Original Research

The Acute Effect of Hip External Rotator Stretches on Hip Internal Rotation Range of Motion

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ABSTRACT

International Journal of Exercise Science 8(1) : 75-84, 2015. The effects of static stretching on range of motion have been widely studied. However, most of the research has focused on hamstring stretching. The purpose of this study was to compare the acute effect of two commonly used static stretches on hip internal rotation passive range of motion (HIR-PROM). Participants (N=30, 15 male, 15 female; 22±1.8 yrs.; 173.5±8.5cm; 73.8±12.7 kg) were randomly assigned (with gender controlled) to one of three groups: control, figure 4 stretch and modified lunge stretch. Pre-test and post-test HIR-PROM was measured on each subject's non-dominant hip. HIR-PROM was measured with a goniometer from the prone position. The knee was flexed to 90° and the hip was passively internally rotated. Each subject completed a 10 minute warm-up on a cycle ergometer. Upon completion of the warm-up the two stretching groups completed the respective stretching protocol while the control group rested on a table. A mixed method factorial ANOVA was used to analyze main effects (group, time) and if a significant interaction occurred. There was no interaction or group main effect ($p>0.05$). However, there was a time main effect regardless of group assignment ($F_{1,27}=33.151$, $p<0.001$). There appears to be no enhanced acute effect on HIR-PROM when a figure 4 or modified lunge stretch is implemented in addition to a 10 minute warm-up on a stationary bike. In an effort to improve efficiency clinicians may choose to forgo post-cycle ergometer warm-up figure 4 or modified lunge stretching when attempting to acutely increase HIR-PROM.

KEY WORDS: Static stretching, flexibility, hip internal rotation

INTRODUCTION

Some activities that promote flexibility are a current topic of debate within the literature and among clinicians, as they may decrease athletic performance when implemented prior to activity (1, 4, 26). Although controversial, activities that promote flexibility are often implemented by clinicians in order to maintain or increase range of motion (ROM) about a joint. This most likely occurs due to the correlation between ROM and flexibility. ROM refers to the amount of mobility a joint has and is affected by soft-tissue and bony structures; flexibility refers to the ability of a musculotendinous unit to elongate (15). The inability of a muscle to change length, which is referred to as limited muscular flexibility, may cause a joint to become less mobile, or hypomobile (15). Within the clinical setting a hypomobile joint is often referred to as having a "ROM deficit", therefore, the terms hypomobile and ROM deficit will be used synonymously.

A ROM deficit may occur due to a restriction of the musculotendinous units surrounding the joint, joint capsule restrictions, or inflammation within the joint or surrounding structures (22, 24). When a ROM deficit is thought to be caused by a musculotendinous restriction, stretching is a common treatment used by clinicians in an effort to restore joint ROM (24). In particular, static stretching is commonly used within the clinical setting to improve ROM.

Static stretching and its effects on ROM have been widely studied (1-3, 7-11, 13, 18, 36, 39, 40). For example, hamstring stretching has been shown to effectively improve knee ROM (1-3, 8, 9, 11, 36). Although previous research has examined the effects of stretching on ROM within the shoulder musculature and various muscles of the lower extremity (18, 39, 40), the majority of the research has focused on hamstring stretching (1-3, 7-11, 36). Therefore, there is little to no work addressing the use of static stretching to improve ROM in many of the joints clinicians routinely deal with in treating athletes, such as hip internal rotation (HIR). Consequently, clinicians may assume ROM improvements do in fact occur via these stretches. The use of assumptions is contrary to the evidenced based medicine model as each joint has unique functions and structures.

The hip joint has three degrees of freedom and is one of two ball-and-socket joints in the human body. Muscles acting on a joint with three degrees of motion do not always maintain the same function as joint position changes (16). For example, the piriformis muscle is considered to be a hip external rotator (5, 17). However, the piriformis' function changes in relation to hip positioning. When the hip is extended the piriformis serves as an external rotator, but when the hip is flexed it serves as a hip internal rotator (16, 29). Thus, it is plausible that the effectiveness of hip external rotator stretches is altered by hip positioning during the stretch. Therefore, research evaluating clinically utilized stretches and their effect on HIR ROM is needed. It would be particularly valuable for clinicians in the prevention and treatment of hip internal rotation deficits (HIRD); which have been associated with a variety of athletic injuries. These injuries include medial tibial stress syndrome, low back pain, groin injuries, and shoulder injuries (19, 20, 27, 32-35, 37). Although no empirical evidence suggests that participation in a stretching program prevents injuries associated with HIRD, stretching is often suggested as a prevention/intervention strategy (25, 33, 34, 37). Evaluating the efficacy of hip external rotator stretches may allow clinicians to make an evidence based choice rather than assume that static stretching will improve HIR ROM.

In an effort to advance scientific knowledge concerning hip external rotator stretching, that would be relevant for clinicians, we chose to compare the "modified lunge" and "figure 4" stretches. The stretches were selected due to their common use within the clinical setting. In addition, the muscles targeted by these stretches have been identified as hip external rotators (5, 28). It should be noted that the modified lunge is commonly used as a hip flexor stretch rather than a hip external rotator stretch. However, the iliopsoas (hip flexor) has been identified as an external rotator (5). It is plausible that a stretch not traditionally used by clinicians, for improving a specific ROM, to improve the desired ROM more efficiently than traditionally used stretches (21). Consequently, the modified lunge stretch was included to compare an anterior external rotator stretch to a traditional posterior external rotator stretch. Therefore, it was the purpose of this study to compare the acute effect of two commonly used static stretches ("modified lunge" and "figure 4") on hip internal rotation passive range of motion (HIR-PROM). A passive range of motion (PROM) measurement was used in an effort to eliminate participant bias. PROM is defined as the amount to which a joint can be moved, without the involvement of muscular contractions, until its end point is reached (24).

METHODS

Participants

A convenience sample of 30 participants (15 male, 15 female; age 22.6±1.8 years; height 173.5±8.5 cm; mass 73.8±12.7 kg) was obtained from the university community. To be included in this study, participants needed to be currently exercising dynamically (e.g., jog, run, cycle, swim, tennis) a minimum of 2 times a week for at least 30 minutes each time and they could not have been diagnosed with hip pathology at any time during their life. Each participant gave signed informed consent prior to participating and the University's Institutional Review Board approved this study.

Protocol

A randomized mixed-model experimental design was used to compare the acute effects of the figure 4 and modified lunge stretches on HIR-PROM. The independent variables were Time (within participants factor) and Group assignment (between participants factor) with the dependent variable being HIR-PROM.

All instructions, ROM measurements and treatments were performed by the same three investigators throughout the study to avoid interexaminer variation. Investigator 1 performed the passive hip internal rotation during the measurement process and was blinded to all measures obtained. Investigator 2 performed the HIR-PROM measurement. Investigators 1 and 2 were blinded to participant group assignment (control, modified lunge stretch, or figure 4 stretch) by leaving the lab while the participants received group assignments, instructions, and performed the warm-up and stretching protocols. After the pre-test measurement, instructions for each group were provided in a video format to ensure consistent instruction for all participants. In an effort to limit infidelity throughout the data collection process, Investigator 3 verified that all procedures were performed as they are reported in the study.

All measurements and treatments took place in the institution's Sports Injury Research Center (SIRC). Upon arrival to the SIRC participants were briefed on the procedures of the study and asked to sign the consent form. Age, height, weight, gender, and dominant leg were recorded. Only the non-dominant leg (28 left, 2 right) was used in this experiment and was defined as the opposite leg with which the participant would choose to kick a soccer ball. Participants were randomly assigned (with gender balanced) to either the control group or one of two stretching groups (figure 4 stretch or the modified lunge stretch). Each group consisted of 10 participants (5 males, 5 females).

Pre-test HIR-PROM measurements were obtained with the participants positioned prone on a treatment table. The hip was neutral in regards to abduction/adduction and the pelvis stabilized to the table with a belt. The knee of the test leg was flexed at 90° flexion. Investigator 1 then passively internally rotated the hip to the end of HIR-PROM (Figure 1A). The end of HIR-PROM was defined as once Investigator 1 felt resistance or the participant expressed discomfort. Investigator 2 then measured the angle with a 12-inch plastic goniometer (Figure 1B). To ensure consistent placement of the goniometer, Investigator 2 placed a small mark on the center of the patella (patellar mark). Investigator 2 measured the distance between the medial to lateral patellar poles and the distance between the superior to inferior patellar poles. The patellar mark was then placed at the midway point of the medial/lateral patellar pole and the superior/inferior patellar pole measurements. Another mark was placed on the anterior tibial crest 20 cm from the patellar mark, which served as a reference for the alignment of the movement arm. The marks were made prior to the pre-test HIR-PROM measurement. A bubble level was attached to the stationary arm of the goniometer to enable Investigator 2 to verify that the arm was parallel to the table (horizontal position). The axis of the goniometer was centered over the midpatellar surface, with the movement arm aligned to the midline of the lower leg (anterior tibial crest) and the stationary arm positioned parallel to the table top (22, 23). The reliability of the HIR-PROM measurement procedures has previously been established (12, 14).

Figure 1A-B. Photographs of the hip internal rotation passive range of motion measurement technique.

Participants watched a video that provided instructions regarding the standard warm-up protocol and the participant's randomly assigned stretch (when applicable). All participants (including the control group) then completed the 10 minute warm-up protocol. Participants pedaled a cycle ergometer at a pace of 50 revolutions per minute (rpm) at a resistance of 1 kilopond (kp). A metronome set at 100 beats per minute was used to ensure a consistent rpm rate. The cycle ergometer seat height was adjusted to each participant's hip level when standing to the side of the ergometer.

The control group was asked to rest lying prone on the treatment table for 3.5 minutes, which was equal to the time taken to stretch other participants, prior to post testing. Participants in the two stretching groups were given a 1 minute period to prepare for the stretching protocol. The stretching protocol for this study was derived from the 2010 American College of Sports Medicine (ACSM) stretching recommendations (31). In addition, a similar protocol has been shown to acutely increase ROM (11). Each static stretch was held for 30 seconds and four repetitions of the stretch (figure 4, or modified lunge depending on group assignment) were performed, with a 10 second rest period between each repetition. Participants were instructed to perform the stretch to the limit of discomfort within the ROM.

The "figure 4 stretch" was derived from a stretch found in a current sports medicine text (28). While lying supine on the floor (a yoga mat was used for comfort) the non-dominant leg was crossed over the dominant leg (Figure 2A). Participants grabbed the dominant leg and pulled the knees toward the chest (Figure 2B).

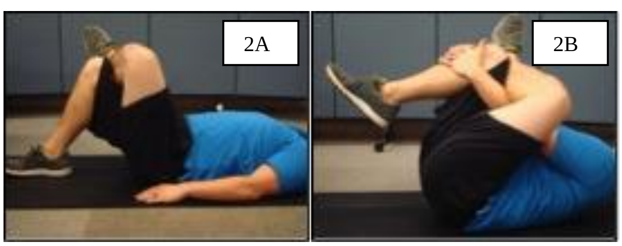

Figure 2A-B. Photographs of the "Figure 4" stretch.

The "modified lunge" stretch was selected due to its common use within the clinical setting. The modified lunge stretch was performed in a half-kneeling position. Participants assumed the half-kneeling position with the non-dominant knee on the ground (a yoga mat was placed under the knee for comfort) and the trunk erect (Figure 3A). Participants performed the stretch by placing the pelvis in a posterior tilt and leaning forward by flexing the dominant hip and knee (Figure 3B) (38). Upon completion of the assigned stretching protocol, participants were repositioned on the testing table and their post-test HIR-PROM measurements were taken following the same procedures as the pre-test.

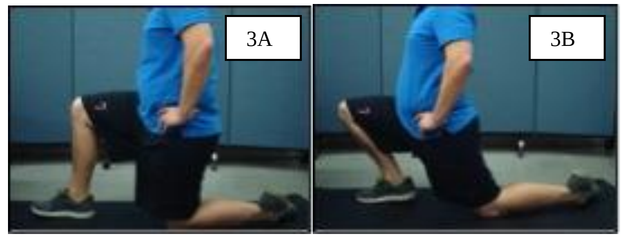

Figure 3A-B. Photographs of the "Modified Lunge" stretch.

Statistical Analysis
SPSS (version 19.0, Chicago, IL) software was used to perform all statistical analysis. A 2X3 (pre/post HIR-PROM X Group assignment) mixed model factorial analysis of variance was used. The alpha level was set at 0.05.

RESULTS

Normality and homogeneity of variance tests were not significant ($p>0.05$). Therefore, normal statistical assumptions were not violated. HIR-PROM was not influenced by the interaction between Time and Group ($F_{2,27}=0.677$, $p=0.396$). HIR-PROM was greater over Time regardless of group assignment ($F_{1,\ 27}=33.151$, $p<0.001$). However, HIR-PROM was not influenced by Group ($F_{2,27}=0.169$, $p=0.846$) (Figure 4).

DISCUSSION

The purpose of this study was to compare the acute effect of two commonly used static stretches ("modified lunge" and "figure 4") on HIR-PROM. Increases in HIR-PROM were seen over time in each group (control, figure 4, modified lunge).

The most noteworthy observation was that ROM increased over time regardless of group assignment. It was not expected that ROM would increase for the control group over time, but it is logical that an increase in ROM may occur since riding a cycle ergometer could have a dynamic stretching effect.

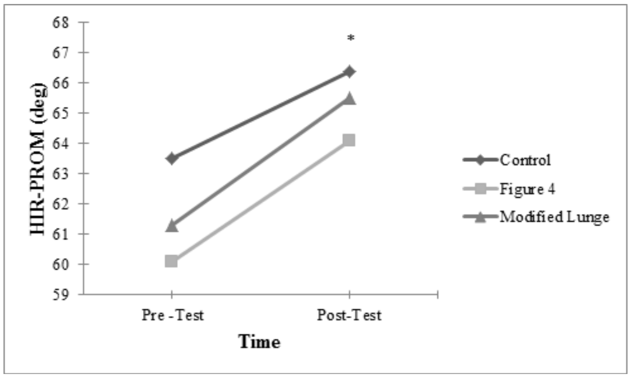

Figure 4. Group at time line graph. Illustrated here is hip internal rotation passive range of motion (HIR-PROM) in degrees (deg) over time (pre-test and post-test). (note:* significant main effect for time $p < 0.001$).

HIR-PROM averaged 61.6 ±11.0° for all pre-test measures and 65.3 ±10.5° for all post-test measures. A previous study has reported means for normal HIR-PROM using a group of 206 healthy adults (102 males, 104 females) with a mean age of 23 years; they also reported a range in which 95% of their measurements occurred (30). The mean value reported for adult females was 52° and 95% of the female measurements taken fell between 34-71°. The mean value reported for adult males was 38° and 95% of the measurements taken fell between 23-53° (30). It is not known why the mean HIR-PROM measures in this study are higher than those reported by Sevenningsen et al. (30). However, the means and ranges reported in their study demonstrate that HIR-PROM varies among genders as well as among individuals.

PROM measurements may differ from active range of motion (AROM) measurements due to the application of an external force in order to produce the motion, the participants' reported level of discomfort, or patient positioning. Bierma-Zeinstra et al.(6) compared mean (no standard deviations were reported) HIR ROM measurements taken actively and passively from three possible positions (prone, seated, and supine). Mean HIR-PROM reported for the measurements taken with the participant in the prone position was 53.2°, and the reported mean HIR ROM for prone AROM was 46.3° (approximately 7° less). In addition, mean HIR-PROM measurements were 13-14° greater when taken from the prone position in comparison to the supine and sitting positions (6). Their measurements demonstrate that a large amount of variability exists between AROM and PROM measures as well as among measurements taken from different patient positions. Therefore, the technique (AROM or PROM) and patient positioning (prone, seated, or supine) used while measuring HIR ROM may influence the amount of ROM measured. A PROM technique and prone patient positioning were used to measure HIR ROM in this study. According to the observations of Bierma-Zeinstra et al.(6) this particular combination would yield the largest amount of HIR ROM. Therefore, it is believed that the HIR-PROM data obtained in this study are reasonable and valid. However, additional research may be needed to more thoroughly understand factors that influence HIR ROM values and why they may differ between studies.

It may be that the amount of force applied to the limb while measuring PROM varies between testers (as well as between studies). In this study, the force was applied to the limb until Investigator 1 felt tissue resistance or until the participant expressed discomfort. Variability in the amount of force used or variability in participant feedback may explain HIR-PROM differences among studies. Further studies could implement the use of a dynamometer to ensure a consistent force is applied during the HIR-PROM measurement. However, this study was a repeated measures design and Investigator 1 was blinded to all measurements as well as participant group assignment in an effort to limit any bias. In addition, Investigator 1 (who applied the force) was chosen to perform the passive movement due to his 17 years of experience as a health care professional.

A limitation of the study was that participants were young, apparently healthy adults. Due to the age and health status of the participants, it is plausible that a ceiling effect occurred; meaning that the participants may have already possessed their maximum (or near maximum) physiological HIR-PROM and thus could not improve further. It is not known if the results of this study can be applied to a population lacking HIR ROM (e.g., geriatric population, population with HIRD). A ceiling effect may be a possible explanation as to why the improvement noted in the control group was equal to the stretching groups. To obtain additional insight from the data, HIR-PROM percent change over time ([post-test- pre-test] /pre-test*100) for each participant was calculated and illustrated in a scatter plot (Figure 5). Upon further review of the scatter plot, it is conjectured there might be a trend that the participants with a smaller amount of pre-test HIR-PROM had a greater ROM percent change. This observation confirms the need to further evaluate the stretching (figure 4, modified lunge) effects on HIR-PROM using a population lacking HIR. However, it is important to note that there was no difference in pre-test HIR-PROM between groups.

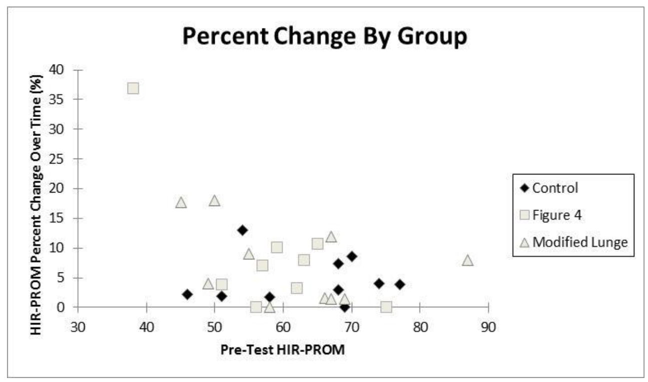

Figure 5. Percent change by group scatter plot. Illustrated here is each participant's hip internal rotation passive range of motion (HIR-PROM) percent change over time ([post-test- pre-test]/pre-test*100) and pre-test hip internal rotation passive range of motion (Pre-Test HIR-PROM). The participants are organized by group (control, figure 4, modified lunge). (note: two participants within the figure 4 group presented with the same measurements so only 9 participants are represented from the figure 4 group).

The pre-test and post-test HIR-PROM measurements were the same between each of the 3 groups and each group showed a similar improvement over time. It is possible that the warm-up may have had a dynamic stretching effect resulting in improved HIR-PROM. However, it was not anticipated that the control group improvement would be comparable to the stretching groups' improvement.

Many questions regarding hip external rotator stretches and their effect on HIR-PROM remain unanswered. Further research is warranted to determine why riding a cycle ergometer for 10 minutes improved HIR-PROM as effectively as performing a hip external rotator stretch in addition to the warm-up. The long-term effects of the figure 4 and modified lunge stretch on HIR-PROM are still unknown. Further research is warranted to determine if a greater ROM improvement does in fact occur when regularly implementing the figure 4 or modified lunge stretch over an extended period of time (i.e. 6 weeks) or within a population lacking HIR ROM.

The increase in HIR-PROM seen over time within each group provides some clinically relevant insight. Athletic trainers, physical therapists and other health care providers are often understaffed. For example, it is not uncommon for one athletic trainer to be responsible for the care of an entire team. Therefore, clinical efficiency is necessary. Furthermore, if a treatment is not effective it should not be implemented; as it is contrary to evidenced based medicine. In order to increase clinical efficiency and provide the best patient care the use of ineffective treatments should be eliminated. The results from this study bring about uncertainty regarding the efficacy for improving HIR-PROM of the figure 4 and modified lunge stretches (within a healthy population). One would expect a greater improvement over time within the stretching groups in comparison to the control group if the stretches were an effective intervention for the improvement of HIR-PROM. Due to the results of this study, it is hypothesized that performing a 10 minute cycling warm-up is just as effective without post warm-up stretching (figure 4 or modified lunge) than it is with post warm-up stretching, to acutely improve HIR-PROM. Therefore, clinicians attempting to acutely increase HIR-PROM may opt to forgo post warm-up figure 4 or modified lunge stretching in an effort to increase efficiency as well as to only provide evidenced based treatments.

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