Pain and Lumbar Muscle Activation before and after Functional Task in Nonspecific Chronic Low Back Pain

Lídia E. O. Cruz, Adriano P. C. Calvo, Renato J. Soares, Regiane A. Carvalho

Abstract**—**Individuals with non-specific chronic low back pain may present altered movement patterns during functional activities. However, muscle behavior before and after performing a functional task with different load conditions is not yet fully understood. The aim of this study is to analyze lumbar muscle activity before and after performing the functional task of picking up and placing an object on the ground (with and without load) in individuals with nonspecific chronic low back pain. 20 subjects with nonspecific chronic low back pain and 20 healthy subjects participated in this study. A surface electromyography was performed in the ilio-costal, longissimus and multifidus muscles to evaluate lumbar muscle activity before and after performing the functional task of picking up and placing an object on the ground, with and without load. The symptomatic participants had greater lumbar muscle activation compared to the asymptomatic group, more evident in performing the task without load, with statistically significant difference (p = 0,033) between groups for the right multifidus muscle. This study showed that individuals with nonspecific chronic low back pain have higher muscle activation before and after performing a functional task compared to healthy participants.

Keywords**—**Chronic low back pain, functional task, lumbar muscles, muscle activity.

I. Introduction

Low back pain is the leading cause of disability worldwide, associated with physical disability, absenteeism at work and high socioeconomic costs becomes a major public health problem [1].

Individuals with chronic low back pain may present several changes in the movement pattern such as increased trunk stiffness [2]. Elevated muscle activity in the trunk increases the load on the structures of the spine, which although beneficial in the short term, can increase the risk of long-term injury [3]. This condition provides a pathophysiological mechanism that affects the functional movements of the trunk performed in daily life and increases the likelihood of subsequent episodes of low back pain [4].

Muscle behavior before and after performing a functional task with different load conditions in individuals with chronic low back pain is not yet fully understood. Thus, its identification and quantification can help clarify the relationship between neuromuscular insufficiencies and recurrent episodes of pain and thus result in more targeted and effective interventions for the clinical improvement of patients.

II. Methods

A. Participants

40 volunteers were divided into symptomatic group (12 women and 8 men) formed by individuals with history of low back pain that may or may not be accompanied by lower limb pain with symptoms for at least 12 weeks, and asymptomatic control group (12 women and 8 men) formed by participants without history of painful experience in the lumbar spine [5]. All volunteers who were unable to pick up and place a light/ moderate load on the floor, who had a history of cancer in the past five years, an unconsolidated fracture of the spine and or lower limbs, a diagnosis of inflammatory disease or infections in the spine, uncontrolled hypertension, unstable cardiac pathology, neurological deficits or were pregnant were excluded from the study [6]. In the sample selection process, only one individual was excluded from the research due to sensory alteration in the inguinal region. All volunteers filled out the Inclusion Protocol (sociodemographic, anthropometric and exclusion criteria form) and signed the Informed Consent Form to participation to research.

This study was approved by the Research Ethics Committee and is in accordance with the guidelines of the Declaration of Helsinki.

B. Experimental Procedure

To verify trunk muscle activity, all participants underwent surface electromyography (EMG-800C; EMG System, SP, Brazil) with 8-channel amplifier and 2000 Hz sampling rate (A/D: 16 bits; gain: 2000; bandpass [20-500 Hz]; rejection > 100 dB). Was used bipolar Ag/AgCL surface electrodes (2223BRQ; 3M, SP, Brazil), square format (25 mm x 25 mm), disposable and hypoallergenic.

After cleansing, hair removal and skin exfoliation, the electrodes were placed bilaterally on the longissimus muscles (LO), ilio-costal (IC) and lumbar multifidus (MU) according to the SENIAM guidelines [7]. Electrogoniometers (EMG System do Brazil®) were placed on the hip of the volunteer in

Lídia E. O. Cruz is with Post Graduate Program in Biomedical Engineering (PPG-EB), Institute of Science and Technology (ICT), Federal University of Sao Paulo (UNIFESP), Sao Paulo, Brazil. (corresponding author, phone: +55 (12) 98841-2443; e-mail: lidia.oliveira@unifesp.br; lidia.eo@hotmail.com).

Adriano P. C. Calvo is with Post Graduate Program in Operational Human Performance (PPGDHO), University of Air Force (UNIFA), Rio de Janeiro, Brazil (e-mail: percivalcalvo.fab@gmail.com).

Renato J. Soares is with University of Taubate (UNITAU), Sao Paulo, Brazil (e-mail: rjsoares1@gmail.com).

Regiane A. Carvalho is with PPG-EB, ICT, UNIFESP, Sao Paulo, Brazil. (e-mail: regiane.albertini@unifesp.br).

orthostatism with their feet together and aligned [8], data were used for synchronized with EMG by the amplifier for identification the phases of the movements described during the proposed task.

The maximal voluntary isometric contraction protocol (MVIC) [7] was performed with a force transducer (Manual Muscle Tester; Lafayette Hand Held Dynamometer, Indiana, USA) to report the strength performed during the movement [9]. The protocol was adapted to perform three maximum isometric contractions lasting 5 seconds and an interval of 60 seconds between them, this sequence was performed only once in order to respect the clinical conditions of symptomatic patients [10]. 30% of the average force found on the dynamometer was applied as a load to the functional task, which was imposed by dumbbells positioned inside a wooden box with negligible mass and "handles" to facilitate the handhold. In the movements carried out without load, the participant took the empty box.

The execution of the proposed functional task was simulated once before the data capture, for a better recognition of the activity to be evaluated. Participants were instructed to stand in the orthostatism position with their feet parallel in the shoulder width in front of the box 15 cm from their feet. After 5 seconds from the beginning of the data capture the individual was asked to pick up take the soil object naturally, by verbal command. After taking the box, the participant held the object in his hands for 5 seconds in orthostatism and by verbal command the individual was asked to put the box on the ground. Signal capture was performed for a further 5 seconds after the end of the movement. The participant had 60 seconds of rest in the orthostatism position and performed the same procedure again. Three repetitions with load and three repetitions without load were randomly performed (Fig. 1). All movements were controlled by the individual's natural speed.

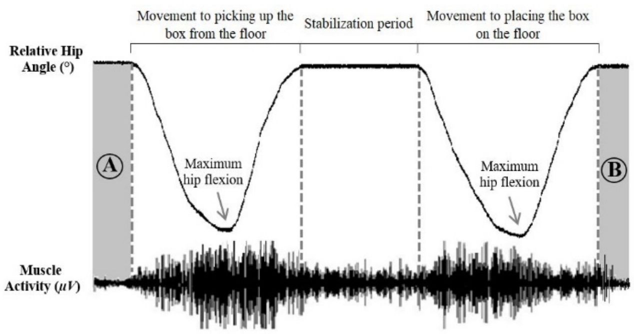

Fig. 1 Demonstration of angled hip variation with electromyographic signal (A: Pre movement; B: Post movement).

The volunteers reported the intensity of pain during the tests, quantified by the Numerical Pain Scale which assesses the individual's perception of their pain experience, with a score from 0 (no pain) to 10 (maximum pain) [11]. To locate the pain the Body Pain Map was used, in which the participant indicates his pain area in the lower back represented by an image [12]. This information was recorded on the Experimental Protocol form during the evaluation of the volunteers.

C. Data Processing

Data were analyzed using a custom algorithm (Butterworth, 4th order, bandpass 6 0Hz and its harmonics). The electromyographic activity of each MVIC was enabled to normalize the muscle activity of the functional task after their respective inspections [13]. The data of the functional task were periodized according to the angular displacement of the hip recorded by the EMG and divided by phases of the movement (pre movement; post movement).

D. Statistical Analysis

The characteristics of the participants are described by means, standard deviation, and absolute and relative frequencies. The amplitude measurements of muscle activity (root mean square, RMS) were transformed by natural logarithm to statistical analysis. To compare the amplitudes of muscle activity between groups, two-way ANOVA (2 X 2) was performed with each muscle with factors of load and group in the pre movement and post movement phase. For non-parametric data, Mann-Whitney tests were applied between groups for each muscle combined with the load condition and task phases. The relationship between intensity of pain with the amplitudes of each muscle activity in the load conditions and task phases of the symptomatic group were analyzed using Pearson's or Spearman's correlation coefficient with the confidence intervals (CI) of 95%. All analyzes were performed assuming $p \leq 0,05$.

III. Results

The control group performed higher mean strength in the MVIC test compared to the group with Chronic Low Back Pain (CLBP), the other sample characteristics did not present statistically significant differences between the groups (Table I). The pain body map indicated that 88% of the symptomatic participants located their pain in the center of the lumbar spine, 6% on the left side and 6% on the right side of the lumbar region.

TABLE I
SAMPLE FEATURES

Variables	CLBP	Control	t-test (p)
Age (years)	43,1 ± 9,0	39,2 ± 10,4	0,267 MW
Height (cm)	166 ± 0,1	171 ± 0,1	0,07
Body Mass (kg)	73,2 ± 12,6	77,1 ± 15,1	0,373
BMI (kg/m²)	26,5 ± 3,8	26,2 ± 4,0	0,816
Mean Strength MVIC (kg)	11,37 ± 4,85	18,02 ± 6,84	0,001**
Load 30% MVIC (kg)	3,41 ± 1,46	5,41 ± 2,05	0,001**
Pain (Numerical Pain Scale)	3 ± 2,6	0 ± 0	-

The variables were described as mean and ± standard deviation. *: p < 0,05; **: p < 0,01. BMI = Body Mass Index; MW: Mann-Whitney.

In the execution of the functional task without load, in the PRE phase the group with CLBP presented the mean muscle activation 31% higher than the asymptomatic participants and in the POS phase presented muscle activation 51% higher than the control group, with a statistically significant difference (p

= 0,033) in the right multifidus muscle (Fig. 2).

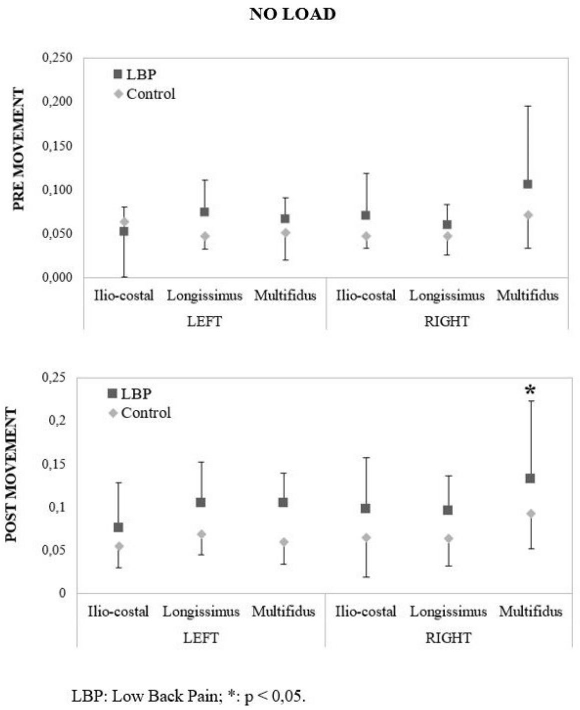

Fig. 2 Representation of the average muscle activity of the groups by movement phases, during the functional task without load

Only 25% of the participants with CLBP showed an increase in pain intensity during the execution of the task and there were 50% occurrences of moderate correlation between electromyographic activity and pain intensity in the functional task without load (Table II).

TABLE II
CORRELATION IN THE FUNCTIONAL TASK WITHOUT LOAD

		r-value, 95% CI and p-value		
Pre Movement	**Right Side**			
	Longissimus	0,335 ^{pe}	(-0,156 to 0,693)	0,174
	Ilio-costal	**0,625** ^{pe}	(0,223 to 0,845)	0,006 **
	Multifidus	0,119 ^{pe}	(-0,368 to 0,555)	0,638
	Left side			
	Longissimus	**0,611** ^{sp}	(0,216 to 0,834)	0,005 **
	Ilio-costal	**0,547** ^{pe}	(0,138 to 0,797)	0,013 *
	Multifidus	0,269 ^{pe}	(-0,211 to 0,644)	0,266
		r-value, 95% CI and p-value		
Post Movement	**Right Side**			
	Longissimus	**0,524** ^{pe}	(0,091 to 0,790)	0,021 *
	Ilio-costal	0,414 ^{pe}	(-0,083 to 0,746)	0,098
	Multifidus	0,087 ^{pe}	(-0,396 to 0,532)	0,731
	Left side			
	Longissimus	**0,662** ^{pe}	(0,282 to 0,862)	0,003 **
	Ilio-costal	**0,534** ^{pe}	(0,105 to 0,795)	0,019 *
	Multifidus	0,489 ^{pe}	(0,045 to 0,772)	0,034 *

^{pe}: Pearson correlation; ^{sp}: Spearman correlation; *: p ≤ 0,05;
*: p ≤ 0,01; Bold: Moderate correlation coefficient (0,5 ≤ r < 0,7).

In the functional task with load, during the PRE phase the symptomatic participants presented muscle activity 17% higher than the control and in the POS phase presented muscle activity 49% higher than the asymptomatic participants, with statistically significant difference (p = 0,034) in the left ilio-costal muscle (Fig. 3).

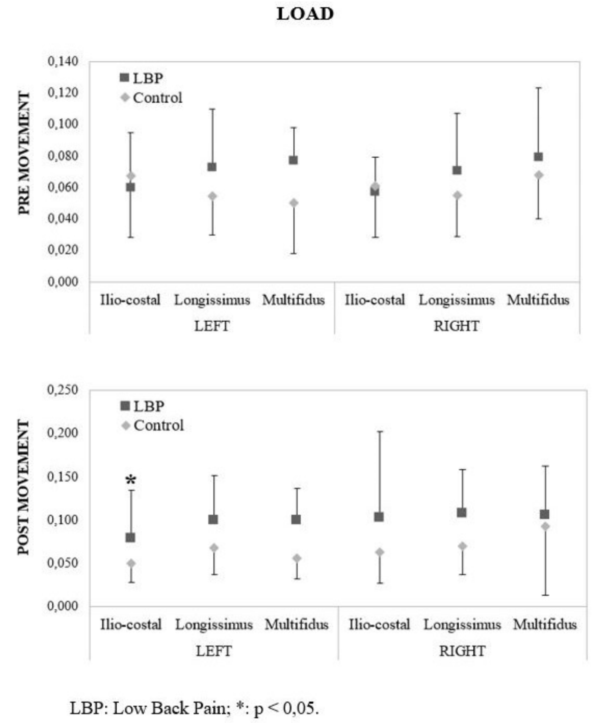

Fig. 3 Representation of the average muscle activity of the groups by movement phases, during the functional task with load

TABLE III
CORRELATION IN THE FUNCTIONAL TASK WITH LOAD

		r-value, 95% CI and p-value		
Pre Movement	**Right Side**			
	Longissimus	0,220 ^{pe}	(-0,261 to 0,613)	0,366
	Ilio-costal	**0,613** ^{pe}	(0,205 to 0,840)	0,007 **
	Multifidus	0,229 ^{pe}	(-0,283 to 0,639)	0,378
	Left side			
	Longissimus	**0,602** ^{sp}	(0,203 to 0,829)	0,006 **
	Ilio-costal	0,308 ^{pe}	(-0,222 to 0,697)	0,246
	Multifidus	0,283 ^{pe}	(-0,196 to 0,654)	0,240
		r-value, 95% CI and p-value		
Post Movement	**Right Side**			
	Longissimus	0,244 ^{sp}	(-0,223 to 0,619)	0,300
	Ilio-costal	0,489 ^{pe}	(0,029 to 0,778)	0,039 *
	Multifidus	0,141 ^{pe}	(-0,349 to 0,570)	0,578
	Left side			
	Longissimus	0,399 ^{sp}	(-0,067 to 0,722)	0,090
	Ilio-costal	0,310 ^{pe}	(-0,154 to 0,662)	0,184
	Multifidus	0,160 ^{pe}	(-0,318 to 0,572)	0,514

^{pe}: Pearson correlation; ^{sp}: Spearman correlation; *: p ≤ 0,05;
*: p ≤ 0,01; Bold: Moderate correlation coefficient (0,5 ≤ r < 0,7).

Only 30% of participants with CLBP showed an increase in pain intensity during the performance of the task and there were 17% occurrences of moderate correlation between electromyographic activity and pain intensity in the functional task with load (Table III).

IV. Discussion

The results presented in this study corroborate the literature, in which the participants with CLBP presented higher electromyographic activity to perform a functional activity. Lima et al. [14] evaluated the tasks of sitting, lifting, climbing steps and picking up and leaving the cake on the ground in individuals with CLBP, in all activities the symptomatic group presented higher muscle activity compared to the control group, however, the task of catching and leaving a ball in the ground showed greater differences in electromyographic activation between the groups, reinforcing the hypothesis of being a more threatening movement with eccentric and concentric contraction of the lumbar muscles.

The difference in lumbar muscle activation between the groups was more evident in performing the functional task without load, in which symptomatic participants presented higher lumbar electromyographic activity. Greater physiological muscle action is expected to lift load however this increased activation is not necessary to perform a simple task without load. This pattern of muscle activation represents a not functional and maladaptive behavior [15].

The POS phase demonstrated an increase in lumbar electromyographic activity of participants with more expressive BPCL compared to the control group and compared with the PRE phase. It is possible that this muscle hyperactivation occurs soon after the execution of the movement due to the increase in lumbar stiffness as self-protection to the activity performed, because individuals with a history of CLBP present altered strategies for maintaining posture after balance disorders [4].

Most of the symptomatic participants did not present increased pain intensity during the execution of the activities, with and without load. However, a moderate correlation was found between electromyographic activity and the intensity of low back pain, being more evident during the performance of the task without load. This finding supports the hypothesis that individuals with nonspecific CLBP present muscle hyperactivation of the trunk as protection to the spine to move in a "safe" way. The purpose is to minimize the forces applied to painful structures and the anticipation of pain. This strategy may assist in the development or continuity of pain through changes in existing neuromuscular deficits [4]. This strategy is obtained by increasing the basal level of activation of the trunk muscles that aims to restrict their movement and can be mediated by changes in the central set that influence the expected and unexpected postural responses [4].

Fear is likely to be one of the mediators between increased muscle activity and pain reported by individuals during movement, in which pain catastrophizing is more associated with increased activity of trunk muscles than pain intensity [14]. Kinesiophobia increases body awareness and pain hypervigilance, resulting in this protected movement, verified by increased electromyographic activity in the trunk muscles of symptomatic participants [16].

This study reinforces the theory that individuals with non-specific CLBP present alterations in motor behavior, such as muscle hyperactivation and may be associated with fear of movement in order to avoid pain [17]. Further studies discussing this theme are necessary to better understand all variables and their correlations in order to increase the efficacy of CLBP treatments.

V. Conclusion

Individuals with nonspecific CLBP showed increased lumbar muscle activity before and after the functional task of picking up and placing an object from the ground with and without a load compared to healthy participants. The difference in lumbar muscle activation between groups was more evident during the execution of the task without load and in the POS phase. A moderate correlation was found between electromyographic activity and pain intensity. Further studies are necessary to better understand all variables and their correlations to increase the efficacy of CLBP treatments.

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