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Gluteus medius coactivation response in field hockey players with and without low back pain

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ABSTRACT

Objectives: To examine the effect of prolonged standing on gluteus medius coactivation and to observe whether the changes in gluteus medius coactivation over time were related to the development of low back pain in elite female field hockey players.

Design: Prospective cohort design.

Methods: Participants were 39 elite female field hockey players (14 with a history of low back pain). Before the prolonged stand, maximal hip abduction strength, side bridge hold endurance and hip abduction range of motion were measured bilaterally. Surface electromyography was collected from the gluteus medius for coactivation analysis during a prolonged stand for 70 min. Low back pain was rated every 10 min on a visual analogue scale.

Results: Fourteen of 39 participants developed low back pain. The Time effect was significant for gluteus medius coactivation response ($p = 0.003$) and visual analogue scale score ($p < 0.001$). There were no significant group × time interactions. Yet athletes who developed pain had higher coactivation for the majority of the stand task.

Conclusions: While female field hockey players have high agonist-antagonist coactivation patterns during prolonged standing, stand task is a useful tool to predict low back pain occurrence in players with and without history of pain.

1. Introduction

Low back pain (LBP) is a common, costly and disabling musculoskeletal condition (Lehmann, Spratt, & Lehmann, 1993) and has a considerable impact on society because of the restrictions it places on those who suffer from it. Approximately 70–85% of the population will suffer from an episode of LBP in their lifetime (Shekelle, Markovich, & Louie, 1995). Static tasks that exhibit low magnitude exposures such as prolonged standing have been identified as important mechanical predictors for LBP (MacFarlane et al., 1997; Sterud & Hynes, 2013). When the standing task is restricted to a fixed or constrained position, research has shown that it is a significant risk factor for LBP (OR = 1.48 (Sterud & Hynes, 2013); OR = 1.67 (Tissot, Messing, & Stock, 2009)). The specific mechanisms that cause LBP to occur from prolonged standing have currently not been identified.

When coactivation occurs in two muscles that typically work in an agonist–antagonist relationship it is generally a strategy used to improve biomechanical stability (Granata & Marras, 2000). Prior research has linked high magnitudes of gluteus medius (GM) coactivation with the development of LBP in an asymptomatic working population during prolonged standing (Marshall, Patel, & Callaghan, 2011; Nelson-Wong, Gregory, Winter, & Callaghan, 2008; Nelson-Wong & Callaghan, 2010). The GM muscle is a pelvic stabiliser and its main role is to abduct and medially rotate the hip (Gottschalk, Kourosh, & Leveau, 1989). Nelson-Wong and Callaghan identified that people who develop pain during a prolonged stand have increased GM coactivation.

LBP has been identified as a significant health problem for field hockey players (Haydt, Pheasant, & Lawrence, 2012). Two separate studies have shown that more than 50% of field hockey players suffered from LBP (Haydt et al., 2012; Murtaugh, 2001) with at least 12% missing practices or games due to pain (Murtaugh, 2001). Field hockey requires all players (exception of the goalie) to spend a considerable portion of the 70 min game in a semi-crouched position with significant lumbar spinal flexion and rotation

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(Murtaugh, 2001). Crouched gait has been shown to have a greater reliance on gluteus medius activity, particularly during the hip extension phase of gait (Steele, Seth, Hicks, Schwartz, & Delp, 2010). Further, this position has been shown to produce excessive spinal loading when compared to non-crouched positions and may place the athlete at increased risk of back injury (McGill, 2002). Most back pain in field hockey players has no identifiable source or is considered non-specific in nature; as evidenced by 94% of female field hockey players suffering from LBP identifying no specific inciting event in the onset of their LBP (Haydt et al., 2012). Potentially, there is a link between gluteus medius function and low back pain in field hockey players. Thus, the prolonged standing test developed by Nelson-Wong et al. (2008) may provide a method of predicting athletes at risk for LBP. This information would be beneficial to trainers and coaches to improve prevention programmes and reduce lost playing time for field hockey teams.

The purpose of the present study was to examine the effect of prolonged standing on GM coactivation and to observe whether the GM coactivation over time was related to the development of LBP in elite female field hockey players with and without a history of LBP. It was hypothesised that there would be a significant difference in the coactivation levels between the pain developing group and the no pain group, further we expect that the VAS score and GM coactivation will change significantly over time for the pain developing group.

2. Methods

Players were invited to take part in the study if they had played competitive field hockey for at least five years and currently participated in field hockey at least two times per week at the premier level. All players were screened for a reported history of non-specific LBP and each potential participant completed a modified Oswestry low back pain disability questionnaire (Roland & Fairbank, 2000). Participants were included in the study if they had no lifetime history of LBP. While LBP athletes were included if within the past 24 months they suffered an acute or subacute episode of LBP lasting up to three months (Bolga & Uhl, 2007), requiring either treatment (seeking professional advice e.g., from a physiotherapist, doctor or massage therapist), or break from physical activity and their Oswestry disability index was less than 20% such that they would be considered minimally disabled and not require treatment or clinical intervention (Fairbank & Pynsent, 2000). Participants were excluded from the study if they had a history of chronic LBP (pain lasting longer than 3 months duration within the last 24 months), spinal fracture, disc rupture, spinal surgery, diagnosed spinal deformity or instability, known congenital anomalies of the hip, pelvis or spine, known systemic arthropathy or neuropathy, diagnosed acute disk herniation/prolapse, pregnancy or less than six months postpartum, recent lower limb injury or surgery or the presence of any other known musculoskeletal red flags. Thirty nine female field hockey players aged 18–25 were eligible and gave consent (granted by the University of Otago Human Ethics Committee) to partake in the study. Twenty five had no lifetime history of pain while 14 had history of acute or sub-acute pain, as defined by the World Health Organization (Bolga & Uhl, 2007), with a mean Oswestry score of 5.86% (range from 2% to 18%). Three participants were excluded at the time of recruitment for failure to meet the LBP requirements (1 with Oswestry greater than 20%, 1 for previous spinal surgery and 1 for history of spinal stress fracture).

Participant profiles were recorded and consisted of age, height, weight, ethnicity, footedness, handedness, number of training hours, number of practices, years of field hockey participation, position on the field and any previous injury history. After completing the paperwork participants performed a sport specific warm-up which consisted of a 5 min stationary bike at a self -selected sub-maximal pace followed by a field hockey specific warm-up drill consisting of 5×30 s ball drills performed at a moderate pace with 1 min rest between sets. Baseline hip range of motion (ROM), GM strength and endurance were measured following standard protocols. GM strength test was measured via Force transducer (Precision Transducers PST250 S type load cell; PT Limited, Auckland, NZ) during a restricted hip abduction test as per Bolga and Uhl (Duthey, 2013). The test was performed three times for each leg and there was 2 min rest between each trial. GM endurance was assessed by a single trial of best effort side bridge hold, where they were instructed to hold for as long as possible using the protocols described by McGill, Childs, and Liebenson (1999). The test stopped when the participant could no longer hold their hips upright and they sagged to the ground. Participants were given 2 min rest between sides. Active hip abduction ROM was measured using a Polhemus Fastrak system (Polhemus, Colchester, VT) operating at 30 Hz. Active sensors were placed on the L5/S1 and the lateral femoral condyle of the testing leg and orientated so they sat superior-inferior on the body. Participants were placed in a side lying position and when instructed, actively abducted the hip as far as possible within a 10 s time limit. The test was performed three times for each leg.

GM surface EMG data was recorded continuously using an eight channel Neotrace NT1900 system with NT114A high gain A.C biopotential amplifiers (Neomedix System Pty, Sydney, Australia). Raw EMG was sampled at 1000 Hz with no pre amplification. Surface areas were prepped for electrode placement by shaving, lightly abrading and cleaning with alcohol swipes. Two disposable AG/AGCl surface electrodes rectangular size 30 $\times$ 20 mm (Ambu blue sensor N, Ambu, Denmark) were placed over the muscle belly so that the centre of the electrodes were 20 mm apart. Placement of the electrodes bilaterally was as per the SENIAM guidelines (Hermens et al., 1999); two electrodes were placed perpendicular to the muscle fibre angle exactly half way between the highest point of the iliac crest and the greater trochanter on the middle subdivision of the GM. A reference electrode was placed on the participant's left lateral malleolus.

For the prolonged stand the participant was positioned barefoot on a 0.50 $\times$ 0.46 m force platform (AMTI, Watertown, MA). A TV monitor was placed in front of them at eye level and they were instructed to watch a field hockey game lasting 70 min. They were instructed to stand in their usual manner if going to watch a ‘live’ game, but had to stay within the confines of the force platform borders. To determine the level of pain experienced by participants a measure of current pain symptoms on a 100 mm visual analogue scale (VAS) with end-points of ‘no-pain’ (far left) and ‘worst pain imaginable’ (far right) was used (Huskisson, 1974). The VAS has good construct validity (Revill, Robinson, Rosen, & Hogg, 1976) and reliability (Summers, 2001). A baseline VAS was collected just prior to commencement of the stand at time = 0 min. The VAS measure was repeated every 10 min until the end of the stand time when the final measure was taken (time = 70 min). The VAS measures taken during the stand were subsequently normalised to the baseline measures to negate any effect of the warm-up and demographic testing on initial VAS, thus subsequent changes were solely reflective of the prolonged stand.

GM strength was analysed using LabChart (Version 7.3, ADI Instruments, Australia). Maximal force outputs (N) for each trial were determined and a mean value was calculated from the three trials for each leg and then normalised for body mass (N/kg). GM endurance was measured in seconds and was determined as the time recorded holding the side bridge hold. ROM was rendered through purpose written Matlab scripts (version 2013b, The