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Original research

Effect of feedback techniques for lower back pain on gluteus maximus and oblique abdominal muscle activity and angle of pelvic rotation during the clam exercise

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ABSTRACT

Objectives: This study was conducted in order to determine the effect of feedback tools on activities of the gluteus maximus (Gmax) and oblique abdominal muscles and the angle of pelvic rotation during clam exercise (CE).
Design: Comparative study using repeated measures.
Setting: University laboratory.
Participants: Sixteen subjects with lower back pain.
Main outcome measures: Each subject performed the CE without feedback, the CE using a pressure biofeedback unit (CE-PBU), and the CE with palpation and visual feedback (CE-PVF). Electromyographic (EMG) activity and the angles of pelvic rotation were measured using surface EMG and a three-dimensional motion-analysis system, respectively. One-way repeated-measures ANOVA followed by the Bonferroni post hoc test were used to compare the EMG activity in each muscle as well as the angle of pelvic rotation during the CE, CE-PBU, and CE-PVF.
Results: The results of post-hoc testing showed a significantly reduced angle of pelvic rotation and significantly more Gmax EMG activity during the CE-PVF compared with during the CE and CE-PBU.
Conclusion: These findings suggest that palpation and visual feedback is effective for activating the Gmax and controlling pelvic rotation during the CE in subjects with lower back pain.

1. Introduction

Lower back pain is a common musculoskeletal problem with high incidence, affecting about 80% of the population at some time in their lives (Lawrence et al., 1998). Uncontrolled motion and insufficient stability in the lumbopelvic region have been suggested by previous studies as causes of lower back pain (Hodges, 2011; McGill, 1997; O'Sullivan, 2005; Panjabi, 2003). Uncontrolled lumbopelvic motion has been defined as excessive or early lumbopelvic motion during limb movements (Hoffman, Johnson, Zou, & Van Dillen, 2012). Repeated and sustained uncontrolled lumbopelvic motion associated with limb movements during functional activities may induce physical stress in specific tissues in the lumbopelvic region, resulting in cumulative microtrauma and lower back pain (McGill, 1997; O'Sullivan, 2005; Sahrmann, 2002).

Some studies have examined the relationship between lower back pain and lumbopelvic movement patterns during limb movement of hip rotation in a prone position (Gombatto, Collins, Sahrmann, Engsberg, & Van Dillen, 2006; Scholtes & Van Dillen, 2007; Scholtes, Norton, Lang, & Van Dillen, 2010). Earlier and more lumbopelvic motion was shown by patients with lower back pain than by a healthy control group during hip internal or external rotation (Gombatto et al., 2006). Restriction and control of lumbopelvic motion during limb movements have been considered effective treatment methods for the management of lower back pain (McGill, 1997; O'Sullivan, 2005; Sahrmann, 2002).

Clinicians commonly instruct patients with lower back pain to control lumbopelvic motion during hip internal and external

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rotation in various positions. Several feedback tools (e.g., tactile feedback using hand, verbal instructions, and corrections; visual feedback; and pressure biofeedback) have been employed to manage uncontrolled lumbopelvic movement in the transverse plane during hip motion (Comerford & Mottram, 2012). Previous studies have found that restricting uncontrolled pelvic rotation using tactile and verbal feedback can be helpful in improving symptoms during prone hip internal or external rotation in patients with lower back pain (Van Dillen, Maluf, & Sahrmann, 2009; Van Dillen, Sahrmann, Norton, Caldwell, McDonnell, & Bloom, 2003). Although various feedback methods to monitor lumbopelvic motion have been suggested, no study has investigated which type of feedback is most effective for patients with lower back pain during limb movements.

Active hip external rotation exercises, such as the top leg turnout in a side-lying position, the bent-leg fall out in a supine position, and the single leg rotation in a prone position, have been recommended to encourage control of lumbopelvic motion using feedback in the clinic (Comerford & Mottram, 2012; Hoffman, et al., 2012; Kisner & Colby, 2012; Scholtes et al., 2010). In the side-lying, hip external rotators can be more activated in response the weight of the body segment than in the prone or supine position because side-lying is antigravity position. The top leg turnout maneuver in a side-lying position, termed the clam exercise (CE), is commonly recommended to strengthen the hip abductors and external rotators. Willcox and Burden (2013) demonstrated that CE was more effective in activating the gluteus maximus (Gmax) when performed by healthy subjects in a neutral than in a reclined pelvic position. Additionally, it is important that the neutral pelvic position of patients with lower back pain be maintained during the CE using various forms of feedback. Although a neutral pelvic position is effective for activating Gmax during the CE, no study has determined which feedback technique is most effective for maintaining a neutral pelvic position in patients with lower back pain.

Thus, the purpose of this study was to determine the effect of feedback tools on the activities of Gmax and oblique abdominal muscles, and angle of pelvic rotation during the CE. This study was based on the following hypotheses: performing the CE using palpation and visual feedback (CE-PVF) and using a pressure biofeedback unit (CE-PBU) will result in (1) less pelvic rotation, and (2) more Gmax muscle activity compared with performing the CE without feedback.

2. Methods

2.1. Participants

Sixteen subjects (9 males, 7 females) with chronic nonspecific lower back pain participated in this study. Participants were recruited via poster, telephone and word of mouth from Masan University in South Korea. The subjects were aged 22.4 ± 2.5 (mean ± SD) years and had a height of 169.3 ± 7.4 cm and body weight of 64.2 ± 12.1 kg. The inclusion criteria used in this study required that subjects have chronic or recurrent low back pain of more than 3 months duration during daily activities and that they have some level of disability, with scores of at least 20% on the Oswestry Disability Index. Volunteers with neuromuscular problems, musculoskeletal pain other than lower back pain, metabolic diseases, or functional limitations in daily activity were excluded. Subjects were advised of the testing procedures, and all provided informed consent. The Institutional Review Board (IRB) at Joongbu University approved all procedures in this study.

2.2. Instruments

The Noraxon TeleMyo system was used for Surface EMG data collection. EMG data were analyzed using Noraxon MyoResearch 1.06 XP software. To measure the angle of pelvic rotation during CE, we used a 3D motion-analysis system with six cameras (BTS Smart-DX500, Milan, Italy). Kinematic data were analyzed using motion-capture software (BTS SMART-Analyzer, Milan, Italy). A Stabilizer pressure biofeedback unit (Chattanooga Group Inc, Hixson, TN, USA), consisting of an inflatable air bag connected to a pressure gauge, was used to monitor pelvic motion during CE-PBU.

2.3. Procedures

Prior to electrode placement, the skin was shaved to reduce impedance and cleaned with alcohol swabs. The distance between each pair of electrodes was 2 cm, and electrodes were attached parallel to the direction of the muscle fibers. EMG electrodes over the ipsilateral and contralateral external oblique muscles (IEO and CEO) were attached midway between the anterior superior iliac spine (ASIS) and the rib cage. Electrodes for the ipsilateral and contralateral internal oblique muscles (IIO and CIO) were attached at 2 cm inferomedial to the ASIS. The Gmax electrode was attached at half the distance from the second sacral vertebra to the greater trochanter (Cram & Kasman, 1998).

To measure the angle of pelvic rotation during CE, three retroreflexive markers were attached to the bilateral PSIS and the highest point of the iliac crest in side-lying (Fig. 1). Before collection of kinematic data, the acquisition volume was calibrated to be calculated with laboratory references to a global coordinate system using a calibration kit.

Subjects practiced each intervention (the CE without feedback, CE-PBU, and CE-PVF) for 15 min for familiarization. To perform the CE, the participants were positioned in a side-lying position with the hips flexed at 45°, the knees flexed at 90°, and the spine and pelvis in neutral positions. To maintain the end position of the CE, thee target bar was adjusted for each individual so the top of the knee would touch it when the angle was 25° from starting position in horizontal plane during CE exercise using gravity goniometer located on frontal side of femur shaft. Participants were asked to separate their knees and rotate the top leg upward while keeping the heels together until lateral epicondyle of the femur touch target bar (Fig. 2A).

For the CE-PBU, a Stabilizer pressure biofeedback unit was placed below the trunk between the iliac crest and the distal ribs with the participant in a side-lying position. The air bag was inflated to 40 mmHg pressure, and participants were instructed to maintain the pressure at 35–45 mmHg during the CE-PBU (McBeth, Boehm, Cobb, & Huddleston, 2012) (Fig. 2B). For the CE-PVF,

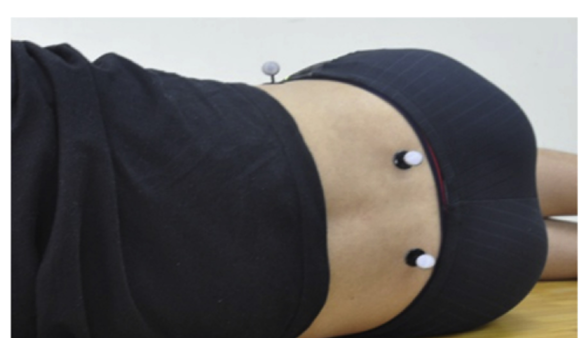

Fig. 1. Three reflective markers for measuring the angle of pelvic rotation.