Effects of Kinesiotaping on Postural Control of the Healthy Adults after Lumbar Muscle Fatigue

Mohammad Akbari [a], **Mehdi Ahmadi** [b*], **Gholamreza Pahnabi** [c]

a Department of Physical Therapy, Iran University of Medical Sciences, Tehran, Iran; b Department of Physical Therapy, University of Social welfare and Rehabilitation Sciences, Tehran, Iran; c Department of Physical Therapy, Tehran University of Medical Sciences, Tehran, Iran

Corresponding Author: Mehdi Ahmadi, Department of Physiotherapy, University of Social welfare and Rehabilitation Science. P. O. Box: 1545913187, Tehran, Iran; ***E-mail***: Ahmadi.mahdi88@gmail.com; ***Tel:*** +98-21 22227124

Submitted: 2016-08-24; **Accepted**: 2016-12-09

Abstract

Introduction: Postural control is necessary to carry out all daily activities. It is the result of corporation between somatosensory, visual, and vestibular systems. Disturbance of each of these systems can lead to impairment of postural control and increased risk of falling and injury. The objectives of the present study were to investigate the effect of lumbar muscle fatigue on postural sway as well as the effect of kinesiotaping on postural sway after lumbar muscle fatigue. **Methods and Materials**: A total of 15 healthy young men participated in the present cross-over randomized study. Participants' mean velocity and sway area were assessed using force platform in bilateral standing position with their eyes closed and in three conditions: 1. Baseline, 2. After fatigue without taping (NT), and 3. After fatigue with kinesiotaping (KT). At baseline measurements, no intervention was carried out on the participants. For the non-taping condition, tape was not applied during postural sway measurement. For the taping condition, kinesiotape was applied on lumbar area before fatigue protocol. Lumbar extensor fatigue was produced maintaining 60% of maximum voluntary isometric contraction. Repeated measure ANOVA was used for data analysis. **Results:** After lumbar extensor fatigue, sway area, and mean velocity were significantly higher than baseline measurements, respectively. Sway area between KT condition and NT condition (0.63±0.19 cm_2) was not found to be significantly different (*P*=0.066), while velocity of sway in KT condition was significantly lower than that in NT condition (*P*=0.006). **Conclusions:** Lumbar muscle fatigue impaired postural control. Lumbar muscle kinesiotaping may be useful to reduce the negative effects of fatigue on postural control.

Key words: Force Plate, Kinesiotape, Low Back, Muscle Fatigue, Postural Control

Please cite this paper as: Akbari M, Ahmadi M, Pahnabi G. Effects of Kinesiotaping on Postural Control of the Healthy Adult s after Lumbar Muscle fatigue. J Clin Physio Res. 2017; 2(1): 43-47. Doi: 10.22037/jcpr.2017.07

Introduction

Postural control involves controlling the body's position in space for the dual purposes of stability and orientation and is necessary to carry out all daily activities [1]. Postural control arises by corporation between somatosensory, visual, and vestibular inputs [2]. Any disruption in one of these systems can lead to postural control impairment and then risk of falling and damage will be increased [3, 4]. Muscle fatigue is one of the factors which can affect postural control [5, 6]. In addition to decreasing muscle force production [7], muscle fatigue can affect joint proprioception [8] and the stabilizing muscle function, thereby it increases the body's postural sway [9]. Taimela *et al.* showed that lumbar muscle fatigue impairs the ability to sense a change in lumbar position [10]. Therefore, any intervention that increases proprioceptive inputs can reduce disturbance of postural control caused by fatigue. However, fatigue of the lumbar muscles, compared to that of other muscles, have more negative effects on postural control [11]; likewise, sensory inputs of the trunk or hip muscles are more important in triggering balance corrections [12].

Kinesiotape is a new form of cotton tape with acrylic adhesive, which can be stretched 20-40% of its original length. Kase, the inventor of this tape, has noted different benefits for this tape, including: 1) improving proprioception by providing a constant sensory stimulation, 2) creating more space for improving circulation of blood and lymph flow to eliminating of extra fluid, edema, or bleeding beneath the skin, 3) correcting muscle function by strengthening muscle weakness, 4) realigning official tissue function by normalizing muscle tension, and 5) decreasing pain through neurological suppression [13]. In the recent years, researchers have

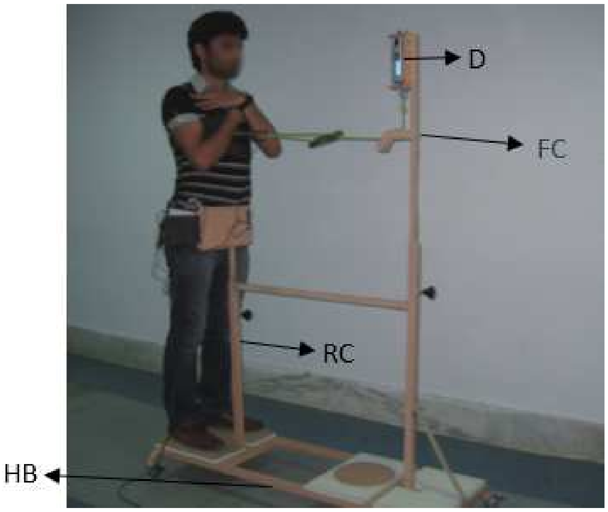

Figure1. FC: Front column, RC: Rear Column, D: Dynamometer, HB: Horizontal Base

Figure 2. Application technique of kinesiotaping for the sacro-spinus muscles

investigated the effects of the kinesiotape on the proprioception and have reported that it can improve joint position sense and force sense through stimulating muscle and cutaneous receptors and increasing sensory inputs [14-16]. It seems that kinesiotape may compensate for the decline in proprioception input induced by muscle fatigue and improves postural control. Therefore, the objectives of the present study were investigation of the effects of lumbar fatigue on postural sway and the effects of lumbar muscle kinesiotaping on postural sway after lumbar fatigue.

Materials and Methods

Participants

A total of 15 healthy male participants took part in the current cross-over study, with a mean age of 22.6 ± 3.1 years, mean height of 175.2 ± 4.9 cm, and mean weight of 78± 3.8kg, after singing an informed consent. The study was approved by the Research Ethics Committee of Tehran University of Medical Sciences (IRCT ID: IRCT201306297057N3). Participants with a history of severe trauma, musculoskeletal surgery, nervous and vestibular system impairments, and congenital anomalies were excluded from the study.

Fatigue protocol

Muscle fatigue was produced by maintenance of 60% of Maximal Voluntary Isometric Contraction (MVIC) of the lumbar extensors. First, MVIC of the lumbar extensors was assessed using dynamometer (Commander Power Track II HHD. JTech Medical, USA), which was performed in standing position with 30° flexion of the lumbar region. For this purpose, a device was designed (Figure.1) with two vertical columns and a horizontal base. Vertical columns were adjustable according to the participant height. The dynamometer was positioned at the front column. Participants were asked to wear a vest and lumbar muscle tension was transferred to the dynamometer using a rope that was attached to the front part of the vest. Participants leaned back at a rear vertical column. Any movements of pelvis and lower extremities were restricted by the waist. After a brief warm-up, the participants were asked to exert maximum extension contraction and maintain this for five seconds. Continuous verbal encouragement was provided during the test. The measurement was repeated three times with one-minute interval between each repetition [17]. The highest value of the three repetitions was considered as the MVIC of the lumbar extensors. To produce muscular fatigue, after a short recovery period, the participants exerted 60% of their MVIC of lumbar extensor in the same position of MVIC measurement, and held this level until they could no longer sustain 20% of the sub-maximal MVIC force output [18].

Taping techniques

Standard 2-in (5 cm) blue Kinesio®TexTape was used for all tape applications. Application technique was the same technique used for sacro-spinus muscles [19]. The base of the Y tape was attached without stretching over the center of the sacrum. Then, one tail of the Y tape with 10 centimeter length was stretched so that its length increased to 11 centimeters and was attached on the paravertebral muscle (near 12th thoracic vertebra) with 10% tension. The other tail was applied on the contralateral side using the same technique. The end of each tail was applied with no tension (Figure. 2).

Measurements

Postural sway was evaluated for each participant in three conditions: 1. Baseline, 2. After fatigue without taping (NT), and 3. After fatigue with kinesiotaping (KT). At baseline measurements, no intervention was carried out on the

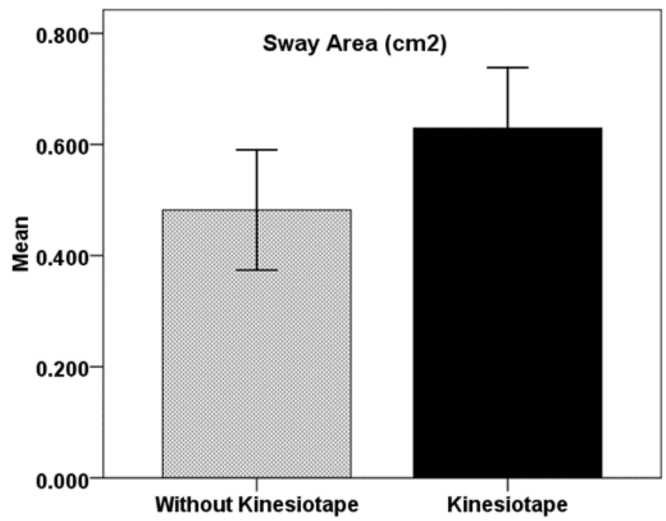

Figure 3. The mean of the sway area with and without kinesiotape

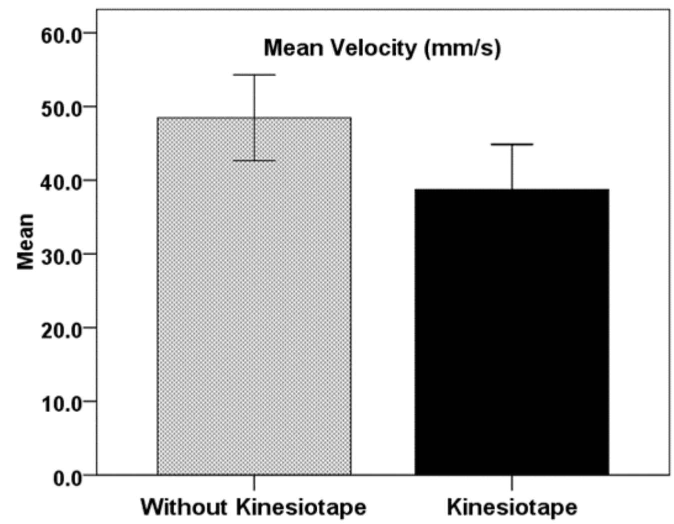

Figure 4. The mean of sway velocity with and without kinesiotape

participants. For the non-taping condition, tape was not applied during postural sway measurement. For the taping condition, kinesiotape was applied on lumbar area prior to fatigue protocol. We considered one-week interval between evaluation of postural control between NT and KT conditions. The order of NT and KT conditions was randomly assigned to each participant. Postural sway parameters, including sway area and mean velocity were recorded using force platform (Kistler - 9260AA6) 4^{th} order, 10 Hz low-pass Butterworth filter. Signals from the force platform were sampled at 400 Hz, amplified and converted from analog to digital form through an A/D converter.

Participants stood on the force plate in a comfortable manner on two limbs, head in neutral position, feet together, arms at sides, and eyes closed for 30 seconds. The area participants had to put their feet on the force plate was marked using signs. For converting the force plate data to numerical value, we used a formula suggested in the previous studies [20-22].

Statistical analysis

Data was analyzed using SPSS (version 17). Normal distribution was checked using the Shapiro wilk analysis. Since data was shown to be normally distributed, repeated measure ANOVA was used to determine any difference among baseline, NT, and KT conditions. Greenhouse-Geisser test showed significant differences among three conditions (P=0.001). Then, pair t-test was used to determine the effect of muscle fatigue on the postural sway parameters (NT and baseline) and to compare these parameters between KT and NT conditions. Statistical significance for all tests was accepted below the 0.05 level.

Results

Effects of fatigue on the postural sway

Mean velocity at baseline and NT condition was 39.4±5.01mm/s and 48.4±10.51mm/s, respectively. Fatigue had a significant effect on the sway velocity with P=0.013 (Table1). Sway at baseline and NT condition was 0.21± 0.12 and 0.48± 0.19_{cm2}, respectively. Fatigue had a significant effect on the sway area with P = 0.002 (Table1).

Effects of kinesiotaping on the postural sway (after muscle fatigue)

Comparing sway area between NT condition (0.48±0.19), and KT condition 0.63±0.19cm_2 revealed no significant difference (P=0.066) (Figure 3). Thus, kinesiotape was found to have no effect on sway area after lumbar muscle fatigue. But, it was found to have significant effect on mean velocity (P=0.006) (Figure 4). Mean velocity of NT condition and KT condition was 48.4±10.51 mm/s and 38.7±11.0 mm/s, respectively.

Discussion

The first hypothesis of the present study was that lumbar extensor fatigue had negative effects on postural sway and the second hypothesis was lumbar muscle kinesiotaping may reduce negative effects of fatigue on postural sway.

Effect of muscle fatigue on postural sway:

The results of data analysis showed a significant increase in the mean velocity and sway area after lumbar fatigue. According to these findings, muscle fatigue impaired postural control and thus confirmed our first hypothesis.

Table 1. Mean (SD) of the sway parameters pre and post fatigue

Variables	Baseline	Non-taping	95% confidence interval of the difference		*P*-value
			Lower limit	Upper limit	
Sway area cm2	0. 21 (0.12)	0. 48 (0.19)	0. 14	0. 38	0.001
Velocity mm/s	39.4 (5.01)	48.4 (10.5)	2.24	15.75	0.013

These findings are consistent with the reported in the previous studies. Pline *et al.* [23] and Davidson *et al.* [9] found that after lumbar muscle fatigue, the mean velocity and sway area increase significantly compared to those in the pre-fatigue state. They used the isotonic contraction to produce muscle fatigue, while in the present study muscle fatigue was preserved by isometric contraction. Reduction in muscle force output is one of the reasons that can lead to postural control disturbance followed by fatigue [9]. Since the lumbar muscles have low discharge to control body in standing position [24], thereby reducing lumbar muscle force output may not be the main factor in postural sway increase after fatigue. The present study was conducted in blind fold. Muscle fatigue does not affect the vestibular system. Since primary sensory afferents of nervous system to maintain postural control originate from somatosensory, visual, and vestibular systems, it seems likely that the lumbar extensor fatigue, caused by proprioception impairment, leads to increase postural sway in the participants of the current study. However, low back muscle fatigue impairs the ability to sense the change in lumbar position. Lumbar muscle fatigue also has negative effects on proprioception of the joints distally of fatigue region, such as ankle joint [25]. Although the lumbar muscles have low activity in the control of standing posture, fatigue of these muscles can cause more impairment on postural control than that of muscles of the other segments. So, it looks that to control standing posture, sensory role of lumbar region is more pronounced than other areas.

The effect of kinesiotaping on postural sway (after muscle fatigue)

Sway area between KT condition and NT condition was not found to be significantly different, but the mean velocity was significantly lower in KT condition. Thus, lumbar muscles kinesiotaping seems to be reducing impaired postural control after fatigue of these muscles.

The positive affect of kinesiotaping on postural control was reported in the previous studies, as well [26-28]. Akbari *et al.* [26] found that kinesiotaping of the calf muscles decrease sway area and mean velocity in people with diabetes. Cortesi *et al.* [27] reported that the calf muscles kinesiotaping reduces anteroposterior sway range in patients with multiple sclerosis.

Based on the results of our study, possible mechanism for the recovery of postural control after kinesiotaping is proprioception improvement of the lumbar region. Muscle fatigue decreases sensory afferent signals from fatigued muscles [29]; therefore, other mechanoreceptors come into play to maintain postural control. Among the most important proprioceptive receptors, cutaneous mechanoreceptors seem to be stimulated by applying pressure and stretching the skin, and can play an important role in determining the position and the motion of the joints [30, 31]. Thanks to its elasticity and adhesion properties with continuous stimulation, kinesiotape can facilitate skin mechanoreceptors activity. Also, muscle fatigue decreases the ability of spindle fibers to generate force and muscle spindles sensitivity, and thus the 1a afferent inputs [32]. Nonetheless, sensory afferent around the skin of the joint can cause activation of gamma motor neurons and help to regulate the activities of 1a afferents [33]. Thus, kinesiotape may also affect the activity of 1a afferents by stimulation of the cutaneous receptors.

Chen and Lou [15] reported reduced variability of position matching with application of kinesiotape. Also, Chang *et al.* [16] found that Kinesiotape of the wrist flexors can improve absolute force sense errors in these muscles. In contrast to these studies, Halseth *et al.* [34] showed that the kinesiotape cannot affect proprioception of the ankle joint. Their study was carried out on healthy participants without any neuromuscular dysfunction. Unlike our study, they included no intervention on neuromuscular function; therefore, the difference between findings of the present study and those of their study may be justified.

It is recommended that the effects of kinesiotaping on postural control be evaluated using other tools.

Limitations: All the participants were healthy males. Tension setting of the kinesiotaping was subjective because selection of standing position to fatigue protocol may produce fatigue in other muscles.

Conclusion

According to the findings obtained in the present study, lumbar extensor muscles fatigue increased mean velocity and sway area. Kinesiotaping of the lumbar muscles can decrease the mean velocity and may improve postural control after muscle fatigue. It may also reduce the negative effects of lumbar muscle fatigue on postural control. Future research is necessary to replicate our findings and assess the usefulness of the kinesiotaping in individuals with postural control impairment.

Acknowledgments:
None

Conflict of interest:
None

Funding support:
The present study was supported by Iran University of Medical Sciences & health Services (Grant No: 21385).

Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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