PM R 7 (2015) 519-526

www.pmrjournal.org

Analytical Review: Systematic

Trunk Muscles Activation Pattern During Walking in Subjects With and Without Chronic Low Back Pain: A Systematic Review

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Abstract

Objective: The purpose of this study was to identify how activity patterns of trunk muscles change in chronic LBP during walking.
Type: This was a systematic review
Literature Survey: ELSEVIER, Pro Quest, PubMed, Google scholar and MEDLINE electronic databases were explored for the period from the earliest researchable time to August 2014. Articles investigating patients with chronic LBP and analyzing trunk muscles with surface electromyography (EMG) during walking were included.
Methodology: All studies had a case-control design. Characteristics of the LBP patients, sample size, studied muscles and EMG parameters, and gait condition and velocity were investigated. Studies were rated as "A" to "E" (5 grades defined) based on study design and performance.
Results: Multifidus (MF), erector spinae (ES), external oblique (EO), and rectus abdominus (RA) muscle activity level were found to be increased in LBP subjects in comparison with controls. ES activity in subjects with LBP was found not to be as adaptive to walking velocity alterations as in healthy controls.
Conclusions: Individuals with chronic LBP exhibit higher global trunk muscle activity. However, the activation pattern appears to vary depending on subphases of gait. It seems that increased walking velocity challenges the stability of the spine and the control system increases muscular activation and variability level to cope with this problem. Further standardized studies with subtyped LBP cases are needed to clarify the controversial findings.

Introduction

Chronic low back pain (LBP) is 1 of the most prevalent and costly health problems [1]. The causes of chronic LBP appear to be complex and multifactorial. Biological and psychosocial components and physical impairments including postural anomalies [2,3], localized intervertebral kinetic [4] and motor control disturbance [5,6], and muscular imbalance [7] have been suggested to be the main causes of LBP.

Patients with chronic or recurrent LBP have been reported to have increased trunk stiffness [6,8], poor proprioception [9], altered patterns of activation of abdominal [5] and extensor muscles [10-13], and postural dysfunction [14,15]. Movement pattern alterations (e.g., changes in muscular recruitment) have been the main concern of chronic LBP management protocols [16-18]. Activation pattern encompasses the timing and level of activity of the muscles [19]. It has been hypothesized that changes in muscle recruitment patterns are a compensation for spinal instability resulting from passive elements (osteoligamentous) laxity or active elements (muscle) dysfunction or reduced neural (neuromuscular) control [20].

Changes in activation pattern are explained in the pain-spasm-pain and pain adaptation models [21,22]. Both models suggest that altered motor control patterns are adaptive in nature. In the pain-spasm-pain model, the muscle activity level is increased in response to pain, which will in turn increase the pain in a vicious cycle. In the pain adaptation model, in contrast, agonist and antagonist muscle activity will decrease and increase in response to pain, respectively. The pain-spasm-pain model considers the activation pattern alterations to be maladaptive, thereby causing pain, whereas the pain adaptation model contends that these changes are appropriately adaptive and serve to protect the musculoskeletal system.

1934-1482/$ - see front matter
http://dx.doi.org/10.1016/j.pmrj.2015.01.013

Studies testing these models often use surface electromyography (EMG) to measure muscle action potentials. One previous review suggested that some of the surface EMG measures could be considered as objective markers of LBP that can accurately differentiate healthy persons from those with LBP [23]. Surface EMG data can be obtained during static postures or dynamic movements.

Walking is 1 of the most functional tasks of everyone's activity of daily living that is of dynamic nature. LBP is often accompanied by changes in gait, such as a decrease in comfortable walking speed, step length, stance and swing time, and changes in trunk coordination [24,25]. Results of the EMG studies during walking are indicative of alterations in persons experiencing LBP [26-29]. LBP patients tend to walk at slower self-selected speeds, with less typical patterns for trunk muscles [30]. Global back extensor muscles in LBP patients exhibit higher level of activation to compensate for spinal instability [27,29].

Comprehensive rehabilitation programs should include functional dynamic tasks such as walking. To address the alterations of gait in LBP subjects as part of the rehabilitation program, it is necessary that the nature of these changes and their association with other factors such as gait speed and pain intensity be clear. Muscular recruitment pattern providing active stabilization of the spine is 1 of these issues to be addressed. This article systematically reviews evidence on alteration of trunk muscle activity during walking in subjects with chronic LBP.

The main research question in this study is the following: How do activity patterns of trunk muscles change in chronic LBP during walking?

Methods

Search Strategy

Five electronic databases (ELSEVIER, ProQuest, PubMed, Google Scholar, and MEDLINE) were explored with no limitation on time (from the earliest researchable time to August 2014 period). "Surface electromyography" OR "SEMG" OR "EMG" AND "back pain" OR "low back pain" OR "LBP" OR "chronic low back pain" AND "back muscles" OR "trunk muscles" OR "core muscles" OR "spinal muscles" AND "walking" OR "gait" were used as keywords. The search was limited to titles and abstracts. Articles were included if they studied patients with chronic LBP at any age and analyzed trunk muscles with surface EMG during walking. Irrelevant articles (e.g., those conducted on surface EMG in acute LBP populations or only in asymptomatic subjects during walking), articles not written in the English language, and unpublished studies were excluded. The reference lists of all included studies were scanned to find other potentially eligible articles.

This systematic review is reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [31].

Data Extraction

A qualitative review of studies is provided in the Results section. From all included articles, both authors independently extracted the following data: compliance with the review inclusion criteria, year of publication, type of LBP, number and gender of participants, muscles assessed, targeted muscle activity characteristic (amplitude, timing), and walking surface (treadmill, mat) and velocity.

Quality Assessment

The quality of methods of each study was independently assessed by the 2 reviewers using the scoring system introduced by Hailey et al [32]. This scoring system classifies the studies into 5 levels of quality, from grade A (high quality) to E (poor quality), according to the study design (large randomized controlled trials (RCTs), smaller RCTs, prospective nonrandomized and retrospective comparative) and performance (patient selection, protocol description, statistical methods and sample size, patient disposal and outcomes reported). Detailed description of the scoring system can be found in Hailey et al's study [32]. Scores by the 2 reviewers were averaged and, if needed, decided on by discussion.

Results

Selection of Publications

A total of 64 studies were identified: 17 duplicates were removed. Thirty-four studies were excluded based on title and/or abstract. Five studies were excluded because they assessed surface EMG of other than the trunk muscles ($n = 2$) or were unpublished studies ($n = 3$). Eight studies assessed activation pattern of trunk muscles during walking in subjects with chronic LBP and were included in this review [26-29,33-36] (Figure 1).

Study Characteristics

From all included studies, 232 subjects (chronic LBP: 130, asymptomatic: 102) were investigated. Sample sizes varied from 4 [28] to 59 [34] patients with chronic LBP. The range of aged was 16 to 70 years. In 6 studies, both genders were included [26,27,33-36], whereas in 2, only male subjects participated [28,29]. Pain duration in chronic LBP subjects ranged from 3 months [33,34] to 14 years [36]. In all studies except 1 [26], the subjects walked on a treadmill. In that study, subjects walked