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Examining the effects of altering hip orientation on gluteus medius and tensor fascae latae interplay during common non-weight-bearing hip rehabilitation exercises

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ABSTRACT

Background: Improving activity and strength of the gluteus medius muscle is a common goal among clinicians aiming to rehabilitate lower extremity and low back injuries. The functional anatomy of the hip is complex, particularly how position-dependent the activity and strength of many muscles surrounding the hip are, and the optimal exercise technique to isolate gluteus medius remains controversial. The objective of this study was to quantify the effect of altering hip orientation during side-lying clamshell and hip abduction exercises on the relative muscle activation profiles of gluteus medius and tensor fascae latae.

Methods: The ratio of gluteus-medius-to-tensor-fascae-latae peak electromyography signal amplitude of 13 healthy, male participants was compared across variations of the clamshell and abduction exercises. The hip flexion angle was varied from 30°, 45°, and 60° for the clamshell, while hip rotation orientation was varied from internal, neutral, and external rotation for the abduction exercise.

Findings: Varying hip angle – flexion in the clamshell exercise and internal/external rotation in the abduction exercise – did not significantly affect the interplay between gluteus medius and tensor fascae latae activation levels. Both exercises remained gluteus medius-dominant across all variations, but the gluteus-medius-to-tensor-fascae-latae ratio was far greater for the clamshell than for the abduction exercise; the clamshell may be the preferred rehabilitative exercise to prescribe when minimal tensor fascae latae muscle activation is desired by the clinician.

Interpretation: These findings provide information for clinical decision-making pertaining to effective gluteus medius activation in lower extremity and low back exercise rehabilitation programs.

1. Introduction

Increasing activity and strength of the gluteus medius (GMed) muscle is a common goal among clinicians aiming to rehabilitate lower extremity and low back injuries with therapeutic exercise. The rationale for targeting this muscle within lower extremity and low back injury exercise rehabilitation programs are the many known associations between hip dysfunction and both lower extremity and low back pain/dysfunction. There is evidence to suggest that perturbed gluteal mechanics may be both the cause and consequence of pain/dysfunction. Pain appears to inhibit the gluteal muscles. For example, chronic low back pain is linked to inhibition of the gluteal muscles (Janda, 1989; Janda et al., 2007) and, recently, acute hip pain was shown to inhibit gluteal activity (Freeman et al., 2013). Furthermore, perturbed gluteal function, specifically, a lack of hip abductor muscle strength is associated with lower extremity injuries, such as ankle sprains (Beckman and Buchanan, 1995; Friel et al., 2006), iliotibial band syndrome (Fredericson et al., 2000), and patellofemoral syndrome (Bolgla et al., 2011), as well as hip osteoarthritis (Rasch et al., 2007) and low back pain (Arab and Nourbakhsh, 2010). Exercise programs that incorporate hip abductor strengthening, specifically GMed strengthening, have demonstrated improvement in lower extremity pathologies (Fredericson et al., 2000; Khayambashi et al., 2012), low back pain in prolonged standing (Nelson-Wong and Callaghan, 2010), and explosive power output in athletes (Crow et al., 2012). It appears justifiable that gluteus medius is indeed a critical component of many lower extremity and low back injury rehabilitation and prevention programs as well as some performance training exercise programs. Questions remain as to how to best train this muscle.

Clinicians prescribe a wide variety of exercises that are assumed to primarily strengthen GMed (Presswood et al., 2008; Reiman et al., 2012) and/or integrate it into the motor control scheme, but this assumption is more often based on knowledge of the anatomy, mechanics, and functions of the muscles about the hip and shared experiences among clinicians rather than on empirical evidence confirming the

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level of GMed activation. Despite the complex nature of the functional anatomy of the hip (Gottschalk et al., 1989), particularly how position-dependent the activity (Delp et al., 1999; Dostal et al., 1986) and strength (Johnson and Hoffman, 2010) of many muscles surrounding the hip are, and evidence of the ability to selectively activate muscles of the posterolateral hip during functional rehabilitation (Cambridge et al., 2012), very little consideration has been given to the optimal variation (with respect to primary GMed activity) of commonly used GMed strengthening exercises and the contribution of synergistic muscles about the hip, such as tensor fascae latae (TFL) (Cobb et al., 2012; Lee et al., 2013). The clinical question regarding prescription of the most effective GMed strengthening exercise must address the relative muscle activation of GMed and TFL in variations of specific exercises.

Perhaps two of the most common GMed strengthening exercises used in clinical practice are the side-lying clamshell (CLAM) and the side-lying hip abduction (ABD) exercise (McGill, 2007). These are typically used in the early stages of lower extremity and low back injury rehabilitation programs because they are non-weight-bearing exercises that put the patient in a highly stable position, isolate movement about the hip, and do not require additional equipment. The level of GMed activation has been reported on for both the CLAM and ABD, but is typically only compared across different GMed strengthening exercises (Bolgla and Uhl, 2005; Distefano et al., 2009; Selkowitz et al., 2013) rather than within variations of the same CLAM or ABD exercise. Only one study (Distefano et al., 2009) has compared two variations of the CLAM – 30° and 60° of hip flexion – and found similar levels of GMed activity between the two variations, but did not report on the contribution of TFL. GMed and TFL activity have been measured during the standard CLAM (Cobb et al., 2012), but variations were not compared. In addition, anecdotal evidence, consistent with the informal evidence acquired by others (Cobb et al., 2012), suggests that many clinicians prescribe variations of ABD, such as ABD while maintaining hip external or internal rotation. One study (Cobb et al., 2012) has compared GMed and TFL activation across two variations of ABD (i.e., ABD and ABD while maintaining hip external rotation) and found that GMed was significantly more active and TFL was significantly less active in ABD, but ABD while maintaining hip internal rotation was not included in this comparison and a weight equivalent to five percent body mass was applied to the ankle in both conditions. The relative muscle activity of GMed and TFL was compared during ABD and ABD while maintaining hip external and internal rotation in another study (Lee et al., 2013); however, all variations of ABD were performed isometrically, so only one point during the movement was measured and findings may not represent muscle activity when the exercise is performed dynamically. Clearly, a comparison of GMed and TFL activity across all three variations of ABD is needed to gain a clear understanding of the interplay between GMed and TFL for each variation.

The objective of this study was to assess the effect of altering hip angle – flexion during the side-lying clamshell and internal/external rotation during the side-lying hip abduction exercises – on the relative muscle activation profiles of GMed and TFL. Based on previous *in vivo* study findings (Boren et al., 2011; Cobb et al., 2012; Distefano et al., 2009) and assumptions formulated from muscle modeling studies (Delp et al., 1999; Dostal et al., 1986; Gottschalk et al., 1989), it was hypothesized that GMed and TFL activation ratios would not be influenced by altering the hip orientation in variations of the CLAM or ABD, respectively.

2. Methods

2.1. Participants

Thirteen healthy males were recruited to participate in this study. Their average age, height, and weight were 24.8 (SD 4.2) years, 179.7 (SD 5.4) centimeters, and 75.9 (SD 9.8) kilograms, respectively. Participants did not have a history of spinal, abdominal, or hip surgery, a pre-existing disabling back or hip condition, or current and relevant musculoskeletal concerns.

All subject recruitment and data collection procedures received the approval of the university's Office of Research Ethics.

2.2. Experimental design

To determine the effect of altering hip orientation on the relative muscle activation profiles of GMed and TFL during two common non-weight-bearing hip rehabilitation exercises (CLAM and ABD), a repeated measures design was employed. The independent variable, hip orientation, was varied three times for each exercise while electromyography (EMG) signals of selected hip muscles were continuously collected for the duration of each trial. For CLAM, the hip flexion angle was varied from 30°, 45°, and 60° while the hip rotation orientation was varied from internal, external, and neutral for ABD. The dependent variables in this study were the EMG signal amplitudes of the right GMed and TFL. Specifically, the ratio of GMed-to-TFL peak EMG signal amplitude was compared across variations of each exercise.

2.3. Tasks

Participants were provided with a demonstration of each exercise and variation and were required to practice these until the researcher deemed their technique and execution to be satisfactory. Achieving this satisfactory level of technique and execution typically only took a few attempts or approximately five minutes per task. Once the practice trials were completed, three consecutive trials of each variation of each exercise were performed with proper execution (visually evaluated by the researcher). The order that each of the following exercises and their variations were performed by each participant was randomized.

2.3.1. Side-lying clamshell

Participants were instructed to lie on their left side with their legs together, hips and knees flexed, and left arm supporting the weight of their head (Fig. 1a). Before each trial, the researcher adjusted the hip flexion angle of the participant to 30°, 45°, or 60° using a standard goniometer and then adjusted their knee angle so that the heels of the participant's feet were in line with their buttocks (from an overhead perspective) (Fig. 1b). Participants were then instructed to keep the medial borders of their feet together as they externally rotate their right hip as much as they can to separate the right knee from the left, stop the movement before having to rotate their pelvis backwards, keep the left leg in contact with the floor throughout the entire movement (Fig. 1c), and, finally, return their right leg to the starting position. Participants were cued to limit any spine 'twisting' during the exercise by stiffening (i.e., co-contracting) their trunk musculature throughout the exercise and coached to initiate external rotation of their hip from their hip muscles (i.e., GMed) — not by rotating their pelvis backwards.

2.3.2. Side-lying hip abduction

Participants were instructed to lie on their left side in a straight line (from an overhead perspective) with their legs together, knees extended, and left arm supporting the weight of their head (Fig. 2a). Before initiating the exercise, participants were asked to change the orientation of their right hip from internal, neutral, or external rotation (Fig. 2b) — to do this, the researcher cued them to point their toes either toward the floor (i.e., internal rotation), forwards (i.e., neutral), or toward the ceiling (i.e., external rotation) by rotating from the hip (not the knee or ankle) as much as they could, without rotating their pelvis forwards or backwards and within a comfortable range. Participants were then instructed to lift their right leg toward the ceiling (i.e., hip abduction) as high as they could, initiate this movement with their hip muscles instead of 'hiking' their hip to abduct, maintain the hip rotation orientation they began with throughout the entire movement, stop the movement before having to 'hike' their pelvis up or