Medical Engineering and Physics 000 (2018) 1–8

Contents lists available at ScienceDirect

Medical Engineering and Physics

journal homepage: www.elsevier.com/locate/medengphy

Correlations between core muscle geometry, pain intensity, functional disability and postural balance in patients with nonspecific mechanical low back pain

Farahnaz Emami [a,b], Amin Kordi Yoosefinejad [a,b,*], Mohsen Razeghi [a,b]

[a] Department of Physiotherapy, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Chamran Blvd., Abivardi 1 Street, Shiraz, Iran
[b] Rehabilitation Sciences of Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

ARTICLE INFO

Article history:
Received 14 December 2017
Revised 4 July 2018
Accepted 22 July 2018
Available online xxx

Keywords:
Low back pain
Ultrasonography
Postural balance
Core muscles
Functional disability

ABSTRACT

Patients with low back pain (LBP) have reduced core muscle geometry and impaired postural balance. Impaired trunk control was shown to be associated with poor balance and limited functional mobility in these patients. However, the relationship between muscle geometry and postural balance is unclear. This study aimed to determine the correlation of core muscle geometry with pain intensity, functional disability and postural balance in patients with chronic nonspecific mechanical LBP. Thirty patients aged 20–50 years were enrolled. Ultrasound imaging was used to assess their muscle geometry. The participants completed a numerical rating scale (NRS) for pain severity, and the Persian version of the Roland–Morris Disability Questionnaire (PRMDQ). To estimate static balance, they were asked to perform the single leg stance test. Dynamic balance was assessed with the Y-balance test. Significant correlations were found between NRS scores and bilateral multifidus cross-sectional area during rest ($r \geq -0.31$, $P \leq 0.04$) and contraction ($r \geq -0.37$, $P \leq 0.02$). NRS scores correlated significantly with bilateral multifidus thickness during rest ($r \geq -0.31$, $P \leq 0.04$) and contraction ($r \geq -0.28$, $P \leq 0.04$). Significant correlations were also observed for PRMDQ scores with thickness ($r \geq -0.35$, $P = 0.04$) and cross-sectional area of the multifidus muscles ($r \geq -0.33$, $P = 0.04$) bilaterally during contraction. A significant correlation was found between Y-balance scores and right abdominal muscle thickness during rest and contraction ($r \geq 0.34$, $P \leq 0.04$). Core muscle geometry correlated with pain, functional disability indices and dynamic balance in these patients.

1. Introduction

Chronic low back pain (CLBP) is a highly prevalent musculoskeletal problem worldwide. In the Iranian population, the lifetime prevalence of LBP has been estimated between 14.4% and 84.1%, and it is considered the third leading cause of disability and work absenteeism [1]. Many people with LBP are labeled as having nonspecific LBP because no known pathological or anatomical cause can be identified [2]. It has been proposed that weakened or insufficient motor control in the deep trunk musculature can contribute to chronic nonspecific low back pain (CNLBP) [3]. Alterations such as delayed activation of the transverse abdominis muscle, altered recruitment patterns in the lumbar multifidus muscles, endurance deficits, and decreased repositioning accuracy have been reported frequently in patients with CLBP [4–7]. In addition, alterations in the information transmitted by mechanoreceptors and impairments in the peripheral proprioceptive system of paraspinal muscles can lead to postural and balance impairments [8]. According to previous research, postural control impairment may be due to reduced coordination of the low back muscles and increased active muscle tension [9]. In this connection, inputs from high-threshold nociceptive muscle afferents were reported to lead to adaptive changes in postural control [8]. Abnormalities in the geometry and activation of the abdominal and lumbar multifidus muscle have been linked to CLBP [10]. The decreased muscle thickness seen both at rest and during contraction is additional evidence for the role of transverse abdominis derangement in LBP [11]. Multifidus muscle atrophy, i.e. decreased muscle size and alterations in muscle consistency, has been identified in people with a history of CLBP [10]. Real-time rehabilitative ultrasound imaging, a highly reliable and valid technique, can be successfully used for the quantitative assessment of

* Corresponding author at: Department of Physiotherapy, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Chamran Blvd., Abivardi 1 Street, Shiraz, Iran.
E-mail addresses: emamif@sums.ac.ir (F. Emami), yoosefinejad@sums.ac.ir (A.K. Yoosefinejad), razeghm@sums.ac.ir (M. Razeghi).

https://doi.org/10.1016/j.medengphy.2018.07.006
1350-4533/

Table 1
Demographic data of the participants. Values are the mean ± SD.

Variable	Mean ± SD
Age (years)	32.03 ± 8.04
Height (cm)	160.30 ± 17.95
Weight (kg)	66.23 ± 20.52
BMI (kg/m^2)	23.73 ± 3.5
Pain duration (years)	2.93 ± 2.79
NRS* (0–10)	6.07 ± 1.04
Persian version of the Roland–Morris Disability questionnaire (0–24)	10.17 ± 2.01
Sex (Male/Female)	7/23
Limb dominancy (RT/LT)	28/2

Abbreviations: BMI, Body Mass Index; RT, Right; LT, Left
*: Numeric Rating Scale

abdominal and lumbar multifidus muscles in spine region diagnostics [12,13].

To our knowledge, the relationship between muscle geometry and postural balance is not yet clear in patients with CNLBP. Hence, this study was designed to determine the correlation of core muscle geometry with pain intensity, functional disability and postural balance in patients with CNLBP.

2. Methods

2.1. Setting and participants

This cross-sectional study was conducted between August and December 2016 at the Rehabilitation Sciences Research Center, Shiraz University of Medical Sciences (SUMS). The study was approved by the Ethics Committee of SUMS in accordance with the Helsinki Deceleration (IR.SUMS.REC.1395.72). A total of 30 patients aged 20–50 years were recruited. All patients provided their written informed consent before their participation in the study began. Sample size was estimated based on a previous similar study [12] and considering an alpha level of 0.05 and a beta level of 0.2. The primary outcome measure was defined as abdominal and multifidus muscle geometry, and the secondary outcomes included pain intensity, functional disability and postural balance. The participants were recruited via convenience sampling from patients referred to physical therapy clinics affiliated with SUMS. Individuals were included if they had local pain in the lumbar and sacroiliac joint regions of at least 4 months duration, pain severity according to a numerical rating scale (NRS) between 3 and 7, and functional disability with a score greater than 8 on the Persian version of the Roland–Morris Disability Questionnaire (PRMDQ). General exclusion criteria were any dysfunctional entrapment of the nerve roots or history of radicular pain [8], leg length discrepancy, any history of hip or knee surgery, ankle or foot problems [8], history of lower extremity orthopedic surgery, chronic ankle instability [14], any vestibular and neurological disease that could negatively influence postural stability [8,15], and any uncorrected auditory or visual impairment [16]. The demographic data are presented in Table 1.

2.2. Ultrasound measurements

Thickness of the TrA, internal oblique (IO) and external oblique (EO) muscles was measured bilaterally with an ultrasonic diagnostic unit (HS-2600, Honda Electronics Inc., Honda, Japan). The ultrasound machine was set to B-mode and a 7.5 MHz, 60-mm, board band linear array transducer was used. Thickness of the lateral abdominal muscles was measured at rest and during the abdominal drawing-in maneuver (ADIM). Participants were asked to lie in the crook-lying position. Electro conductive gel was applied to the skin and the examiner then placed the ultrasound transducer transversely at the midpoint of the anterior axillary line (a line midway between the 12th rib and the iliac crest) [17]. A Stabilizer Pressure Biofeedback unit (PBU, Chattanooga Group, Hixson, TN, USA) was placed between the firm mattress and the participant's lumbar spine in the crook-lying position, and the bulb was inflated to create a pressure of 40 mmHg [18]. The participants were instructed to slowly draw in their lower abdominal muscles [19] and hold the contraction for 7 s. While participants performed the ADIM, pressure applied by the PBU was increased by 0–2 mmHg [20,21]. At the end of expiration, a clear image of the deep abdominal layers was stored for later analysis (Fig. 1A and B).

Ultrasound images of bilateral lumbar multifidus muscles were acquired with the participant lying prone with a pillow under the hips and abdomen to minimize lumbar lordosis. In the standard position, they were relaxed with their arms by the sides and their face resting in a face cradle [22]. The spinous process of L5 was marked as a reference and the transducer was placed longitudinally and lateral to the L4 spinous process. The transducer was rotated slightly in a medial direction until the L4/L5 facet joint could be identified in the center of the window [23] (Fig. 2A and B).

In cases when it was difficult to differentiate the lateral border of the lumbar multifidus muscle from the longissimus, the patient was asked to raise his or her ipsilateral leg slightly off the table and relax before the image was acquired [24]. The distance from the L4/L5 facet joint to the plane between the muscle and subcutaneous tissue was considered for linear muscle thickness measurements [25]. To determine lumbar multifidus cross-sectional area (CSA), the transducer was positioned transversely over the L4 spinous process. To ensure precision, images were obtained separately from the left and right multifidus muscles. Ultrasound measurements were also recorded during multifidus muscle contraction while the patients performed a contralateral arm lift maneuver. With the participant lying prone, he or she was instructed to lift the contralateral arm with the elbow flexed 90° and the shoulder abducted 120° while holding a hand weight cuff based on the their body mass [12]. They lifted their contralateral arm off the table approximately 5 cm and held this position for 8 s [6]. The linear dimension (thickness) of the lumbar multifidus was measured between the most posterior portion of the L4/L5 facet joint and the facial plane between the muscle and subcutaneous tissue [26]. In the cross-sectional view, the multifidus muscle is demarcated by superior, medial, lateral and deep borders. The superior border was demarcated by the thoracolumbar fascia. The medial border was the acoustic shadow of the tip of the marked spinous process. The lateral border was the fascia surrounding the multifidus muscle – i.e. the element that separates the multifidus muscle from the longissimus component of the lumbar erector spine [27]. The deep border of the muscle was identified as the acoustic shadow of the same vertebral laminae [28]. All measurements were performed bilaterally.

2.2.1. Intra-rater and inter-rater reliability assessment

Two raters were involved in this study. Both were physical therapists with more than 5 years of experience in musculoskeletal sonography. In the intra-rater reliability part of the study, the first rater positioned the patients and then measured the thickness and CSA of the multifidus muscles bilaterally during both rest and contraction. The same measurements were obtained by the first rater 1 week after all data were collected. To evaluate inter-rater reliability, the second rater obtained the same measurements simultaneously with but independently from the first rater, with no contact or verbal communication between raters. Each rater's measurements were compared pairwise to the other rater's measurements. It was decided that only one measurement for each image would be recorded, because this approach was considered more consistent with clinical practice. The second rater's measurements were recorded manually and were not saved on the