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Activation of the hip adductor muscles varies during a simulated weight-bearing task

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ABSTRACT

Objective: To investigate the pattern of muscle activation of the individual hip adductor muscles using a standardised simulated unilateral weight-bearing task.
Design: A repeated measures design.
Setting: Laboratory.
Participants: 20 healthy individuals (11 females, 9 males) participated in the study. Age ranged from 20 to 25 years.
Main outcome measurements: Surface electromyography recordings from adductor magnus and adductor longus muscles were taken at levels representing 10–50% of body weight during a simulated weight-bearing task. Electromyography (EMG) data were normalised to maximal voluntary isometric contraction.
Results: The adductor magnus was recruited at significantly higher levels than the adductor longus muscle during a simulated weight-bearing task performed across 10–50% of body weight ($p < 0.01$).
Conclusions: Adductor magnus and adductor longus muscles are recruited to different extents during a simulated weight-bearing task. This information should be considered when selecting exercises for management and prevention of groin strains. Closed chain exercises with weight-bearing through the lower limb are more likely to recruit the adductor magnus muscle over the adductor longus muscle.

1. Introduction

Groin pain in athletes is a common musculoskeletal complaint. It occurs commonly in sports involving kicking, twisting, cutting and sprinting such as soccer, rugby, hockey and Australian Rules Football (Bradshaw, Bundy, & Falvey, 2008; Jansen, Mens, Backx, Kolfschoten, & Stam, 2008). Adductor-related groin pain has been reported to account for 58% of groin injuries in all sports and 69% of groin injuries in footballers (Holmich, 2007). The musculo-tendinous junction of the adductor longus muscle, is thought to be the structure most commonly involved (Renström, 1992). A twenty-year injury surveillance in the Australian Football League (AFL) recently reported that groin strains/osteitis pubis had the second highest incidence of all injuries, averaging 3.2 new injuries and 12.3 missed matches per club per season (Orchard, Seward, & Orchard, 2013). Whilst the majority of groin pain seen in athletes recovers quickly (within 3 weeks), the condition can become long-standing in nature and become difficult to treat. In these cases, there can be a relatively long period before athletes can return to full sports activity (Hölmich et al., 1999).

Both the management (treatment) and prevention of this condition are therefore important current goals in sports medicine. However, there is currently a lack of randomised trials evaluating exercise therapy for groin pain. Positive treatment outcomes for adductor groin injury in athletes have been reported by Hölmich et al. (1999). Using a program based on increasing strength, stability and co-ordination of the pelvic region and adductor muscles, 79% of athletes with long-standing adductor-related groin pain who underwent exercise therapy were able to resume sports at their pre-injury level. The median time to return to sport, however, was long, at 18.5 weeks (range 13–26). A more recent study using the same exercise regime was less effective, with 50–55% of athletes

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making a full return to sports (Weir, Jansen, van de Port, Van de Sande, Tol, & Backx, 2011). With respect to prevention of groin injury, a program based on these exercises was implemented in a large cluster-randomised trial including 1211 football players (Holmich, Larsen, Krogsgaard, & Gluud, 2010). The program consisted of six exercises including concentric and eccentric strength training of the adductor, abdominal and low-back muscles, combined with coordination and balance exercises. Although a reduction in groin injury was reported in this study, these results were not significant.

The adductors include the pectineus, adductor magnus, adductor longus, adductor brevis and gracilis. Although all termed "adductors," individual muscles from the group may have different functional roles. The adductors are required to work under both closed chain (for example, in the stance leg, with the axial compressive forces from gravity) and open chain conditions (for example, during kicking, where movement occurs in the absence of axial compression through the limb). The most obvious differences in function have been reported between the adductor magnus and adductor longus muscles. Whether the adductor longus is more active during open or closed chain exercises is controversial. This muscle which originates on the pubis and attaches to the middle third of the linea aspera of the femur, functions primarily in adduction of the femur (Moore & Dalley, 2006). A number of functional EMG studies have reported peak levels of muscle recruitment in adductor longus during the open chain, swing phase of gait (Green & Morris, 1970; Lyons, Perry, Gronley, Barnes, & Antonelli, 1983; Perry & Burnfield, 2010). After performance of a kicking task, a greater change in signal intensity has been reported in the adductor longus of the kicking leg, compared to the adductor magnus, with a reversal of this pattern for the stance leg (Baczkowski, Marks, Silberstein, & Schneider-Kolsky, 2006). Two recent studies, however, have reported conflicting information, with increased activation in the adductor longus evident during both open (Delmore, Laudner, & Torry, 2014) and closed (Serner, Jakobsen, Andersen, Holmich, Sundstrup, & Thorborg, 2014) chain exercise, however, as adductor magnus was not included in these studies, no comparisons were able to be made.

Evidence on the function of the adductor magnus muscle is more consistent. This muscle is the largest of the adductor group, comprising up to 63% of the mass of the adductor volume (Takizawa, Suzuki, Ito, Fujimiya, & Uchiyama, 2014) and has both an extensor portion originating on the ischial tuberosity and an adductor portion, originating on the pubic ramus (Bardeen, 1907). In a study of functional tasks, the adductor magnus muscle was found to be most active in the particular components of these tasks which involved weight-bearing, such as sit to stand (Green & Morris, 1970) and walking up stairs (Lyons et al., 1983). Furthermore, during normal gait, peak activity has been documented in the adductor magnus of the "stance leg" during the initial contact and loading phases of ambulation (Green & Morris, 1970; Lyons et al., 1983; Perry & Burnfield, 2010). Results from bed-rest studies have also provided an insight into adductor muscle function in healthy populations. After 56 days of bed-rest, the greatest amounts of muscle atrophy have been reported in the adductor magnus muscle, followed by the adductor longus, with no significant atrophy of the adductor brevis (Belavý, Miokovic, Armbrecht, Richardson, Rittweger, & Felsenberg, 2009; Miokovic et al., 2014). Together, this information suggests that although the adductor muscles may act as synergists, they may function differently depending on the demands of the task.

It would seem that while progress has been made, there is a need for a better understanding of both the mechanisms underlying adductor related groin pain and the rationale for selection of exercises for the management and prevention of this condition. Examining the roles and functions of the individual adductor muscles in more detail could provide a basis for the refinement of the selection of prevention exercises currently in use. The main purpose of this study was therefore to investigate the individual adductor muscles and quantify their activation patterns during a simulated, unilateral, weight-bearing task in normal subjects who did not have groin strains. Based on previous research, it was anticipated that the adductor magnus would be more active in the simulated weight-bearing task than the adductor longus muscle.

2. Methods

2.1. Participants

A convenience sample of 20 healthy individuals (11 females, 9 males) from the university population, ranging in age from 20 to 25 years volunteered for the study. All individuals provided informed written consent prior to the commencement of the study. Ethical clearance was obtained from the University of Queensland Research and Postgraduate Studies Human Ethics Committee, School of Health and Rehabilitation Sciences. Individuals were excluded from the study if they had a history of adductor muscle dysfunction, spinal or hip joint surgery, low back pain or sacro-iliac joint pain, musculoskeletal abnormalities of the spine, pelvis or lower limbs, had a medical condition affecting the musculoskeletal system, or were undertaking intensive training more than 3 times per week. Participants were also excluded if pain was experienced during the testing procedures.

2.2. Procedure

Fig. 1 illustrates the unilateral simulated weight-bearing task (modified leg press) that participants performed. The unilateral simulated weight-bearing task has been described in detail in previous publications (Hides, Belavý, Cassar, Williams, Wilson, & Richardson, 2009; Hides, Wong, Wilson, Belavý, & Richardson, 2007; Hyde, Stanton, & Hides, 2012), however, in brief, a foot plate with a force transducer was designed to allow a static leg-press action in lying. This was used to simulate different levels of weight-bearing in the sagittal plane as occurs when the body is upright. The participant was positioned in supine on a moving platform with the heel of the test leg against a fixed foot plate, the hip in 45 degrees of flexion and the knee in 90 degrees of flexion (Lovell, Blanch, & Barnes, 2012). A brace worn over the shoulders and back provided a longitudinal compressive force, similar to

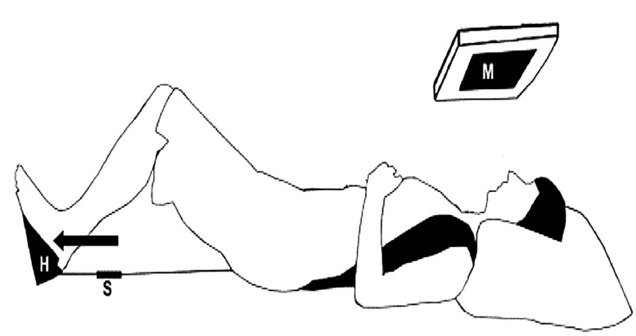

Fig. 1. The unilateral, simulated, weight-bearing task. The unilateral simulated weight-bearing task (modified leg press) was conducted with the participant lying supine on a moving platform, with the foot supported at the heel (H). A monitor (M) was placed in the subject's field of view to provide feedback on force output as the subject pressed through their heel. Shoulder straps over both shoulders, which restrained cephalad movement, were connected to the foot support via a strain gauge (S), which measured loading levels.