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Original article

Manual therapy directed at the knee or lumbopelvic region does not influence quadriceps spinal reflex excitability

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Manual therapies, directed to the knee and lumbopelvic region, have demonstrated the ability to improve neuromuscular quadriceps function in individuals with knee pathology. It remains unknown if manual therapies may alter impaired spinal reflex excitability, thus identifying a potential mechanism in which manual therapy may improve neuromuscular function following knee injury.
Aim: To determine the effect of local and distant mobilisation/manipulation interventions on quadriceps spinal reflex excitability.
Methods: Seventy-five individuals with a history of knee joint injury and current quadriceps inhibition volunteered for this study. Participants were randomised to one of five intervention groups: lumbopelvic manipulation (grade V), lumbopelvic manipulation positioning (no thrust), grade IV patellar mobilisation, grade I patellar mobilisation, and control (no treatment). Changes in spinal reflex excitability were quantified by assessing the Hoffmann reflex (H-reflex), presynaptic, and postsynaptic excitability. A hierarchical linear-mixed model for repeated measures was performed to compare changes in outcome variables between groups over time (pre, post 0, 30, 60, 90 min).
Results: There were no significant differences in H-reflex, presynaptic, or postsynaptic excitability between groups across time.
Conclusions: Manual therapies directed to the knee or lumbopelvic region did not acutely change quadriceps spinal reflex excitability. Although manual therapies may improve impairments and functional outcomes the underlying mechanism does not appear to be related to changes in spinal reflex excitability.

1. Introduction

Decreased quadriceps strength is a common impairment following knee joint injury (Snyder-Mackler et al., 1994; Chmielewski et al., 2004; Ingersoll et al., 2008; Pietrosimone et al., 2011a; McLeod et al., 2012) and is a risk factor for knee osteoarthritis (Segal et al., 2010). This weakness is partially due to arthrogenic muscle inhibition which is defined as reflexive inhibition of musculature surrounding a joint following joint injury (Stokes and Young, 1984; Hopkins and Ingersoll, 2000). Previous studies have indicated decreased spinal reflex excitability, specifically presynaptic and postsynaptic mechanisms contribute to quadriceps inhibition following experimental knee joint effusion (Hopkins et al., 2001; Palmieri et al., 2004).

Traditional quadriceps strengthening rehabilitation interventions do not specifically address quadriceps arthrogenic muscle inhibition (Chmielewski et al., 2004; Pietrosimone et al., 2011b). Interventions which alter sensory output, such as transcutaneous electrical nerve stimulation (TENS) and cryotherapy increase quadriceps voluntary activation in individuals with knee pathology (Pietrosimone et al., 2009). Increased voluntary activation may result from increased spinal reflex excitability, which has been demonstrated following cryotherapy and TENS using a joint

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effusion model (Hopkins et al., 2002). Graded knee joint mobilisation can increase pain thresholds (Moss et al., 2007; Courtney et al., 2010) and modulate the flexor withdraw reflex in individuals with knee osteoarthritis (Courtney et al., 2009, 2010), but mechanism for changes in quadriceps function are less understood.

Manual therapy interventions applied at distant sites, such as the lumbopelvic region, have been shown to decrease knee pain (Iverson et al., 2008) with mixed results regarding changes in quadriceps force output and voluntary activation (Suter et al., 1999, 2000; Hillermann et al., 2006; Grindstaff et al., 2012). Furthermore, the duration of change in quadriceps inhibition may range from seconds to minutes. It is not clear if changes in quadriceps muscle activation following manual therapies are dependent on the intensity of the mobilisation (Dishman et al., 2002a; Dishman et al., 2005) or the site of application (Dishman et al., 2002b). The purpose of this study was to determine the effect of local and distant mobilisation/manipulation interventions on presynaptic and postsynaptic inhibition of the quadriceps muscle in individuals with existing quadriceps inhibition. Better understanding potential mechanisms of manual therapies will help guide future development of optimal treatment interventions for joint pathologies.

2. Methods

Seventy-five individuals with a history of knee joint injury and current quadriceps inhibition volunteered for this study (Table 1 and Fig. 1). All participants were between 18 and 40 years of age and had a body mass index (BMI) below 30. Participants also had current or a history of knee joint pathology, which resulted in quadriceps inhibition. Specifically, we included participants who had diagnosed knee osteoarthritis (grades I–II), patellofemoral joint pain, or participants who have undergone arthroscopic surgery for anterior cruciate ligament reconstruction, meniscotomy, plica removal, or debridement. Quadriceps inhibition was quantified as voluntary activation below 90% (Pietrosimone et al., 2011a) and confirmed through burst-superimposition testing of the involved limb (Grindstaff et al., 2009). Values above 95% are considered normal and 100% indicates complete voluntary activation (Stackhouse et al., 2001; Stevens et al., 2003). Finally participants had to have a measurable quadriceps H-reflex. Presence of quadriceps inhibition and H-reflex were determined during an initial screening session using previously described methods (Palmieri et al., 2005; Grindstaff et al., 2009). Exclusion criteria included pregnancy and other lumbar spine or lower extremity injury within the past six months. All participants read and signed the informed consent form for the study, which was approved by the Institutional Review Board at The University of Virginia (IRB-HSR# 13648).

All measurements, interventions, and testing were performed on the ipsilateral side of pain/dysfunction. In the event of bilateral pathology, the participants were asked to determine which leg was more symptomatic. If the participant was not able to differentiate between legs, then a coin toss determined the test limb.

2.1. Instrumentation

H-reflex, paired reflex depression, and recurrent inhibition measurements were collected using surface electromyography (MP150, BIOPAC Systems Inc., Santa Barbara, CA). Signals were amplified (EMG100C, BIOPAC Systems Inc.; Gain = 1000) from disposable, 10 mm pre-gelled Ag–AgCl electrodes (EL503, BIOPAC Systems Inc). The EMG signal was band-pass filtered from 10 to 500 Hz and sampled at 1024 Hz with a common-mode rejection ratio of 110 dB. H-reflex measurements were elicited using the BIOPAC stimulator module (STM100A, BIOPAC Systems Inc.) with a 200-V (maximum) stimulus isolation adapter (STMISOC, BIOPAC Systems Inc.), 2 mm shielded disc electrode (EL254S, BIOPAC Systems Inc.) and a 7 cm dispersive pad.

2.2. Outcomes procedures

2.2.1. Spinal reflex excitability

Skin preparation and electrode placement were consistent with previously published methods (Palmieri and Ingersoll, 2005; Palmieri et al., 2005). The skin was prepared for EMG electrode application by shaving, debriding with fine sandpaper, and cleansing with isopropyl alcohol. The surface EMG electrodes were on the *vastus medialis* to capture the maximum peak to peak amplitude of the H-reflex for all measurements. A percutaneous stimulating electrode (2 mm Ag–AgCl) was covered with conductive gel and placed superficial to the femoral nerve, lateral to the femoral artery, in the femoral triangle and secured with adhesive tape. A dispersive electrode (7 cm diameter, rubber carbon impregnated) covered in conductive gel was placed over the posterior proximal thigh. Participants were in a supine position with the knee in approximately 15° of flexion and asked to keep their hands at their sides with palms open and their eyes open while looking at the ceiling (Kameyama et al., 1989). When these factors are controlled, the reliability of quadriceps H-reflex amplitude measures are good ($ICC_{3,1} = 0.97$) (Hopkins and Wagie, 2003).

Recruitment curves were derived for each participant by gradually increasing stimulus intensity and examining peak-to-peak measures of the H-reflex and M response (maximal compound muscle action potential). Stimuli (1 ms square wave pulse) were delivered by increasing the intensity in 0.2-V increments until the maximum peak-to-peak amplitude for the H-reflex (Hmax) was obtained. A 12-sec rest interval was provided after each stimulus. Once Hmax was determined three measures were obtained. Next stimulus intensity was increased in 1-V increments until a plateau was reached in the peak-to-peak amplitude of the M response (Mmax). M response plateau was verified by applying a single

Table 1
Participant demographics. Values are mean ± SD.

	Lumbopelvic joint manipulation (Grade V) (7 female; 8 male)	Positioning similar to lumbopelvic joint manipulation (10 female; 5 male)	Patellar mobilization (Grade IV) (5 female; 10 male)	Patellar mobilization (Grade I) (10 female; 5 male)	Control no intervention (6 female; 9 male)	Total (38 female; 37 male)
Age (years)	20.9 ± 2.2	19.3 ± 2.0	21.7 ± 3.8	21.7 ± 3.4	22.5 ± 3.5	21.4 ± 3.1
Height (cm)	173.9 ± 7.6	168.4 ± 9.2	168.3 ± 10.3	166.1 ± 13.9	170.4 ± 10.5	169.4 ± 10.5
Mass (kg)	76.7 ± 8.4	68.2 ± 11.4	67.5 ± 11.4	72.2 ± 9.3	72.2 ± 15.3	71.4 ± 11.6
Voluntary quadriceps activation (%)	77.4 ± 10.1	72.1 ± 15.7	73.9 ± 16.3	75.9 ± 9.8	77.3 ± 10.4	75.3 ± 12.6

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