Research Paper: Immediate Effects of Lumbosacral Belt on Postural Control During Challenging Tasks in Patients With Chronic Low Back Pain

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Citation: Ghofrani M, Olyaei Gh, Talebian S, Bagheri H, Malmir K, Mousavi Sh. Immediate Effects of Lumbosacral Belt on Postural Control During Challenging Tasks in Patients With Chronic Low Back Pain. Journal of Modern Rehabilitation. 2017; 11(2):119-126.

doi: ???

Article info:
Received: 12 Oct. 2016
Accepted: 23 Jan. 2017

ABSTRACT

Introduction: Chronic Low Back Pain (CLBP) may be associated with impaired proprioception which can result in joint instability and balance deficit. However, wearing a lumbosacral belt may be helpful in this situation. This study aimed to identify postural control impairments in patients with CLBP and determine the effect of lumbosacral support on postural control strategies in these patients.

Materials and Methods: A total of 16 patients with CLBP and 16 healthy subjects participated in this study. Center of Pressure (COP) data were recorded for 30 seconds while wearing or not wearing a belt in four standing positions; double leg with open eyes, double leg with closed eyes, single leg with open eyes, single leg with closed eyes. Postural control was assessed using range, area and total mean velocity for each experimental condition.

Results: Patients with CLBP showed significantly larger mean COP range and mean area compared to the healthy controls in single leg stance with closed eyes (P<0.05). Lumbosacral belt reduced significantly mean COP range, mean COP area and mean total velocity during challenging conditions (P<0.05).

Conclusion: Individuals with CLBP had poorer postural control compared to the healthy controls as determined by changes in COP. Lumbosacral belt can improve postural control during challenging tasks.

Keywords:
Chronic Low Back Pain, Postural control, Lumbosacral belt

1. Introduction

Low back pain (LBP) is one of the most common health problems. The prevalence rate of this disorder is 15% among adults and ranges from 60% to 80% over the course of an entire life time [1, 2]. Postural control system operates on the basis of integrated information from three independent sensory sources; somatosensory, vestibular, and visual [3]. Thus, derangement in any of these sensory systems will influence the overall output of

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the postural control system. Several studies have shown impaired proprioception in these patients [4, 5].

Control of posture, therefore, may be affected in patients with Chronic Low Back Pain (CLBP) [6, 7]. In this regard, wearing a lumbar belt may be beneficial. Lumbar belt may increase compression forces on the skin, thereby providing extra sensory afferents to the central nervous system by the cutaneous mechanoreceptors, which in turn would improve lumbar proprioception [8-10]. This situation may compensate for proprioceptive impairment in CLBP patients and restore postural balance for them. Assessment of human postural or balance control is of high interest to researchers and clinicians. In this regard, many measures have been proposed from force platform signals to quantifying postural steadiness. However, Center of Pressure (COP), defined as the point of application of the ground reaction forces under the feet, is found the most commonly used variable [11].

Postural control can be assessed using COP variables such as COP range in the Anterior-Posterior (AP) or Medial-Lateral (ML) direction, sway area and mean velocity. To the authors' knowledge, no article has yet investigated the effect of lumbosacral belt on balance parameters in CLBP patients. Therefore, the main purpose of the present investigation was to determine whether a commonly used lumbosacral belt can improve COP range in the AP or ML direction, sway area, and mean velocity in CLBP patients. The next goal was to identify postural control impairments in patients with CLBP and compare them during four balance tasks related to different activities of daily living.

2. Materials and Methods

Participants

Sixteen patients with CLBP participated in this study. Samples were recruited in an unpredictable way through advertising in physiotherapy departments of Rehabilitation Schools in Tehran.

Inclusion criteria were as follows: having localized back pain, feeling pain intensity less than 4 based on visual analog scale, lasting pain more than 6 months and radiating no further than the buttock, and lacking previous history of sciatica or other radicular involvement. The patients had neither history of vestibular and neurological disease nor of hip, knee, ankle or foot problems. Sixteen matched healthy subjects as control group were also participated in the study. They had neither low back pain 6 month prior to testing, nor evidence of vestibular, postural or musculo-skeletal impairments. The demographic characteristics of the participants are presented in Table 1. Each participant signed an informed consent form approved by the Institutional Review Board of the Tehran University of Medical Sciences (IR.TUMS.REC.13942145).

Instruments

A force platform (Bertec Corporation, Columbus, OH, USA) with sampling frequency of 500 Hz was used to record the COP data. Data were stored on a Pentium-based PC and then fed to MATLAB software for calculation of COP parameters. AP and ML displacement of COP were measured along the y-axis and x-axis, respectively. An extensible lumbosacral belt with posterior metal bar (Sacro Lumbar Support 2164 Oppo USA www.reidko) was used to assess the effects of lumbosacral belt on postural control (Figure 1).

Testing procedures

After familiarization with the tests, all participants completed balance tests during four conditions barefoot on a force platform. The arms were parallel to the trunk. A physiotherapist blinded to experimental objectives performed all testing procedures. The balance conditions were

Table 1. Mean(SD) of the demographic characteristics of the participants (n=16 in each group)

Variable	Group	
	CLBP, Mean (SD)	Control, Mean (SD)
Age (y)	24.8(3.8)	23.2(2.2)
Mass (kg)	64.8(12.0)	68.7(10.9)
Height (m)	1.66(7.6)	1.7(9.1)
BMI (kg/m²)	23.3(2.9)	23.5(2.9)

BMI: Body Mass Index

JMR

Figure 1: Lumbosacral belt

performed randomly with and without lumbosacral belt as follows: 1. Two-legged stance with eyes open; 2. Two-legged stance with eyes closed; 3. One-legged stance with eyes open; and 4. One-legged stance with eyes closed.

The position of the feet was standardized using a tape marker on the force platform. Three trials, with a rest period of approximately 2 minutes, were performed for each condition, and each trial lasted for 30 seconds.

Data analyses

The raw data were filtered with a sixth order Butterworth, zero-phase low-pass filter at 10 Hz and converted into COP data using MATLAB-based routines (Mathworks, Natick, MA, USA). Parameters calculated from COP data were as follows: AP displacement, ML displacement, area and total mean velocity. The formulae used to calculate each parameter are presented in Table 2 [12].

Statistical analyses

SPSS (version 20.0 for Windows, Inc., Chicago, IL) was used to analyze all the data, with significance level set at $P \leq 0.05$. After passing normality test of Kolmogorov-Smirnov, a 2(LBP vs. control)×4(conditions)×2(with belt vs. without belt) repeated-measures multivariate analysis of variance (MANOVA) of 2 groups was used to assess postural control during different conditions between groups. Independent t test was used to analyze balance control between groups. Paired t test and effect size were further used to determine lumbosacral belt effectiveness. Cohen's d was used to describe the effect size: 0.2 is considered a "low" effect size, 0.5 an "average" effect size and 0.8 a "strong" one [13].

3. Results

Table 3 presents comparisons between groups in four balance conditions. Participants with CLBP showed significantly larger mean COP AP displacement and area in tasks 1 and 4, larger mean COP ML displacement in task 4 and higher mean of COP total mean velocity in task 1 compared to those in controls ($P<0.05$). The CLBP group reported 6.21 cm, 5.65 cm and 15.10 cm^2 for the means of the AP, ML displacement and area, respectively, compared to the healthy controls with 5.03 cm, 4.20 cm and 7.86 cm^2 of increased COP sway in task 4 (with strong effect size d=0.68 for AP displacement, d=1.19 for ML displacement and d=1.24 for area) suggesting poor postural control balance in CLBP group in challenging tasks.

Table 4 presents the effect of lumbosacral belt in four balance tasks. Conditions with lumbosacral belt presented significantly smaller COP displacement in AP direction in task 3, significantly smaller COP displacements, area and lower COP mean velocity in task 4 compared to conditions without lumbosacral belt ($P<0.05$). For the mean of the variables, the condition with lumbosacral belt reported AP displacement 3.05 cm in task 3, AP displacement 4.97 cm, ML displacement 4.18 cm, area 9.20 cm^2 and mean

Table 2. Formulae used to calculate COP parameters

Parameter	Formula
Anterior-posterior displacement (cm)	$\lvert y_{max}-y_{min} \rvert$
Medial-lateral displacement (cm)	$\lvert x_{max}-x_{min} \rvert$
Area (cm^2)	$A=2\pi F_{0.05[2,n-2]}\sqrt{(\sigma_x^2 \sigma_y^2-\sigma_{xy}^2)}$ Where $\sigma_{xy}=\sum \frac{(x_i-x)(y_i-y)}{n}$
Mean velocity (cm/s)	$\bar{u}=1/T \sum_1^T \sqrt{(x_{t+1}-x_t)^2+(y_{t+1}+y_t)^2}$

Table 3. Mean(SD) of balance parameters of individuals with and without CLBP during four balance tasks (MANOVA, independent t test and effect size)

Variables	CLBP	Independent T-Test				MANOVA		
		Balance Tasks				Group P-Value	Task P-Value	Interaction
		1	2	3	4			
Range AP (cm)	No	1.98(0.81)	1.90(0.87)	3.23(0.94)	5.03(1.75)	0.003*	0.000*	0.040*
	Yes	2.56(1.26)	1.75(0.79)	3.59(0.90)	6.21(2.32)			
	P between	0.038*	0.480	0.134	0.030*			
	Effect size (d)	0.71	_	_	0.68			
Rang ML (cm)	No	1.23(1.28)	1.08(0.90)	2.42(0.80)	4.20(1.21)	0.010*	0.000*	0.055*
	Yes	1.49(0.84)	1.14(0.97)	2.71(0.64)	5.65(3.53)			
	P between	0.370	0.780	0.132	0.038*			
	Effect size (d)	_	_	_	1.19			
Area (cm^2)	No	1.11(0.93)	1.02(1.20)	3.05(1.97)	7.86(5.82)	0.008*	0.000*	0.009*
	Yes	2.02(2.05)	1.01(1.30)	4.00(2.16)	15.10(17.05)			
	P between	0.030*	0.970	0.080	0.032*			
	Effect size (d)	0.97	_	_	1.24			
Mean velocity (cm/s)	No	0.55(0.17)	0.67(0.59)	1.51(0.60)	3.02(0.67)	0.277	0.000*	0.455
	Yes	0.65(0.20)	0.58(0.22)	1.58(0.35)	3.32(0.88)			
	P between	0.038*	0.422	0.580	0.316			
	Effect size (d)	0.58	_	_	_			

JMR

(1) Two-legged stance with eyes open; (2) Two-legged stance with eyes closed; (3) One-leg stance with eyes open; and (4) one-leg stance with eyes closed
Range AP: COP displacement in anterior-posterior direction; Range ML: COP displacement in medial-lateral direction.
*Significant differences between groups (P<0.05; with vs. without CLBP)

velocity 2.88 cm/s in task 4 compared to conditions without lumbosacral belt with AP displacement 3.78 cm in task 3, AP displacement 6.26 cm, ML displacement 5.65 cm, area 13.76 cm^2 and mean velocity 3.37 in task 4 of decreased COP sway in task 3 and 4 (with medium effect size d=0.70 for AP displacement in task 3 and d=0.55 for displacements in directions, mean velocity and d=0.47 for area in task 4) suggesting better postural control in condition with lumbosacral belt in challenging tasks.

4. Discussion

Our study compared individuals with and without CLBP under four balance tasks. Our results supported poorer postural control in CLBP group. Also more challenging balance tasks like "one-legged stance with closed eyes" can detect more tactfully CLBP effects on balance. In addition, the effect of lumbosacral belt on postural control was assessed under four balance tasks. It was found that wearing lumbosacral belt could improve postural control, especially in challenging conditions.

Between group comparisons

The present study showed significant differences between groups, in that CLBP group reported poorer postural control compared to the healthy controls. Apparently, the differences between CLBP and healthy

Table 4. Mean (standard deviation) of balance parameters of two conditions without belt and with belt during four balance tasks in CLBP (MANOVA, paired t test and effect size)

Variables	Belt	Paired T-Test				MANOVA		
		Balance Task				Belt P-Value	Task P-Value	Interaction
		1	2	3	4			
Range AP (cm)	No	2.20(1.41)	1.82(0.72)	3.78(0.90)	6.26(2.36)	0.005*	0.000*	0.007*
	Yes	2.35(0.24)	1.83(0.93)	3.05(0.82)	4.97(1.65)			
	P between	0.595	0.936	0.001*	0.005*			
	Effect size (d)	_	_	0.70	0.55			
Rang ML (cm)	No	1.32(1.38)	1.01(0.83)	2.67(0.62)	5.67(3.37)	0.050*	0.000*	0.009*
	Yes	1.43(0.71)	1.22(1.02)	2.47(0.83)	4.18(1.59)			
	P between	0.66	0.362	0.206	0.005*			
	Effect size (d)	_	_	_	0.55			
Area (cm^2)	No	1.30(1.38)	0.91(1.16)	3.80(2.35)	13.76(13.81)	0.195	0.000*	0.124
	Yes	1.83(2.06)	1.11(1.33)	3.26(1.82)	9.20(12.25)			
	P between	0.205	0.505	0.346	0.013*			
	Effect size (d)	_	_	_	0.47			
Mean velocity (cm/s)	No	0.56(0.18)	0.62(0.57)	1.64(0.42)	3.37(0.71)	0.023*	0.000*	0.011*
	Yes	0.65(0.21)	0.63(0.27)	1.45(0.54)	2.88(0.78)			
	P between	0.089	0.971	0.101	0.005*			
	Effect size (d)	_	_	_	0.55			

JMR

(1) Two-legged stance with eyes open; (2) Two-legged stance with eyes closed; (3) One-leg stance with eyes open; and (4) one-leg stance with eyes closed
Range AP: COP displacement in anterior-posterior direction; Range ML: COP displacement in medial-lateral direction
*Significant differences between conditions (P<0.05; with vs. without Lumbosacral belt)

individuals were task dependent and these differences are seen in more challenging activities. Likewise, Da Silva et al. [14] compared the balance of individuals with and without CLBP in five tasks. They concluded individuals with CLBP would present poorer postural control determined by center of pressure measurements compared to the healthy controls, mainly during more challenging balance tasks like semi-tandem and one-legged stance conditions.

In a systematic review of the literature, Ruhe et al. [14] determined differences in COP between LBP patients and control group. The patients with LBP showed a greater postural instability than the control group. This difference was noticed in 88% of the studies. Only two studies reported significantly lower COP excursions in patients suffering from LBP [15, 16]. Compared to the control group, participants with LBP exhibited a greater sway area [17, 18], increased COP mean displacement [19-23], and finally higher COP sway velocity [24-28]. Mazaheri et al. [29] reviewed postural control studies which manipulating sensory systems (visual, vestibular, proprioception). The study showed controversial results. Participants with CLBP sometimes had less, sometimes more, and sometimes the same COP sway as participants without LBP in double leg standing.

Effect of wearing a lumbosacral belt

The present study showed a significant reduction in the COP measurements after wearing lumbosacral belt during challenging tasks. Previous studies showed that lumbosacral orthoses for patients with LBP can decrease the pain and help improve balance ability by stabilizing the lumbar region [30, 31]. Redford et al. [32] reported that lumbosacral orthoses would limit movement of the trunk and decrease the load on the lumbar region by transmitting forces applied to intervertebral disks to soft tissues surrounding the abdomen which ultimately result in pain relief. The result of Vogt et al. [33] study revealed that lumbosacral orthoses might increase joint position sense as a result of increasing afferent proprioceptive inputs through mechanoreceptors of the skin, facilitate voluntary extension of the spine and improve postural control.

In another study, Sinaki et al. [34] reported that wearing kypho-orthosis could heighten location awareness of the vertebral joint or proprioception and improve balance and walking quality in over 60 years old subjects with risk of falls. Balancing in a postural task is a dynamic response, consisting of the body (including the spine) and the Central Nervous System (CNS) as the controller. Apparently the CNS tunes stiffness to optimize system's performance [35, 36]. It is possible that the CNS senses the added information from the lumbosacral orthoses and modulates postural balance easier. This scenario is consistent with our results, where a decrease in COP measures occurred by lumbosacral orthoses in challenging tasks.

As a conclusion, this study and literature demonstrate that wearing lumbosacral may improve postural control by manipulating sensory inputs from lumbosacral region. These results will help prepare baseline data providing related information with proper mediation about wearing lumbosacral orthoses rightly. A limitation of this study was the duration that the subjects wore the orthoses which was just a few seconds. Further studies are needed to evaluate utility of orthoses prescribed as a therapy method for patients with LBP in longer periods. There are different types of orthoses including soft and hard ones. It is suggested to investigate application of different lumbosacral orthoses in patients with CLBP and their effects on postural control and low back pain.

Acknowledgements

We appreciate the Postgraduate Studies and Research Program, Tehran University of Medical Sciences, for providing the generous grant to carry out this research. We also acknowledge the generous assistance of the staff and students of the Rehabilitation school, Tehran University of Medical Sciences.

Conflict of Interest

The authors declared no conflicts of interest.

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