the standing and supine stretch is significantly higher than the DROM stretch, as well as there is no significant difference between the supine and standing

stretch in increasing the hamstring flexibility. The supine stretch does not require control of the pelvic motion as standing stretch, also isolate the hamstring muscles during stretching. Moreover, during standing stretch must avoid bending of the spinal column. So, the supine stretch requires less instruction and supervision; it may be more effective for home exercise programs or during athletic training.

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المخلص العربي

تأثير الشد الثابت من وضعي الوقوف والنوم على الظهر والشد الديناميكي على مرونة عضلة الفخذ الخلفية

الهدف من الدراسة هو مقارنة تأثير الشد الثابت من وضعي الوقوف والنوم على الظهر والشد الديناميكي على مرونة عضلة الفخذ الخلفية . تم إختيار خمسة وأربعون شخص متطوعاً لهذه الدراسة يتراوح عمرهم ما بين 18-32 سنة وعندهم قصر في عضلة الفخذ الخلفية والذي يعنى أن الشخص يفقد على الأقل 25° درجة من مدى حركة فرد الركبة من وضع إنحناء الفخذ 90° درجة ، تم توزيع الأشخاص بطريقة عشوائية على ثلاث مجموعات متساوية . المجموعة الأولى تقوم بعمل شد ثابت من وضع الوقوف لمدة 30 ثانية ثلاث مرات أسبوعياً . والمجموعة الثانية تقوم بعمل شد ثابت من وضع النوم على الظهر لمدة 30 ثانية ثلاث مرات أسبوعياً . والمجموعة الثالثة تقوم بعمل شد ديناميكي ثلاث مرات إسبوعياً حيث ينام الشخص على ظهره ومفصل الفخذ منحنى 90° درجة ثم يقوم الشخص بفرد الركبة في خلال 5 ثواني ويحافظ على هذا الوضع لمدة 5 ثواني ويرجع مرة ثانية إلى الوضع الأول في خلال 5 ثواني وهكذا تكون مدة الشد 30 ثانية مع فترة الراحة . كل الإجراءات السابقة تكرر ثلاث مرات في كل جلسة لكل نوع من أنواع الشد الثلاثة مع فترة راحة حوالي 15 ثانية ما بين كل تكرار (المدة الكلية للشد في كل جلسة 90 ثانية) . وقد أوضحت النتائج أن الثلاث أنواع من الشد أدت إلى زيادة مرونة عضلة الفخذ . وأن الشد الثابت من الوضع واقفاً وناماً على الظهر كانا أكثر تأثيراً في زيادة مرونة عضلة الفخذ الخلفية عن الشد الديناميكي . كما أنه لا يوجد فرق ما بين الشد من وضع الوقوف أو النوم على الظهر على مرونة عضلة الفخذ الخلفية . هذه الدراسة أثبتت أن الشد من وضع الوقوف أو النوم على الظهر متساويان في تأثيرهما على مرونة عضلة الفخذ الخلفية وكلاً منهما مفضلان عن الشد الديناميكي أثناء تمارين مرونة عضلة الفخذ الخلفية .

الكلمات الدالة : مرونة ، عضلة الفخذ الخلفية ، الشد .