EMG Activity of Trunk Muscles in Patients with Chronic Low Back Pain after Fatigue

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Abstract

Background: Low back pain (LBP) is one of the most prevalent musculoskeletal disorders. Altered movement patterns in LBP patients can reflect changes in neuromuscular control.

Objective: This study aimed to assess trunk muscle electromyographic (EMG) response after trunk extensor muscle fatigue in LBP subjects.

Methods: Sixteen patients with chronic non-specific LBP and twenty healthy matched subjects volunteered to participate in this interventional study. EMG activity of trunk muscles was assessed before and after lifting fatigue task in two groups. Multivariate Analysis of variance (MANOVA) was used for statistical analysis.

Results: The results were significant for the main effects of fatigue (F=6.64, P <0.05) and interaction of group by fatigue (F=5.34, P <0.05) in lower erector spine muscle activity.

Conclusions: Muscular fatigue is not unusual in daily activity and work place. According to the results of the current study, trunk extensor muscles fatigue altered trunk muscles activation in both healthy and CLBP but the alteration was greater in CLBP patients.

1. Introduction

Low back pain (LBP) is one of the most prevalent musculoskeletal disorders [1]. Altered movement patterns which have been demonstrated in LBP patients can reflect changes in neuromuscular control [2]. Evidence illustrates impaired neuromuscular control over maintaining trunk posture and movement in these patients [3].

Spinal Stability is mainly controlled by muscular activation, active muscle stiffness, and reflex response [4]. Each of these neuromuscular parameters and therefore spinal stability can be affected by fatigue [4]. Mechanical stiffness of the musculoskeletal system is one of the primary components of trunk stability [4]. Antagonistic co-contraction can be utilized to modulate stiffness and enhance

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spinal stability [5]. Muscle fatigue reduces muscle force generating capacity, and also it has a detrimental effect on proprioception [6, 7]. Therefore, in response to reduced muscle stiffness in muscular fatigue condition, modifications in co-contraction patterns may be necessary to maintain spinal stability. Modified trunk muscle recruitment pattern has been reported with trunk fatigue [8].

While sustained neutral standing is one of the common body postures in workplace and daily activities. Studying the stability of the spine in this position has been the topic of many researches. Previous data represented that low level of trunk flexor and extensor co-contraction was necessary to maintain the spinal stability in the upright neutral posture. And this co-contraction has been shown to increase during vertical loading [9]. It seems reasonable that segmental instability and buckling of the spine can occur under sub-maximal conditions, to be expected as a result of faulty motor control which is probable in muscular fatigue [10]. According to the impaired neuromuscular control in LBP patients, the purpose of this study was to assess trunk muscle electromyographic response in axial loading task after trunk extensor muscle fatigue in LBP subjects.

2. Materials and Methods

2.1. Subject

Sixteen patients with chronic non-specific LBP who reported episodes of LBP with no specific etiology volunteered to participate in this interventional study. Twenty healthy women without any history of back pain were matched according to sex, age and body mass index (BMI) with LBP patients were also participated in this investigation (Table 1).

The procedures were performed in accordance with the Declaration of Helsinki and approved by the research Ethics Committee at the Department of Physical therapy at Tarbiat Modares University. All subjects provided signed informed consent prior to inclusion.

Subjects with dysfunction of upper or lower extremity joint or muscle pain, lower extremity, trunk surgery, lifting jobs, professional sports activities and neurologic, systemic or heart diseases were not entered. Exclusion criteria for the subjects(LBP & healthy) was included not intended to continue the experimentation in the middle of test and having pain more than 3 through the experimental test according to visual analog scale (VAS).

2.2. Apparatus

Electromyography (EMG) activity was collected using eight channels EMG surface recording (Biometrics LS900) through the use of bipolar silver–silver chloride disposable surface electrodes with a diameter of 10mm and inter-electrode distance of 20mm.
Electrodes recorded the trunk muscle activity of the thoracic erector spinae (TES), lumbar erector spinae (LES), transverse abdominis/internal oblique (TrA/IO), rectus abdominus (RA), external oblique (EO) unilaterally from the dominant side of the participants. Electrodes were placed over these muscles according to Hodges (1996) [11] methods. EMG sampling frequency was 1000 HZ with 20-450 HZ band width and 50 HZ notch filter and the sensitivity was 500 µs. Total root mean square (RMS) of the recorded signals was obtained by Data link software.

The collected data were normalized to their maximum voluntary contractions (MVCs) that were obtained from the trunk extensor and abdominal muscles. For the TES, LES and LMF, subjects lay in prone position on a padded table with the leg extended over the table and hands beside their body. For the right TrA/IO, EO and RA muscle MVCs, subjects lay supine on the padded table, with their knees extended.

Table 1. Demographic data of the subjects in each group (mean± SD).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Healthy (N=20)</th>
<th>CLBP (N=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(years)</td>
<td>26.26 ± 1.88</td>
<td>27.56 ± 1.71</td>
</tr>
<tr>
<td>Weight(kg)</td>
<td>58.46 ± 7.68</td>
<td>60.12 ± 8.71</td>
</tr>
<tr>
<td>Height(m)</td>
<td>1.61 ± 6.18</td>
<td>1.61 ± 6.11</td>
</tr>
<tr>
<td>BMI(kg/m²)</td>
<td>22.4 ± 2.75</td>
<td>22.9 ± 2.88</td>
</tr>
</tbody>
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Subjects were then asked to flex their abdominal muscles and bend at the waist to elevate their upper torso (to about 45 degree with the table). Isometric MVC trials were performed in symmetrical flexion without twisting and with twisting to the right and left. For each direction, two straps were used to fix the subject’s legs and the researcher provided as much resistance at the shoulder(s) as was necessary to keep the efforts isometric. Each MVC was performed two times and the subjects were asked to gradually ramp up the force to reach an absolute maximum force, and then to hold for 8-10 s. Approximately 30 s of rest was given between MVC contractions.

2.3. Procedure

EMG activities of the trunk extensor and abdominal muscles were recorded in two conditions in relax standing position before and after performing fatigue task. One of the conditions was when the participants stand and just put on a vest (with 4 symmetric pockets in back and front) and another was when loads equal to 25% of subject’s body weight were put in the vest’s pocket symmetrically (Figure 1). EMG signals were recorded for 10 seconds in every condition.

2.4. Fatiguing task

A dead-lift task (Figure 2) was used to induce fatigue on trunk extensor muscles based on Strange et al [12] method. Dead-lift repetition was performed with 50% of their maximum voluntary efforts by all subjects to exhaustion (according to every participant report through the
fatigue task based on Borg scale). The maximum isometric force exerted by the leg and back musculature in dead-lift task was measured using an isometric leg and back dynamometer prior to start the fatigue task.

![Figure 1](image1.png) Comfortable upright standing with a vest with four symmetric pockets.  
![Figure 2](image2.png) Dead-lift exercise used to induce fatigue.

2.5. Data analysis

Normalized total root mean square (RMS) of the EMG signals to their muscle MVC was used for statistical analysis. The main effects of group (healthy or CLBP subjects), fatigue (with or without back extensor muscle fatigue) and weight (0% or 25% body weight) was assessed by Multivariate Analysis of variance (MANOVA). SPSS statistical package (version 16) was used for statistical analysis and the statistical significance set at P < 0.05.

3. Result

There were no significant differences between healthy and CLBP subjects in age (P =0.71), height (P =0.99), weight (P =0.86) and BMI (P =0.78). Table 1 summarized the demographic data of two groups.

The results of MANOVA revealed a significant difference for the main effects of fatigue (F=6.64, P <0.05) on the RMS of LES muscle. This difference was also significant for interaction of groups by fatigue (F=5.34, P <0.05) in LES activity (Figure 3). Although other muscles represented differences between two groups but the amount was not significant (Figure 4).
Figure 3. Interaction of groups by fatigue on the RMS of LES muscle (nFatigue = before fatigue task, Fatigue = after fatigue task, nLBP = healthy group, LBP = CLBP group).

4. Discussion

The current study compared trunk extensor and abdominal muscles activation patterns between CLBP patients and healthy control subjects before and after performing lifting fatigue task (deadlift task). While numerous authors have reported differences in muscle activation pattern in patients with CLBP and healthy control [13, 14], trunk muscle response has not been investigated after fatigue phenomenon in CLBP patients. Findings of the current study demonstrate differences in trunk activation patterns between two groups after fatigue phenomenon. Well-coordinated neuromuscular control is stability [15]. It has been proposed that patients with CLBP have an underlying instability of the spine, and this instability was the result of osteoligamentous laxity or damage, dysfunction of the trunk muscles or diminished neuromuscular control [16] that may cause changes in muscle activation patterns.

It is well documented that trunk muscle fatigue reduces neuromuscular control of trunk movement by deteriorating muscle coordination [17, 18], and so it can lead to instability of the spine [18]. Modified trunk muscle recruitment has been reported previously by trunk muscle fatigue in normal subjects [8, 18-20].

According to results of the present study, in CLBP group, all the investigated muscles both trunk extensors and abdominals represented higher recruitment after becoming fatigue in comparison with healthy group but the amount of difference was only significant for LES. The effect of fatigue on trunk extensor and abdominals was investigated in the prior work by the same authors [8]. It has been shown that trunk extensor has a greater role in axial loading after fatigue task to make the spinal column stable [8]. Therefore, significant increase in LES EMG activation in CLBP group in comparison to healthy individuals was logical.
Individuals with LBP behave in a guarded manner to minimize forces applied to painful structures [21] or in the anticipation and fear of pain [22]. Regarding to the medium value of fear of movement and injury measured by Tampa Scale of Kinesiophobia questioner in CLBP patients in this study (32.81 ± 4.13 in the CLBP patients), it appears that these subjects increased their trunk muscle activity to stiffen the spinal column due to their fear of movement and to reduce the risk of re-injury.

Higher activation of the trunk muscle in CLBP subjects might be also related to higher rate of neuromuscular noise in these patients [23]. Authors have been reported that trunk proprioception may impair by low back trouble and this might be compensated for by antagonistic co-activation to stiffen the lumbar spine and make it stable [18, 24].

**Figure 4.** Interaction of groups by fatigue on the RMS of TrA/IO

**Figure 4.** Interaction of groups by fatigue on the RMS of RA

**Figure 4.** Interaction of groups by fatigue on the RMS of EO

**Figure 4.** Interaction of groups by fatigue on the RMS of LMF

**Figure 4.** Interaction of groups by fatigue on the RMS of TES

(nFatigue = before fatigue task, Fatigue = after fatigue task, nLBP = healthy group, LBP = CLBP group).
Some of the previous studies examining static surface EMG reported higher levels in patients with CLBP compared to healthy subjects, whereas others reported no difference [25]. Results of the present study represented no between-group differences in trunk muscle EMG activities with and without axial loading before performing dead-lift fatiguing task. While, after fatiguing task between-group differences was appeared. Indeed, CLBP patients use co-contraction strategy in more demanding situations to encounter the underlying loss of stability but greater amount of compressive load may be induced on musculoskeletal system which may be hazardous in longtime [26].

5. Conclusion
According to the results of the current study trunk extensor and abdominal muscles activation changed after becoming fatigue in both LBP and healthy subjects. Although these changes in muscle activation were in the same direction in both groups, LBP patients revealed more guarded and protected behavior. Therefore, more spinal loading in LBP subjects in muscular fatigue situations may contribute to other episodes of acute back pain and more care should be devoted to these patients in long duration daily activities and work places.

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