DOES HIP CONTRACTURE EFFECT ANTERIOR PELVIC TILT CHANGES DURING SQUATTING?

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The purpose of this study was to examine possible effects of hip flexor contractures on changes in pelvic anterior tilt during the squat. Twenty recreationally active subjects were evaluated for hip contracture using the Modified Thomas test. Eight subjects were found to have iliopsoas contracture and twelve were found to have rectus femoris contracture. A 2x8 mixed-model repeated measures ANOVA was completed between the positive and negative hip contracture groups for both the iliopsoas and rectus femoris results. No significant differences were found between the hip contracture groups for the iliopsoas (p=.90) or the rectus femoris (p=.18). These results indicate the Modified Thomas test results about hip contracture do not have an effect on changes in pelvic motion during the squat.

KEY WORDS: Hip flexors, iliopsoas, Modified Thomas Test, rectus femoris, squat

INTRODUCTION: Flexibility and strength changes in muscles surrounding the body's joints may affect posture and the chance of injury (Harvey, 1998; Winters et al., 2004; Zhu et al., 2010). Therefore, certified athletic trainers use special tests to evaluate the possiblility of injury or reinjury (Iversen et al., 2016; Winters et al., 2004). These tests can also be used to examine for abnormalities and the range of motion and flexibility of the hip/leg complex. Any restrictions in range of motion around joints can lead to changes in the movements of a motor skill, increasing energy expenditure and the likelihood of injuries (Witvrouw et al., 2003). Analyzing the affects of the restrictions around the pelvis using special tests may provide information about the effects of the pelvis on posture (Gajdosik, 1985; Riley et al., 2010).

Increases in the anterior tilt of the pelvis is a possible outcome of restrictions in the range of motion around the pelvis. Anterior pelvic tilt is diagnosed when the distance between the midpoint of both anterior-superior iliac spines and the coronal plane is greater than the distance from the symphysis pubis and the coronal plane (Zhu et al., 2010). Among the dominant anterior hip musculature is the rectus femoris, which becomes tight during anterior pelvic tilt. Additionally, the iliacus, psoas major, and psoas minor accompany the rectus femoris in its contracted state, known as hip flexor contracture. If the hamstrings are weak or can not lengthen appropriately, the hamstrings might also increase anterior pelvic tilt. The anterior hip musculature on the anterior of the hip may dominate the movement of the hip (Wolf et al., 2014).

One of the special tests that is used by athletic trainers to assess hip contracture is the Modified Thomas test. This test assesses the contracture of the iliopsoas and the rectus femoris. The Modified Thomas test is commonly used by Athletic Trainers, however, there is a lack of research examing a positive result and its possible affect on motor skills and sports performance. The squat is used in most resistance training programs for athletes and involves considerable hip flexion. However, the squat is often done incorrectly and could result in injuries. The purpose of this study was to examine possible effects of hip flexor contractures on changes in pelvic anterior tilt during the squat. We hypothesized that hip contracture related to the iliopsoas and rectus femoris would result in more pelvic anterior tilt change during the squat.

METHODS: A repeated measures experiment was used to assess hip flexor contracture and its effect on pelvic anterior tilt changes during the squat technique. The researchers recruited

10 males and 10 females (22.0±2.21 years, 175.13±11.25 cm, and 84.91±20.72 kg) who were active in resistance training. In addition, to be eligible, the subjects had to do the squat exercise in their workouts at least once per week for at least the last six months. To validate the individuals' squat experience, they were instructed to perform a body weight squat during which their form was assessed. This study was approved by the North Dakota State University Institutional Review Board.

Reflective markers based on Norris and Olson (2011) were placed on the posterior aspect of the humeral head, anterior superior iliac spine (ASIS), posterior superior iliac spine (PSIS), the midline between the ASIS and PSIS, approximately 6 inches above the midline marker that intersects the midline at 90°, greater trochanter, lateral femoral condyle, and the lateral malleolus. Next the Modified Thomas Test was conducted as directed by Starkey and Brown (2015) by three board certified athletic trainers with 42 total years of experience. In order to minimize outcome bias by the participant completing three tests, the order of the Athletic Trainers was randomized and the subject rested for one minute between tests.

After the Modified Thomas tests the subjects completed a maximum isometric squat test on an American Medical Technologies Incorporated (AMTI) AccuPower (Watertown, Massachusetts) force plate inside a squat rack (Bazyler et al., 2015). On the right side of the squat rack was a Casio camera at approximately hip level. The subjects then performed 8 squat repetitions at 80% of their maximum isometric test.

Joint angles were measured using Dartfish software version 8.0 (Fribourg, Switzerland). Anterior pelvic tilt was measured in the lowest position of the squat when the knees were at approximately 90 degrees. Unfortunately, the view of the ASIS marker was obscured by the trunk and thigh at the bottom of the squat in most cases. Therefore, the following process was used to calculate the amount of pelvic tilt: the posterior pelvic angle was measured and subtracted from 180 degrees to get the anterior tilt angle, which was then subtracted from 90 degrees to get the change in the anterior pelvic tilt from the subject's starting 90-degree position.

If at least two of the Athletic Trainers determined there was hip contracture the subject was considered positive for hip contracture based on the criteria for iliopsoas and rectus femoris contracture. A 2x8 mixed-model repeated measures ANOVA was completed between the positive and negative hip contracture groups for both the iliopsoas and rectus femoris results. SPSS version 25 was used to analyze the anterior tilt angles data, with a level of statistical significance set at $p<0.05$.

RESULTS: Out of the 20 subjects, 8 were diagnosed with iliopsoas contracture and 12 were disposed with rectus femoris contracture by at least two of the athletic trainers. The mean change in anterior pelvic tilt for the iliopsoas non-contracture and contracture groups during the squat were 48.1 degrees and 47.2 degrees respectively. The mean change in anterior pelvic tilt for the rectus femoris non-contracture and contracture groups were 41.9 degrees and 51.6 degrees respectively.

There were no significant differences between the iliopsoas contracture groups $F(1,18)=0.017$, $p=.90$, $\eta_p^2 =.001$ or between the rectus femoris contracture groups $F(1,18)=2.00$, $p=.18$, $\eta_p^2 =.100$. Although there were no statistically significant differences, the iliopsoas contracture group had slightly more anterior pelvic tilt change during the first four repetitions, but less than the iliopsoas non-contracture group after repetition five (Figure 1). There also were no statistically significant differences between the rectus femoris contracture groups, however, the contracture group was found to have a greater anterior pelvic tilt change at every repetition during the squat (Figure 2).

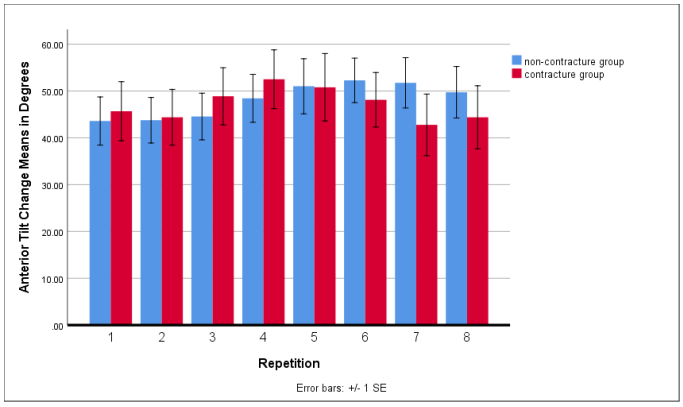

Figure 1. The subjects in this study were tested for hip flexor contracture using a Modified Thomas test. The figure above shows the mean change in anterior pelvic tilt angles from the starting position of the squat to the lowest position of the squat for each repetition for the subjects found to have iliopsoas contracture or non-contracture.

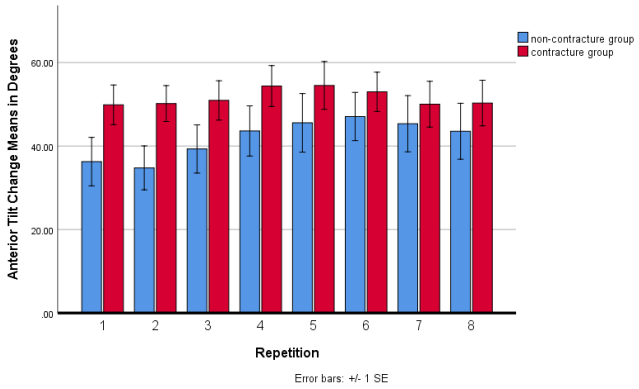

Figure 2. The subjects in this study were tested for hip flexor contracture using a Modified Thomas test. The figure above shows the mean change in anterior pelvic tilt angles from the starting position of the squat to the lowest position of the squat for each repetition for the subjects found to have rectus femoris contracture or non-contracture.

DISCUSSION: The purpose of this study was to examine the possible effect of hip flexor contractures on changes in pelvic anterior tilt during the squat. We had hypothesized that hip contracture related to the iliopsoas and rectus femoris would result in more pelvic anterior tilt change during the squat. However, we did not find any significant differences in pelvic anterior tilt changes between the non-contracture and contracture groups. Although not significant, the rectus non-contracture group had less change in anterior pelvic tilt than the contracture group for all 8 repetitions. The assessment of hip contracture by special test such as the Modified Thomas Test is commonly done by Athletic Trainers and the squat is used in most athletic resistance training programs. However, only one study was found that examined changes in anterior pelvic tilt during squatting (Lamontagne et al., 2009). In this study the researchers compared femoroacetabular impingement participants and non-pathological participants and noted an effect that occurred on the pelvis from femoroacetabular impingement. The pelvic tilt measures for femoroacetabular impingement participants averaged 14.7 ± 8.1°, while the control group averaged 24.2 ± 6.8°. These values are much lower than those determined by our study (41.9° to 51.6°). This may be due to the type of motion analysis used, Lamontagne et al. performed three-dimensional motion analysis and we performed two-dimensional motion analysis. Another difference may stem from marker placement and measurement method. Lamontagne et al. (2009) did not specify which markers were used specifically for pelvic tilt and our marker placements may have been influenced by trunk movement, which could have affected the accuracy of our measurement of anterior pelvic tilt. Lamontagne et al. (2009) also used body weight squats, whereas, we used a load of 80% of the subject's maximum isometric test, which could result in more anterior tilt. Therefore, we achieved much higher measurements of anterior pelvic tilt than this study (Lamontagne et al., 2009).

In addition to using two-dimensional analysis, other limitations of our study included only examining changes in anterior tilt in one position at the bottom of the squat, and the reliability and validity of the Modified Thomas Test. It is possible there could be greater differences in anterior tilt changes between non-contracture and contracture groups at other squat positions. However, based on our observations and experience we feel the greatest changes are likely to occur at the position we analyzed. Given the limitations of the current study, we didn't find any significant differences between subjects diagnosed with hip contracture due to iliopsoas or rectus femoris tightness and those that were not. This would indicate that the results of a Modified Thomas Test don't make a difference in anterior pelvic tilt motion when completing a squat exercise.

CONCLUSION: Hip contracture results of the iliopsoas or rectus femoris based on the Modified Thomas Test were not found to lead to significant differences in changes in pelvic anterior tilt during a squat. More research is needed in changes to anterior pelvic tilt during dynamic movements such as the squat and the reliability and validity of the Modified Thomas Test.

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