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Original article

The immediate effect of lumbopelvic manipulation on EMG of vasti and gluteus medius in athletes with patellofemoral pain syndrome: A randomized controlled trial

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A B S T R A C T

Objective: To evaluate the immediate effect of lubmopelvic manipulation on EMG activity of vastus medialis, vastus lateralis and gluteus medius as well as pain and functional performance of athletes with patellofemoral pain syndrome.
Design: Randomized placebo-controlled trial.
Methods: Twenty eight athletes with patellofemoral pain syndrome were randomly assigned to two groups. One group received a lubmopelvic manipulation at the side of the involved knee while the other group received a sham manipulation. EMG activity of the vasti and gluteus medius were recorded before and after manipulation while performing a rocking on heel task. The functional abilities were evaluated using two tests: step-down and single-leg hop. Additionally, the pain intensity during the functional tests was assessed using a visual analog scale.
Results: The onset and amplitude of EMG activity from vastus medialis and gluteus medius were, respectively, earlier and higher in the manipulation group compared to the sham group. There were no significant differences, however, between two groups in EMG onset of vastus lateralis. While the scores of one-leg hop test were similar for both groups, significant improvement was observed in step-down test and pain intensity in the manipulation group compared to the sham group.
Conclusions: Lubmopelvic manipulation might improve patellofemoral pain and functional level in athletes with patellofemoral pain syndrome. These effects could be due to the changes observed in EMG activity of gluteus medius and vasti muscles. Therefore, the lubmopelvic manipulation might be considered in the rehabilitation protocol of the athletes with patellofemoral pain syndrome.

1. Introduction

Patellofemoral pain syndrome (PFPS) causes pain and discomfort in the anterior part of the knee. Although the severity of pain and physical impairment varies in PFPS patients, functional postures and physical activities (e.g. sustained sitting, squatting) usually increase the symptoms (Thomeé et al., 1999; Brechter and Powers, 2002). PFPS is common among young active individuals especially those who are involved in sports activities requiring high levels of quadriceps activity with jumping, cutting and pivoting activities (Nejati et al., 2011; Roush and Bay, 2012). For instance, a point prevalence of 16.3% of PFPS has been reported in basketball players (Myer et al., 2010).

Although the etiology of PFPS has not been fully understood, some possible risk factors include malalignment of the lower extremity, joint laxity, and neuro-motor dysfunction of the quadriceps muscles (Thomeé et al., 1999; Waryasz and McDermott, 2008). Among these factors, the latest has received great attention. It is hypothesized that poor coordination between vastus medialis obliquus (VMO) and vastus lateralis (VL) muscle activation may cause lateral tracking of the patella. This neuromuscular imbalance could overload the lateral aspect of the patellofemoral joint and eventually leading to PFPS (Voight and Wieder, 1991; Witvrouw et al., 1996; Coqueiro et al., 2005; Van Tiggelen et al., 2009; Briani et al., 2015). The findings of a systematic review and meta-analysis revealed a trend towards a delayed onset of VMO relative to VL in patients with anterior knee pain (Chester et al., 2008).

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However, because of heterogeneity of the included studies, no definite conclusion can be drawn yet with respect to this association (Chester et al., 2008).

To understand further the link between PFPS and neuro-motor dysfunction, some researchers have paid attention to the activation patterns of muscles located more proximal to the knee joint. Motealleh et al. showed a delayed onset of activity in some core muscles during stair negotiation in patients with PFPS compared to healthy controls (Motealleh et al., 2011, 2015). In another study, Cowan et al. compared EMG activity of the anterior and posterior parts of the gluteus medius (GM) between PFPS patients and healthy controls during a stair-stepping task; and observed a delay in activation of both parts of GM in patients with PFPS (Cowan et al., 2009). In a recent comparative study of PFPS patients and healthy controls, the PFPS group was found to have an earlier and longer activation of their abdominal and erector spinae muscles following an external lateral perturbation. For the GM, however, a delayed response was observed in EMG activity (Shirazi et al., 2014). Moreover, Brindle et al. identified a delay in EMG onset of GM in people with anterior knee pain during both stair ascending and descending (Brindle et al., 2003). It is claimed that such deficit in neuromuscular control of the hip and trunk might aggravate the PFPS symptoms. For instance, it has been shown that the timing of gluteal muscles is correlated with greater internal rotation and hip adduction (Willson et al., 2011). These abnormal hip mechanics were found to be significant predictors of patellofemoral pain (Nakagawa et al., 2013).

Previous studies have shown that lumbopelvic manipulation could effectively increase quadriceps activation and strength as well as knee extensor moment in patients with PFPS (Suter et al., 1999; Hillermann et al., 2006). Similar results were also observed in healthy individuals (Grindstaff et al., 2009). As mentioned earlier, the activation timing of different components of quadriceps muscle is considered as an important risk factor in developing PFPS. The previous studies have mainly looked at the EMG amplitude of quadriceps muscles in response to lumbopelvic manipulation with no assessment of their EMG onsets or the EMG activity of muscles proximal to the knee joint. The effects of lumbopelvic manipulation on clinical outcomes such as pain or functional level have not been much studied either. To our best of knowledge, there has been only one study reporting some improvement in knee pain after lumbopelvic manipulation (Crowell and Wofford, 2012). This study, however, lacked a placebo or control group, and additional studies were recommended to verify these findings (Crowell and Wofford, 2012).

The aim of current study was, therefore, to assess immediate effect of lumbopelvic manipulation on EMG activity of GM and vasti muscles, lower limb function as well as pain intensity in athletes with PFPS. Our first hypothesis was that lumbopelvic manipulation could improve the EMG parameters of GM and vasti muscles. Our second hypothesis was that an immediate improvement would be observed in the clinical outcomes following the lumbopelvic manipulation.

2. Materials and methods

2.1. Participants

This trial obtained approval from the Medical Ethics Committee of Shiraz University of Medical Sciences (Registration No. CT-92-6722), and all participants signed a written informed consent form before study commencement. Athletes diagnosed with PFPS were referred by an orthopedic surgeon to the outpatient physical therapy clinic of Shiraz University of Medical Sciences. Inclusion and exclusion criteria were similar to previous studies (Cowan et al., 2001a; Van Tiggelen et al., 2009; Cowan et al., 2009). We included patients if they were aged 40 years or less, to reduce the likelihood of osteoporosis (a contraindication for manipulation) and osteoarthritis in the knee and patellofemoral joint. Patients were to have a non-traumatic unilateral anterior knee pain lasting for no more than 6 months. They also needed to be athletes involved in regular sports activity (at least 3 sessions per week).

The clinical criteria for diagnosis of PFPS were as follows: (a) anterior knee pain or a pain on palpation of patellar facets provoked by at least two of these activities: jumping, squatting, ascending/descending stairs, kneeling and prolonged sitting, (b) positive sign in eccentric step down test and/or patellar apprehension test and/or vastus medialis coordination test, (c) a pain level of at least 3 points (0: no pain; 10: worst possible pain) on the numerical pain rating scale during resisted knee extension, and (d) knee disability level between 45 and 70 based on the Kujala patellofemoral questionnaire (KPQ) (Kujala et al., 1993; Negahban et al., 2012). The KPQ is a 13-item questionnaire with different categories. The total score ranges from 0 to 100, with higher scores indicating lower levels of disability (Kujala et al., 1993; Negahban et al., 2012). The KPQ is a valid and reliable measure of disability in patients with patellofemoral pain (Kujala et al., 1993; Negahban et al., 2012). The patients were excluded if they had bilateral PFPS, a history of knee surgery, meniscal lesion, patellar subluxation/dislocation, evidence of tendinopathy or ligamentous pathologies, dislocation or fracture in pelvic or spinal surgery, and neurologic disorders. Further, the patients who had previously received physiotherapy treatment or used analgesic drugs within 72 h prior to the experiment were excluded.

2.2. Study design and sample size calculation

This study was a randomized, single-blind, placebo-controlled trial. A convenience sample of patients with PFPS was randomly assigned to two groups using a block randomization procedure. One group received a general manipulation of the lumbopelvic region whereas the other group received a sham manipulation. Sample size calculation was based on EMG onset of the VMO during a "rock" task reported in a previous study (Cowan et al., 2001b). The sample size was estimated to be at least 26 patients (13 per group) for a power of 80% and $\alpha = 0.05$ to detect a difference of 50 ms of EMG onset between the two compared groups.

2.3. Outcome variables

The primary outcomes of interest included EMG activity of VMO, VL and GM muscles. The secondary outcomes included functional performance and knee pain.

2.4. EMG recordings

The ME6000 16-channel EMG telemetry system (Mega Electronics Ltd, Kuopio, Finland) was used to obtain and transmit the data to the computer wirelessly. The system had a common mode rejection ratio of 110 dB. EMG data sampled at the rate of 1000 Hz and band-pass filtered at 8–500 Hz through a 14-bit analogue-to-digital converter. The EMG activity of the vasti and GM was recorded using round, pre-gelled, self-adhesive, Silvere-Silver Chloride surface electrodes, with a 20 mm center-to-center distance. The Megawin software (Mega Electronics Ltd, Kuopio, Finland, version 3.0), and a custom-made Matlab™ program (R2010a) were used to receive and analyze EMG data respectively.

Before electrode attachment we prepared the skin by shaving, cleaning with an alcohol wipe and rubbing with a fine sandpaper. VMO electrodes were placed over the muscle belly approximately