



Comparison of Two Static Stretching Procedures on Hip Adductor Flexibility and Strength

BRANDON M. FJERSTAD^{†1}, ROGER L. HAMMER^{#1}, ADAM M. HAMMER^{†2}, GAVIN CONNOLLY^{†1}, KAREN V. LOMOND^{#1}, PAUL O'CONNOR^{#1}

¹Herbert H. and Grace A. Dow College of Health Professions, School of Health Sciences, Division of Exercise Science, Central Michigan University, Mt. Pleasant, MI, USA; ²Herbert H. and Grace A. Dow College of Health Professions, School of Rehabilitation and Medical Sciences, Doctoral Program in Physical Therapy, Central Michigan University, Mt. Pleasant, MI, USA

*Denotes undergraduate student author, [†]Denotes graduate student author, [#]Denotes professional author

ABSTRACT

International Journal of Exercise Science 11(6): 1074-1085, 2018. It has been shown that acute static stretching (SS) may increase flexibility, improve performance and reduce the risk of muscle strains, but may also result in decreased maximal force output. Literature review revealed little research had specifically been done on the most effective ways to stretch the hip adductor muscles. The purpose was to determine the effects that an acute bout of SS (active vs passive) has on hip adductor flexibility and maintenance of strength. Randomized cross-over study using a 3 X 2 (Condition X Time) repeated measures ANOVA statistical design. Forty healthy and physically active subjects (20 male and 20 female) that screened positive for limited flexibility in hip adductor range of motion (ROM) participated. Following a warm-up, baseline maximal voluntary isometric contraction (MVC) and peak static ROM tests were administered. On separate days subjects randomly performed either 60 seconds of passive SS, active SS, or a time-matched control protocol before post measures were recorded for MVC and ROM. There was a significant time effect ($p < 0.001$) that revealed both types of SS and control resulted in increased ROM pre-to-post (passive = 1.0; active = 1.1; control = 0.6 degrees) with no between condition differences ($p = 0.171$). Neither type of SS resulted in reduced strength. Both methods minimally increased hip adductor flexibility without a decrease in force output. This suggests that individuals do not need to avoid SS for the hip adductors prior to engaging in physical activity for fear of a strength decrement.

KEY WORDS: Stretching intensity, warm-up procedures, maximal force output, passive stretching, active stretching, weight bearing, non-weight bearing, range of motion, hip abduction, groin muscles

INTRODUCTION

Involvement in structured exercise has expanded to include not only accomplished athletes, but recreational participants, both young and old. This is partly due to an upsurge of participant interest and availability of recreational resources (33). As access to physical

activities continues to rise, more people may choose to participate in sports that incorporate movements that require high performance criteria, such as: hockey, soccer, skiing, basketball, football, gymnastics, dance and martial arts (32, 33). These types of activities often require a large amount of hip mobility where participants may make sudden changes in direction that could increase the risk of hip adductor strains (27, 42). Although the causes of hip adductor strains are multifactorial, they may occur when the groin muscles are torn when stretched beyond the limits of normal range of motion (ROM) (3). Appropriate stretching may help reduce the risk of these types of injuries (24, 2, 14), which is why it is important to establish an effective warm-up intervention that includes increasing flexibility, even if only slightly.

Among stretching methods commonly practiced by athletes and other fitness enthusiasts, evidence has accumulated indicating that static stretching may induce strength and physical performance decrements (6, 30, 7). The question then must be asked, why include static stretching in a warm-up? There is evidence that static stretching may be the preferred method used by many individuals because of its ease and safety of implementation that may result in greater flexibility gains than either dynamic, ballistic or proprioceptive neuromuscular facilitation (PNF) methods (44, 12, 22, 38). However, the fear of a stretch-induced strength deficit has led to a paradigm shift on optimal stretching routines within a warm-up (35). Anecdotally, many athletic teams and individuals have removed static stretching for fear of diminished force output and performance and have incorporated dynamic stretching into their warm-up routines instead (46). However, the evidence supporting this shift in practice is not unanimous (18, 38, 6, 43, 35).

Until recently, a warm-up before exercise or sports events often included a short submaximal aerobic component (i.e. jogging, cycling) to increase peripheral blood flow and tissue temperature, followed by a bout of static stretching to lengthen the tissue prior to the activity being performed (47, 25, 46). Static stretching was used almost universally as an essential component to the warm-up due to its demonstrated effectiveness to increase flexibility of the joint (46, 6, 5). It usually involves stretching a limb to its end length and holding the outstretched position for 15-60 seconds (15, 36, 5, 4, 25). Bandy and Irion (4) found 30 and 60 seconds of static stretching were more effective at increasing flexibility of the hamstring muscles than stretching for 15 seconds or no stretching at all. With respect to static stretching effect on strength, Stafilidis and Tilp (38) recently observed that 15 or 60 seconds of static stretching resulted in no decline in isometric force output in muscles of the lower extremities. Additionally, Cannavan et al. (10) showed that four-45 second static plantar flexor stretches increased calf muscle length without a concomitant decrease in strength performance. Conversely, it appears that strength is consistently compromised when static stretching intensity is high and durations are longer than 60 seconds (19, 6, 20).

Among static stretching methods, both active static stretching (SS) and passive SS techniques are easy to implement and are frequently utilized by exercisers (37, 8). Active SS is done by contracting the muscle in opposition of the one being stretched (8). Focus is placed on relaxing the muscle that is being stretched, and relying on the opposing muscle to contract to initiate the movement and hold the position. Passive SS is performed with additional external

assistance to help achieve a stretch. This additional assistance could be from a strap, gravity, another person, or a stretching device. With passive stretching, focus is placed on relaxing the muscle being stretched and relying on the external force to hold the position (8). Studies comparing the effectiveness of active SS vs. passive SS in weight bearing (WB) or non-weight bearing (NWB) positions in effecting change in joint flexibility are lacking (3, 28). Of the few investigations that exist, however, plantar flexors have been studied and it was shown that both active SS and passive SS can be performed using either WB and/or NWB methods resulting in equally effective changes in joint flexibility (14).

Increases in joint flexibility, affected by static stretching, are thought to mainly be attributed to the increased compliance of the targeted limb musculotendinous unit and stretch tolerance (1, 5). Variability in the amount of improvement in flexibility has been associated with differences in stretch intensity, duration, frequency, position, sex, training status and experience (23, 45). Intensity of the stretch is often determined by subjective terminology (i.e. point of discomfort), with few studies that actually try to quantify the intensity and/or consistently control the force of the stretch (3, 16, 18). Initial level of subject flexibility is also an important consideration in designing a stretching study. Highly flexible participants may benefit less from stretching routines than inflexible subjects, as it may be reasoned that they are closer to their maximum developmental potential (34).

Due to gaps in the literature, this study aimed to compare the effects of two different static stretching techniques, passive NWB vs active WB, in less flexible ($< 45^\circ$ hip abduction ROM) (21) males and females, on hip adductor ROM and maximal voluntary isometric contraction (MVC) while monitoring stretching force, intensity and duration. We hypothesized that active SS would be at least as effective as passive SS and that they both would result in a greater ROM outcome than control, without compromising static muscle contractile performance.

METHODS

Participants

A randomized crossover design was used to examine the acute effects of static stretching (passive vs active) interventions against a time-matched control on hip adductor ROM and MVC. This trial was part of a larger study that also examined other stretching methods (foam rolling, static stretching while undergoing whole body vibration, modified lunge stretch, 3-dimensional dynamic stretch and manual joint mobilization) where subjects experienced each intervention and acted as their own control. A portion of this was recently published and findings will be briefly reported in the discussion of the present paper (18).

Forty volunteers were screened and then selected from a larger pool of interested participants recruited from Central Michigan University (CMU) via flyer, email and verbal announcements (Table 1). Study approval was granted by the CMU Institutional Review Board, and all participants completed an informed written consent form. To be included subjects had to be within the ages of 18 to 35 years old, self-identified as positive for limited flexibility ($< 90^\circ$ bilateral hip abduction) of the hip adductors and confirmed to have verified inability to

achieve a selected level of passive hip abduction ROM while seated in the Cybex Hip Abductor/Adductor Machine (model #1181-91 Cybex International Inc., Medway, MA) (Figure 1). Participants were excluded from the study if their bilateral adductor flexibility was considered normal or greater (90° and above), if they had self-reported groin pain or a recent injury within the last 6 months. Also, females were excluded if they were currently or recently (within 6 months) pregnant.

Participants were encouraged to maintain regular activities of daily living, but were asked to not partake in intense lower extremity exercise within 24-48 hours prior to testing to reduce the risk of delayed onset muscle soreness confounding the results. Those who reported soreness were rescheduled to a later date.

Table 1. Subject Characteristics (n=40)

	Males (n=20) Mean \pm SD	Females (n=20) Mean \pm SD
Age (yr)	22.5 \pm 1.8	23.6 \pm 4.2
Height (cm)	181.7 \pm 6.1	168.8 \pm 6.3
Mass (kg)	88.8 \pm 13.1	70.6 \pm 10.3

Protocol

Because this was part of a larger overall study, eligible participants reported to the laboratory on nine days total (1 familiarization day and 8 testing days), at least 48 hours apart, dressed in non-restrictive shorts and a t-shirt. For this manuscript, focus was placed on only four of the nine days (familiarization, passive SS, active SS and control). The schedule of participants and stretches per testing day were selected using a random function generator in Excel® 2010 (Microsoft Corp., Redmond, Washington, USA) to eliminate effects from sequencing. Procedures followed in our lab for this study, including reliability, instrument calibration, and intraclass correlation coefficients on measurements for the ROM test (Figure 1) and the MVC test (Figure 3), have been previously reported in detail (18).

In brief, each participant was familiarized with all testing and interventional procedures, and the load applied on the Cybex machine that caused movement into end hip abduction ROM was determined. On an ensuing day following a warm-up and pre-intervention measures of ROM (Figure 1) and MVC (Figure 2), subjects were randomly assigned one of two SS procedures- passive (Figure 1), active (Figure 3) or the control condition.

Post-intervention measures of ROM and MVC were recorded immediately following completion of the assigned condition. Individual stretching intensity was monitored using a previously published *Stretch Sensation Scale* (18), where a 7 out of 10 was considered ideal based essentially on reaching the point of discomfort. Stretching force was controlled and kept consistent by using the same preselected weight on the Cybex machine for each trial. Subjects underwent the subsequent two remaining conditions on separate days at least 48 hours apart.



Figure 1. Cybex machine being used for pre and post intervention to measure ROM, and for the passive SS intervention.



Figure 2. MicroFET2 (Hoggan Health Industries, Inc. West Jordan, Utah) being used pre and post intervention to measure MVC, modified from the



Figure 3. Participant demonstrating active SS intervention, similar to the *frog straddle* stretch described by Blahnik (8).

Statistical Analysis

SigmaPlot 13.0 (Systat Software, San Jose, CA) was used to perform two separate 3 X 2 repeated measures analysis of variance (ANOVA) to test for the interaction between the stretching interventions for ROM and MVC. Sex as a between-subjects factor was also measured. The 2 factors included Time (pre vs. post stretching intervention) and Test (passive SS, active SS, and control). Assumptions of ANOVA were examined and MVC scores, $D(40) = 0.999$, $p < 0.001$ were found to be non-normally distributed. As such, the variables were transformed by using a two-step transformation technique put forward by Templeton (40). The newly transformed data identified normality for MVC values, $D(40) = 0.013$, $p = 0.200$. A p-value of 0.05 was used for statistical significance.

For each significant interaction found, post-hoc analyses were performed using the Holm-Sidak method. Pearson Correlation was used to determine the linear relationship between

repeat day ROM measures, simultaneous interrater ROM comparison, and between-day variability. A correlation coefficient value of 1 was used to indicate a perfect positive linear relationship between variables. Minimum detectable change (MDC) with 95% confidence interval for ROM and MVC was calculated as $MDC_{95} = SEM \cdot \sqrt{2} \cdot 1.96$ (39). It is important in crossover studies to ensure no day-to-day carryover or additive effects from the selected methods employed, therefore a paired t-Test was used to see if there was an increase in flexibility over time by comparing pre-intervention ROM on the first and last days of data collection.

Table 2. Summary of Static Stretching ROM and MVC Means and Standard Deviations (SD).

Dependent Variable (units)	Passive SS	Active SS	Control
ROM (degrees)			
Pre-test mean (SD)	53.8 (4.9)	53.8 (4.1)	53.7 (4.8)
Post-test mean (SD)	54.8 (4.8)	54.9 (4.3)	54.3 (4.8)
Mean gain (SD)	1.0 (1.9)*	1.2 (1.5)*	0.6 (1.4)*
MVC (kg)			
Pre-test mean (SD)	23.5 (7.0)	23.2 (6.9)	23.1 (7.0)
Post-test mean (SD)	24.3 (7.4)	23.5 (7.2)	24.1 (7.2)
Mean gain (SD)	0.8 (2.2)*	0.3 (1.9)	1.0 (2.5)*

*Indicates mean changes that were statistically significant over time. ($p < 0.05$)

RESULTS

Within-day repeated ROM measurements were shown to have a Pearson Correlation of $r = 0.960$. Simultaneous interrater ROM comparisons had a correlation of $r = 0.995$. Between-day variability was found to be $r = 0.763$ (all correlation p values < 0.001). The paired t-Test (1-tailed) did not reveal a significant difference ($p = 0.11$) between first session pre-test ROM and final session pre-test ROM, indicating that there were not significant increases in hip abduction flexibility over the period of the study. This suggested there was no concern for any day-to-day carry-over or additive effects of the various stretching methods employed. The ANOVA for ROM revealed no significant ($p = 0.719$) interaction between sex and stretching interventions, thus sexes were combined. All three conditions had statistically significant p values (passive SS = < 0.001 ; active SS = < 0.001 ; control = 0.033) indicating increases from pre-to-post measurements; however, none of the conditions were statistically different from one another ($p = 0.171$). MDC at 95% confidence interval for ROM and MVC was 0.6 degrees and 0.9 kilograms respectively. Both static stretching procedures resulted in roughly a 2-fold greater ROM than the calculated MDC, whereas the control condition was only equal to the MDC.

The ANOVA for MVC revealed that no significant ($p = 0.306$) interaction between sex and stretching interventions existed, thus sexes were combined. Both the passive SS ($p = 0.027$) and control conditions ($p = 0.005$) were significantly increased over time, whereas the active SS was not ($p = 0.374$). There was no statistical difference between either of the interventions or control ($p = 0.286$). The mean gain in both SS interventions did not reach the MDC level. Means and standard deviations for ROM and MVC are summarized in Table 2.

DISCUSSION

Establishing effective stretching techniques, that include prescriptions for intensity and duration, may assist individuals with tight muscles in selecting appropriate warm-up protocols prior to participating in activities requiring high performance criteria. This study compared the effects of two forms of static stretching (passive and active) techniques on hip adductor flexibility and strength. The most important observation made was that both acute static stretching techniques resulted in similar increases in flexibility, of about 1° per leg, while maintaining or slightly increasing, rather than decreasing, muscle contractile performance determined using MVC. These small changes are similar to the findings from our previously published paper, which showed significant increases in hip abduction flexibility of from 1.0 - 1.7° from stretching interventions that included a modified lunge stretch, a manual joint mobilization procedure and an active 3-dimensional stretch. Statistically, only the 3-dimensional stretch (1.7°) exceeded control (0.6°) ($p = 0.031$) but was not different than the other stretching methods (18).

Although the slight increase in hip abduction ROM in the control group was equal to the MDC, it was not necessarily unexpected and was thought to have occurred due to participants receiving a slight stretch stimulus from the two trials during each of the pre- and post-ROM control measures. The flexibility increases in both passive and active SS were approximately twice the MDC, but statistically no greater than control and this result is counter to our hypothesis. However, others have also reported only small increases in muscle length following static stretching when studying various muscle groups of the lower limbs (12). With respect to the hip adductors specifically, Rubini et al. (34) observed a 1.4° increase in hip abduction flexibility per leg following passive SS (4 sets of 30 seconds each), which was similar to our findings of about 1° or more. In regard to other muscles of the lower extremity, Bremner et al. (9) observed minimal responses in hip internal rotation regardless of which of the three static stretching interventions (4 sets of 30 seconds each) they examined. These stretching interventions were also not different than control. Konrad (22) determined maximum dorsiflexion ROM by comparing static stretching, ballistic and PNF methods (4 sets of 30 seconds each) and showed only a slight 1.4° improvement in static stretching, which was no different than the other techniques. Stafilidis and Tilp (38) also found no increase in or difference between 15 seconds or 60 seconds of passive SS of the quadriceps, hamstrings, and calf muscles and control on ROM of the knee joint.

Counter to our findings and those cited above which reported only slight increases in ROM are other studies which have shown more dramatic increases in ROM following acute stretching. These were conducted primarily by measuring the hamstrings which have been shown to be more responsive than the hip adductors and other muscle groups to a single bout of stretching (12). For example, Kataura et al. (19), found the hamstrings increased in length by 4.9° following a 180 second static stretch. DePino et al. (13), stretched the hamstrings statically for 4 repetitions of 30 seconds each and increased flexibility by 6.8°. Albeit speculative, the longer length of the hamstring muscles along with their biarticular attachments may account for their increased ROM response to static stretching.

Lack of a significant acute change in flexibility in the present study may have also been due to several anatomical factors that may be inherent in inflexible individuals, like those who participated in our study including: capsular and bony limitations, muscular limitations, and ligamentous limitations in the hip joint (17, 41, 11). Restrictions in hip abduction ROM are more capsular and bony rather than muscular (11). Individual variations in femoral neck angle predisposing towards coxa vara morphology could explain why limited hip abduction flexibility is present in some individuals. A joint with a capsular or bony end range limit would be harder to increase the ROM of, compared to a joint with a muscular limitation (17).

With five major muscles described as adductors of the thigh, there is a high likelihood for contribution of structural properties such as cross-sectional area, pennation, and fascicle lengths that could cause an increase in passive tension as ROM increases and restricts the stretch. Additional external supporting structures of the hip, such as ligaments, may also restrict flexibility (17, 41, 11). For example, the pubofemoral ligament is located anteriorly and inferiorly as it attaches at the pelvis to the iliopubic eminence and obturator membrane. The ligament is composed of a single fiber band and has a narrow, triangular shape. Its primary function is to provide stability of the hip joint by restricting abduction and extension past normal ROM (41). In those individuals where this ligament is shortened, ROM is limited into hip abduction.

Another major point of interest was that neither active SS nor passive SS induced a deficit in post intervention MVC which is line with previous findings investigating similar stretching protocols (10, 38). In contrast to this, others have found that when using an isometric contraction as the testing measure for strength, following static stretching, the testing outcomes on force are often worsened (31). Specifically, Ogura et al. (29) found that 60 seconds of static stretching induced significant strength impairments. However, they studied the hamstring muscles and similar results were not observed in the current study of the groin muscles. Kay and Blazevich (20) found that a maximal contraction of the muscle being stretched before static stretching may decrease stretch-induced strength loss, which could have led to the absence of a decline in post intervention MVC seen in our study. Furthermore, they also concluded that static stretching longer than 60 seconds is generally where decrements in strength begin to manifest and occur more so in the knee flexors than either the knee extensors or plantar flexor muscles. Effects of static stretching on hip adductor strength has not been evaluated prior to our work (18). Perhaps these muscles are less susceptible to static stretching-induced force decreases. The lack of congruency in the literature, in regard to static stretching and its impact on muscular strength, is evidence for the need for more research. It is important to further elucidate any potential mechanisms by which different stretching techniques may or may not impact strength output, and if potential discrepancies may also be attributable to different muscle groups tested and their specific anatomical makeup.

Though this study provides meaningful data and results, it does not go without limitations. The first concern is that a sample that by design includes only participants with less than average hip abduction flexibility may reduce the generalizability of the findings. It is also

possible that those with greater initial flexibility would have had better results as they presumably would not have bony limitations to end ROM. A second concern is that the Cybex machine used to assess hip abduction ROM restricted the participant to a uniplanar movement which was primarily in the frontal plane. Functionally the hip adductors play a much larger role than just femur adduction, especially when performing actions that require multiplanar movements. Therefore, the results and implications from a uniplanar test of extensibility may not accurately transfer to all sports activities. Another potential issue is that we compared passive NWB and active WB, whereas future studies may wish to include passive NWB and WB vs active NWB and WB comparisons. Lastly, testing was designed so that each intervention was performed for a single bout of 60 consecutive seconds. As stretching duration is often dependent on the activity being performed, selecting a variety of stretching durations would provide a broader representation of typical warm-up practices.

In conclusion, our findings suggest that fitness enthusiasts and athletes do not need to shy away from acute bouts of hip adductor static stretching, either using passive or active methods, for up to 60 seconds for fear of a resultant strength decrement. Choice of stretching method should therefore be determined by preference of the individual. Since acute stretching seems to increase flexibility only slightly in the hip adductors, further studies should include a focus on other muscle groups as well. It may also be helpful in the future to study the potential of static stretching for improving neuromotor control which may lead to better performance outcomes.

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