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Comprehensive review

Do various baseline characteristics of transversus abdominis and lumbar multifidus predict clinical outcomes in nonspecific low back pain? A systematic review

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ABSTRACT

Although individual reports suggest that baseline morphometry or activity of transversus abdominis or lumbar multifidus predict clinical outcome of low back pain (LBP), a related systematic review is unavailable. Therefore, this review summarized evidence regarding the predictive value of these muscular characteristics. Candidate publications were identified from 6 electronic medical databases. After review, 5 cohort studies were included. Although this review intended to encompass studies using different muscle assessment methods, all included studies coincidentally used ultrasound imaging. No research investigated the relation between static morphometry and clinical outcomes. Evidence synthesis showed limited evidence supporting poor baseline transversus abdominis contraction thickness ratio as a treatment effect modifier favoring motor control exercise. Limited evidence supported that high baseline transversus abdominis lateral slide was associated with higher pain intensity after various exercise interventions at 1-year follow-up. However, there was limited evidence for the absence of relation between the contraction thickness ratio of transversus abdominis or anticipatory onset of lateral abdominal muscles at baseline and the short- or long-term LBP intensity after exercise interventions. There was conflicting evidence for a relation between baseline percent thickness change of lumbar multifidus during contraction and the clinical outcomes of patients after various conservative treatments. Given study heterogeneity, the small number of included studies and the inability of conventional greyscale B-mode ultrasound imaging to measure muscle activity, our findings should be interpreted with caution. Further large-scale prospective studies that use appropriate technology (ie, electromyography to assess muscle activity) should be conducted to investigate the predictive value of morphometry or activity of these muscles with respect to LBP-related outcomes measures.

1. Introduction

Approximately 9.2% of the global population is affected by low back pain (LBP), while LBP-related disability is the leading cause of disability in the world [91]. Although certain cases of LBP are ascribed to specific pathology, 90% of those with LBP experience LBP of unknown origin or pathology, known as nonspecific LBP [24].

Notwithstanding the lack of consensus regarding the causal relation between deficits in spinal muscles and the onset of LBP, the transversus abdominis (TrA) and lumbar multifidus (LM) play important roles in intersegmental spinal control [32,46,53,73,75,100] and may affect the progression and recurrence of LBP. Anatomically, TrA connects to the lumbar vertebrae through the thoracolumbar fascia, forming a corset-like structure encircling the trunk, which controls intra-abdominal pressure and vertebral stiffness [4,31,34,43]. In contrast, the LM muscles are deep paraspinal muscles with densely packed short muscle fibers that generate large forces over short distances [20] for intersegmental control [9,100].

Various investigations have demonstrated associations between LBP and the characteristics of TrA/LM [15,18,57]. Research has revealed that patients with acute or chronic LBP have increased fat infiltration and abnormal changes of type I and II fibers in LM [2,3,42,56,58,70], while patients with unilateral LBP display localized asymmetrical LM atrophy at the painful vertebral level [15,33,70,92]. Functionally, patients with LBP demonstrate

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significantly less TrA/LM thickness changes than asymptomatic individuals during voluntary tasks as measured by B-mode ultrasound imaging (USI) [14,18,48,82] and a delayed anticipatory onset of TrA or deep LM fibers as measured by intramuscular electromyography during trunk loading or limb movement [37–39,57]. Collectively, it is hypothesized that the aberrant morphometry, histology, and activation of these muscles in individuals with acute [16,35,47,75], chronic [61], and recurrent [75] LBP may cause prolonged LBP and its recurrence [32,57].

Recent research suggests that baseline morphometry of TrA/LM may be a treatment effect modifier (a characteristic that predicts who will or will not benefit specifically from a particular treatment) or a prognostic factor for LBP-related clinical outcomes [26,29,85]. Specifically, decreased LM thickness change during contraction as measured by B-mode USI was correlated with the predictors for clinical success with a stabilization exercise program [29]. Poor baseline TrA lateral slide measured with B-mode USI may also predict positive recovery of chronic LBP regardless of the intervention [85]. Taken together, a comprehensive review of evidence for the predictive or treatment modification value of TrA/LM measurements may help clinicians predict LBP prognosis and determine the best treatments for specific patient subgroups. However, to our knowledge, no systematic review on this topic has been conducted.

The primary objective of this review was to summarize the evidence with respect to the ability of morphometry, histology, or activation of TrA/LM to predict clinical outcomes and recurrence of nonspecific LBP among untreated or conservatively treated patients. The predictive ability of TrA/LM includes the prognostic value and treatment effect modification. The secondary objective was to review whether baseline features of TrA/LM would have differential prognostic effects or modify treatment effects in subgroups of patients with different (1) chronicity, (2) age, and (3) inception or survival stage.

2. Methods

This review protocol was registered with PROSPERO (CRD42012002703). The methodology and reporting format of this review follows the recommendations and guidelines of the Preferred Reporting Items of Systematic Reviews and Meta-analyses (PRISMA) [63] and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) [80].

Relevant articles were systematically identified through Medline, Embase, PEDro, SPORTDiscus, CINAHL, and the Cochrane Library (from the beginning of each database up to December 2012) using keywords, MeSH, and free-text words, which included: low back pain, LBP, backache, lumbago, lumbalgia, multifidus (truncated), LM, MF, transversus abdominis, TrA, lumbar muscle, erector spinae, stabilizing muscle, predict (truncated), follow-up, cohort, course, longitudinal, and randomized control (truncated). Appendix I shows the exact search strings utilized. In addition, ClinicalTrial.gov, NIH Clinical Center Clinical Research Studies, and Current Controlled Trials Register were searched to identify relevant ongoing research. The principal investigators of relevant ongoing research, 11 prominent researchers who have published more than 5 articles in this area, as well as the corresponding author of each included article, were contacted to identify any additional studies of potential relevance. The results of the search strategy are shown in Fig. 1.

2.1. Selection criteria of studies

Only full reports published in English, Chinese, French, or Portuguese and meeting the following criteria were included for analysis (Appendix II).

2.1.1. Design

Longitudinal cohort research is the preferable design for identifying a causal relation for prognostic factors [26,64], while randomized controlled trial design is desirable for evaluating treatment effect modifiers [78]. As such, the eligible study design included primary longitudinal (both prospective and retrospective) cohort studies and randomized controlled trials. Other eligible study designs included observational studies, case series with 10 or more subjects involving untreated or conservatively treated patients with nonspecific LBP, systematic reviews, and meta-analyses. Studies from books were excluded as secondary sources of information.

Studies that investigated "inception" or "survival" cohorts were included where inception cohort refers to a group of patients early in the course of nonspecific LBP, while survival cohort refers to a group of patients who were at various stages of the LBP development at the time of recruitment [13,41].

2.1.2. Population

Studies that investigated self-ambulatory adults older than 18 years, with acute (<6 weeks), subacute (6 to 12 weeks), or chronic (>3 months) nonspecific LBP were included [28]. Nonspecific LBP was defined as pain or discomfort between the 12th rib costal margin and above the gluteal folds, with or without leg pain, where pain is not attributed to specific physical cause or pathology [90,101]. Articles were excluded if they were (1) multiple reports that included duplicated results of identical patient cohorts or (2) studies involving less than 80% of participants with nonspecific LBP.

2.1.3. Predictors or treatment effect modifiers

It is hypothesized that spinal stability is maintained by the passive (such as disc, ligaments, and facets), active (spinal muscles), and neural control (sensory and neuromotor control) subsystems. Dysfunctions in any of the 3 subsystems may increase the risk of spinal injury by overloading the other subsystems [67–69]. As such, aberrant changes in morphometry, histology, or activation of TrA/LM may affect or predict future clinical outcomes or recurrence of LBP. To be included, studies had to investigate the effect of static and dynamic morphometry, histology, or activation of TrA/LM in predicting the clinical outcomes of patients with nonspecific LBP. Static morphometry was defined as the measurement of architectural characteristics (such as shape, cross-sectional area, volume, length, depth, diameter, and pennation angles) of a given muscle at rest [98], whereas dynamic morphometry referred to the measurement of change in architectural features of a muscle during contraction [98]. Histology was defined as the study of microscopic composition of a muscle (such as muscle fiber types) [7]. Muscle activation indicated the change in myoelectric signals as measured by electromyography during muscle contraction [8]. Studies that investigated the onset of lateral abdominal muscles (TrA, obliquus internus, and obliquus externus) as measured by M-mode USI or tissue Doppler imaging were included because they are valid assessment of deep abdominal muscles function by taking account of intra- and interindividual variability in the onset of the 3 muscles [59,60,85,88]. In order to identify potential studies that investigated the morphometry, histology, or activation of TrA/LM at baseline, our search strategy did not place any restrictions on the type of muscle measurement techniques.

2.1.4. Clinical outcomes

Clinical outcomes included type and duration of LBP symptoms, LBP-related disability, return to work or sports, recurrence of LBP, LBP-related medications, and visits to health care professionals.

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