



## Full length article

## Chronic low back pain and back muscle activity during functional tasks

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## ARTICLE INFO

## Keywords:

Low back pain  
Electromyography  
Back muscle  
Fear

## ABSTRACT

There is evidence that patients with low back pain favor their trunk muscles when moving. However, it is unknown whether this maladaptive behavior is generalized across different functional tasks. This study analyzed the back muscle activity of patients with chronic low back pain compared to asymptomatic controls during five functional tasks. The secondary aim of this study was to test whether the electromyographic activity of patients' back muscles was correlated with either the TAMP scale score or the Örebro Questionnaire. Forty patients with chronic, non-specific low back pain and 40 asymptomatic participants were assessed on the electromyographic activity of the lumbar longissimus, ilio-costal and multifidus while picking up and placing an object on the ground, sitting down and standing up, and climbing stairs. There was statistical evidence of two-way interactions involving group by task ( $F_{4,308} = 7.921$ ,  $p < 0.001$ ,  $\eta^2 = 0.049$ ) and task by muscle ( $F_{18,1386} = 2.912$ ,  $p < 0.001$ ,  $\eta^2 = 0.004$ ), but not group by muscle ( $F_{7,539} = 1.104$ ,  $p = 0.359$ ,  $\eta^2 = 0.004$ ). Patients with chronic low back pain showed an increase in back muscle activity regardless of the type of functional task, except the left side of multifidus muscle during the picking up of a ball on the ground task. There was no correlation between the measure of kinesiophobia or the Örebro questionnaire score and the level of electromyographic activity.

## 1. Introduction

Low back pain is the most frequent cause of long-term disability worldwide [1]. Since the pathoanatomical cause of the pain cannot be determined in 90% of the cases, the term non-specific low back pain is commonly used. While the majority of episodes of acute low back pain are resolved after a period of six weeks, regardless of the treatment implemented, some patients develop chronic, non-specific low back pain (CNSLBP) within one year [2,3].

Psychosocial factors seem to be the main mediators between pain and disability and the most important prognostic factors for the transition from acute to chronic pain [4–6]. Furthermore, patients with CNSLBP seem to exhibit maladaptive functional behavior that includes increased trunk muscle activity and decreased trunk mobility [7–9]. Cognitive factors, such as catastrophizing, are hypothesized to mediate the trunk muscle activity both in low back pain patients and in experimentally induced low back pain participants [10,11].

A systematic review showed higher activation in the back and abdominal muscles and decreased trunk mobility during movement [12].

Nonetheless, patients with CNSLBP do not show a delayed onset of feedforward activation of the transversus abdominis muscle during rapid arm movement, and changes in pain and disability seem not to be mediated by deep muscles activity changes implemented during clinical trials [13–15]. Therefore, recent research has focused on the superficial trunk muscle activity of patients with low back pain and its relationship with cognitive and emotional factors. Ross et al. showed that individuals with high level of pain catastrophizing tend to stabilize their spines during a repetitive unloaded spine flexion/extension movement after a noxious stimulation to induce low back pain [10]. Pakzad et al. found a significant correlation between trunk muscle activation amplitude and pain catastrophizing in patients with CNSLBP during walking on a treadmill [11]. It remains unknown whether this maladaptive behavior is generalized across different functional tasks and whether pain-related psychosocial factors are correlated with back muscle activity. Thus, the aims of this study were (1) to analyze the activity of the back muscles during five functional tasks and (2) to test whether the electromyographic activity of the back muscles is correlated with kinesiophobia scores and scores on the Örebro Questionnaire in CNSLBP patients.

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<https://doi.org/10.1016/j.gaitpost.2018.01.021>

Received 28 September 2017; Received in revised form 5 January 2018; Accepted 21 January 2018

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## 2. Methods

### 2.1. Participants

Forty patients with CNSLBP and 40 asymptomatic who have never experienced important disability caused by LBP were enrolled in this study. Participants of the symptomatic group had experienced low back pain for more than three months, were between 18 and 60 years old and were referred by a physician. The exclusion criteria included the presence of at least one of the following: pain that rendered the participant unable to perform the functional tasks required for the study; a psychiatric diagnosis; neurological deficits (e.g., radiculopathy); being pregnant; having unconsolidated fractures in the spine or lower limbs; spinal infection; unstable cardiac disease; or taking any medication that could interfere with the functional tasks. Participants of the asymptomatic control group had no history of low back pain and did not have any of the exclusion criteria.

Participants were recruited from the Marcilio Dias Navy Hospital and from the Almirante Adalberto Nunes Physical Education Centre (CEFAN), and provided written, informed consent prior to participation. The Research Ethics Board of Augusto Motta University Centre approved the study.

### 2.2. Sample size

The sample size was calculated based on the mean and standard deviation of the electromyographic activity of the trunk muscles [8]. Using a statistical power of 80%, a  $p$ -value  $< 0.05$  and a  $V_{rms}$  mean of the trunk muscles of  $42.5 \mu V$  for the patients and  $37.5 \mu V$  for the asymptomatic controls with a standard deviation of  $7.1 \mu V$ , the necessary sample size was calculated to be 40 participants per group.

### 2.3. Measures

#### 2.3.1. Questionnaires

All participants answered sociodemographic (age and sex) and anthropometric (height, weight) questions. Low back pain participants answered pain-related psychosocial questions by the Örebro Musculoskeletal Pain Screening Questionnaire short version (OMPSQ-short) and the Tampa Scale of Kinesiophobia, disability by the Oswestry Disability Index [16], and pain by the Visual Analogue Scale (0 = no pain, 10 = most severe pain). The OMPSQ-short aims to identify the risk of developing chronic pain and disability associated with psychosocial factors in patients with non-specific LBP [17]. The Tampa Scale is aimed at the assessment of fear of (re)injury due to movement [18]. Both the Brazilian-Portuguese OMPSQ-short and Tampa Scale of Kinesiophobia showed acceptable psychometric properties similar to the original versions [17,18].

#### 2.3.2. Surface electromyography acquisition and signal processing

Electromyographic activity of the lumbar longissimus, ilio-costal and multifidus was recorded simultaneously using an 8-channel amplifier (model 810, EMG System, SP, Brazil). Data were collected at a sampling rate of 2000 Hz and were bandpass filtered using a first order filter of 20–1000 Hz. Bipolar, Ag/AgCl circular electrodes (model 2223BRQ, 3 M, SP, Brazil) with an inter-electrode distance of 20 mm were used after removal of hair and cleaning the participant's skin with alcohol.

Electrodes were positioned according to the SENIAM guidelines [19]. Electrodes for the lumbar longissimus were placed bilaterally, parallel with the muscle fibers at two levels, 30 mm lateral to the first lumbar processus spinosus. For the ilio-costal, the electrodes were placed one finger width medial from the line from the posterior iliac spine superior to the lowest point of the lower rib at the level of L2.

Multifidus electrodes were placed on and aligned with a line from the caudal tip posterior iliac spine superior to the interspace between L1 and L2 interspace at the level of L5 spinous process (i.e., approximately 2–3 cm from the midline). The muscles were assessed on the left and right side, summing up six channels. The reference electrode was placed on the 7th neck spinous process. All electrodes were secured with tape to the participants' skin to avoid movement artifacts without limiting motion.

The collected data were exported for off-line analysis using a custom-made software SuiteMYO written in LabVIEW 8.0 (National Instruments, Texas, USA). Signals were pre-processed using low-pass filters (cut-off 500 Hz) after mean and linear trend removal. Notch filters were also applied to minimize powerline interference at 60 Hz (59–61 Hz band) and all harmonics up to 500 Hz. Epochs of muscle activity were programmatically selected using a double-threshold method for both signal amplitude ( $> 1$  SD from baseline) and task duration ( $> 1$  s). Event detection was applied for the linear envelope obtained from a full-wave rectification followed by a 2-Hz low-pass 2nd order Butterworth filter. Muscle activity was quantified using the root mean square value ( $V_{rms}$ ) on the pre-processed data.

Electromyographic recordings were not normalized herein as in other studies [20] because (1) the choice of normalization task is not standardized in literature and commonly used methods (e.g., maximal isometric or dynamic voluntary contractions) are useful though still criticized [21], (2) variability introduced by reapplication of electrodes was not of concern because the electrodes were retained between tasks, (3) within-subject variability was minimized by taking the average of three repetitions of each functional task and (4) low back pain may lead to underestimation of the maximum voluntary contraction [22,23].

#### 2.3.3. Functional tasks

Participants were asked to perform five functional tasks: picking up an object from the ground; placing an object on the ground; sitting down; standing up; and climbing up a stair (Fig. 1). Before the analysis, the sequence of the tasks was randomized using Excel software. Each participant was informed about the order of the tasks and was allowed to perform one practice round to familiarize themselves with the tasks. The resting time between the tasks was two minutes, and the tasks were repeated three times.

During the tasks of picking up and placing an object, the participants were instructed to pick up a medicine ball of 1 kg, stand for a few seconds with the ball and then immediately lower the ball to the ground. For the task of sitting down and standing up, the participants remained in the orthostatic position with their feet parallel, shoulder-width apart. At the verbal command of the examiner, the volunteers sat, and after a short period, a new command was given for the individual to stand up. During the third and last task, the individuals were directed to the ladder where they were asked to perform the action of climbing stairs.

### 2.4. Statistical analysis

The characteristics of the sample are described by means and standard deviations or by percentages and number of participants. The measure of electromyographic activity of the back muscles was the mean of the three repetitions of each functional task. We used the  $t$ -test to compare the means of continuous variables and a chi-square test to compare differences in proportion. Mean differences and 95% CI were calculated to compare the muscle activity of the three muscles (longissimus, ilio-costal and multifidus) for both body sides across the five activities (picking up and placing an object on the ground, sitting down and standing up, and climbing stairs) in a full-crossed design ( $3 \times 2 \times 5 = 30$ ). A repeated-measures analysis-of-variance (rm-ANOVA) evaluated the main and interaction effects by group (between-

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