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Original article

Increased sliding of transverse abdominis during contraction after myofascial release in patients with chronic low back pain

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ABSTRACT

Purpose: Recent evidence suggested the significance of integrity of the tension balance of the muscle-fascia corset system in spinal stability, particularly the posterior musculofascial junction which is adjacent to dorsal located paraspinal muscles joining each other at lateral raphe (LR). The purpose of this study was to compare the contraction of the transversus abdominis (TrA) at both anterior and posterior musculofascial muscle-fascia junctions in patients with low back pain (LBP) and asymptomatic participants before and immediately after a sustained manual pressure to LR.
Methods: The present observational cohort study used a single-instance, test-retest design. The outcome variables included the resting thickness (Tr), the thickness during contraction (Tc), change in thickness (ΔT), sliding of musculofascial junction (ΔX), muscle length at rest (L) and displacement pattern (ΔD) of the TrA using ultrasonography. Vertical tolerable pressure at the LR was applied manual for 1 min. Tr, Tc, ΔT, and ΔX were analyzed by three-way ANOVA (musculofascial junction sites*group* pre-post manual release). ΔL and ΔD were analyzed by two-way ANOVA (group* pre-post manual release).
Results: Participants with LBP revealed less Tc, ΔT and ΔX at both sites ($p < 0.005$). After myofascial release, LBP group demonstrated a positive ΔD of the musculofascial junctions at both end ($p < 0.001$). Nevertheless, both groups increased the ΔT and ΔX at both sites ($p < 0.001$ and 0.001, respectively).
Conclusion: The result indicated immediately effect of sustained manual pressure on musculofascial junction of TrA and supported the concept that the possible imbalanced tension of the myofascia corset of TrA in patients with LBP.

1. Introduction

Transversus abdominis (TrA) and thoracolumbar fascia (TLF) form the musculofascial sling. The TrA is attached dorsally to the middle layer of the TLF (Barker et al., 2007) and the transverse process of the spine via the lateral raphe (LR) (Willard et al., 2012). These deep muscles and fascia of the trunk form a continuous musculofascial corset-like system (Barker and Briggs, 1999; Barker et al., 2004, 2006; Gatton et al., 2010). Based on the musculofascial corset concept, tension is balance in different segments. The fascial system is considered as a “tensegrity” or tensional integrity structure to manage the balance between tension and compression around the organs, joints and muscles.

During chronic LBP, deep muscles show dysfunction as their attaching fascia structures are changed (Gatton et al., 2010). Patients with low back pain (LBP) (Hides et al., 2011) demonstrate delayed contractions of the TrA (Ferreira et al., 2004) and attenuated thickness changes in patients with chronic LBP (Critchley and

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Coutts, 2002; Ferreira et al., 2004; Teyhen et al., 2009). Degenerative changes in the TLF (Bednar et al., 1995) and increased thickness of the perimuscular connective back muscles tissues have also been observed in individuals with chronic LBP (Langevin et al., 2009). The muscle function of the TrA in the corset sling may be compromised by imbalanced tension with different stiffness properties at the two ends of fascia attachment. Furthermore, patients with chronic LBP demonstrate decreased activation of deep muscles such as the TrA and multifidus, and overactivation of superficial muscles such as the erector spinae (Hides et al., 1996; Hodges and Richardson, 1996; Hodges, 2001; Ferreira et al., 2004; Hides et al., 2008, 2009). This may be a potential source of myofascial tension imbalance, because these mentioned muscles connected via different layers of thoracolumbar fascia at LR.

Clinically, sustained manual pressure on the LR has been used to release muscle tightness in patients with LBP. Sustained manual pressure is applied to the location of the LR, which is a junction between the layers of the TLF and abdominal muscles (Willard et al., 2012). Sustained pressure on the LR frequently results in the release of tightness and positive subjective responses in patients with LBP. However, the effect of this manual technique on specific tissues, such as the length, change of thickness of TrA, muscle-fascia sliding of TrA, has not been identified objectively during in vivo studies. Ultrasound imaging is a non-invasive and reliable instrument to examine the morphological change during activation of abdominal muscles (Critchley and Coutts, 2002; McMeeken et al., 2004; Hides et al., 2007; Koppenhaver et al., 2009). Thus, US images could be used to visualize in vivo tissue changes after manual techniques and then quantify the changes.

The purpose of this study was to compare the contraction of the transversus abdominis (TrA) at both anterior and posterior musculofascial junctions in patients with LBP and asymptomatic participants before and immediately after a sustained manual pressure to LR using ultrasound imaging. The hypotheses were: (1) there would be differences in resting and contractile tissue properties of muscle-fascia junctions of TrA (Tr, Tc, ΔT, and ΔX) between LBP patients and asymptomatic participants; (2) resting tissue properties of the TrA (muscle length (L) and displacement pattern of TrA (ΔD)) would be difference between LBP patients and asymptomatic participants; (3) sustained manual pressure to the LR would alter resting and contractile tissue properties of muscle-fascia junctions of TrA and the resting tissue properties of the TrA; and (4) these alterations would be different between LBP patients and asymptomatic participants.

Using ultrasound imaging, we measured the resting and contractile tissue properties of anterior and posterior muscle-fascia junctions of TrA; and the resting tissue properties of the TrA, in LBP patients and asymptomatic participants, at pre-post sustained manual pressure to LR.

2. Methods

2.1. Participants

The advertisement for participant recruitment was posted on the Internet and at a rehabilitation center. Twenty asymptomatic participants and twenty participants aged from 20 to 40 years old with recurrent LBP during non-pain period were recruited. In order to eliminate the influence of pain, all participants were without pain. The definition of recurrent LBP is pain that occurred more than once per day during the last three months. Other exclusion criteria were pregnancy, neoplasm, system disease, significant lumbar abnormities, previous surgery or injury of the lumbar spine or abdomen, and elite athletes or people that had engaged in spinal stabilization exercise before. After enrollment, all participants were assessed by a physical therapist for eligibility to make sure that the patients are in a remission period with minimal pain. To eliminate the influence of pain, all participants were without pain while the examination was taking place. Participants provided informed written consent before commencing the baseline assessment.

2.2. Instrument

A real-time ultrasonography apparatus (HDI 5000 system, Philips/ATL, Bothell, WA, USA) with a 5–12-MHz 38-mm linear transducer was used in the study.

2.3. Procedure

2.3.1. Screening

The present observational cross-sectional study used a single-instance, test-retest design. The purpose and procedures of the study, which were approved by the local ethics committee, were explained to the participants, after which they signed a written consent form. The participants completed a questionnaire related to their basic personal information and the Oswestry Disability Index (ODI) questionnaire.

2.3.2. Initial evaluation

The participants were positioned in a supine crook-lying position (Fig. 1), with their arms crossed over their chest; both the anterior and posterior sites of the TrA were examined in random order. Previous studies considered the dorsal attachment side to be the fixed end (Hodges et al., 2003) and focused on the anterior morphological change and sliding of the anterior abdominal fascia. However, our previous study demonstrated that the measurement of morphological changes in the posterior musculofascial junction of the TrA is also reliable. Our pilot study demonstrated good reliability [$ICC_{(3,3)}$ = 0.888–0.978] in measuring the thickness and sliding of the posterior musculofascial junction of the TrA. The correlation of measurements between the anterior and posterior sites of the TrA were moderate to good [Pearson correlation (r) = 0.41–0.74]. Thus, measurement of both the anterior and posterior musculofascial junctions of the TrA–TLF may reveal the possible mechanism of LBP in relation to the change of the integrated musculofascial corset-like system.

The transducer was placed on the anterior or posterolateral abdomen at the same level as the umbilicus at the inferior angle of the rib cage. An echo-absorptive material was attached on the participant's abdomen with Sellotape in order to generate a reference line on the US image as an internal marker for measuring the sliding of the musculofascial junction of TrA (Jhu et al., 2010) (Fig. 1). To measure the muscle length in the resting state, a panorama scan (extended field-of-view ultrasonography) was used to obtain the extended view of the TrA from its anterior to the posterior site. For measuring the contraction of the TrA, the participants were instructed to practice the abdominal drawing-in maneuver.

2.3.3. Sustained manual pressure on the LR

After the initial evaluation, the participants changed to the side-lying position for the evaluation of the opposite site. The middle point of the LR of the TLF between the posterior musculofascial junction of the TrA and the erector spinae muscle was identified by US. Vertical manual pressure was applied on the middle point of the TLF for 1 min according to the technique in “The myofascial release manual,” page 13–19 (Fig. 2) (Manheim, 2001). The pressure was maintained steady at a level that the participant could tolerate. The subjective discomfort level was scored by the participants using a verbal rate scoring method (score: 0–10). If any intolerable pain