

Original Article

Altered postural sway during quiet standing in women with clinical lumbar instability

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Abstract. [Purpose] The current study aimed to investigate the center of pressure, as an indicator of postural sway, to determine any differences between women with clinical lumbar instability and asymptomatic low back pain. [Participants and Methods] Thirty healthy and fifteen clinical lumbar instability participants were measured for their postural sway in the anterior-posterior and medial-lateral directions. The women were tested for postural sway on a force plate in quiet standing and eyes closed. Center of pressure path length and mean velocity in the anterior-posterior and medial-lateral directions and total area of excursion were measured and analyzed for 30 seconds. [Results] Clinical lumbar instability participants showed a significantly increase when compared with healthy participants, in path length and mean velocity in both directions and total area of excursion. [Conclusion] The findings suggest that chronic low back pain patients with clinical lumbar instability have increased postural sway when vision is deprived. The clinical significance of this has not yet been determined but may provide an opportunity for therapy directed at improving balance control in this patient group.

Key words: Center of pressure, Lower back pain, Visual deprivation

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INTRODUCTION

Chronic low back pain (LBP) is the most common musculoskeletal complaint in modern society. Chronic LBP causes reduction in function and work productivity, which possibly stem from impairment of postural control during daily activities¹⁻⁴⁾. Chronic LBP has a number of subcategories⁵⁾, one of which is clinical lumbar instability (CLI). CLI is defined as the inability of the spine to maintain its normal patterns of displacement under physiologic loads⁶⁾ and accounted for 13% of individuals with chronic LBP^{7, 8)}. Frequent episodes of chronic LBP including recurrent symptoms are the most common complaints associated with CLI in relation to work⁹⁾.

Postural sway or balance involves sensory input including visual, vestibular and somatosensory input which is reflected by the motion of center of pressure (COP) during quiet standing. Postural sway presents a linear relationship to pain¹⁰⁾. Pain in the lower back causes an increased pre-synaptic inhibition of muscle input and may be associated with diminishing proprioception in muscle spindles causing prolonged latencies by the decrease in muscle spindle feedback and trunk muscle strength¹⁰⁻¹²⁾. Additionally, proprioceptive alteration is one of the possible causes of postural instability during upright stand-

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ing in patients with chronic LBP. The COP represents the distribution of the total force applied to the supportive area, and has been commonly used as an index of postural stability during quiet stance¹³). Previous studies presented the alteration of postural sway in chronic LBP^{4, 14}).

Understanding postural control during standing in chronic LBP patients with CLI undoubtedly provides useful information to help improve balance in CLI patients. The purpose of this study was to investigate the postural sway during quiet standing with feet shoulder width apart and eyes closed in chronic LBP patients with CLI in comparison with healthy participants.

PARTICIPANTS AND METHODS

This study was approved by the Khon Kaen University Ethics Committee in Human Research (HE 572089) in accordance with the Declaration of Helsinki. All participants gave their written informed consent before participating in the investigation. Thirty healthy and fifteen CLI women, aged between 20–60 years, were recruited in this study.

The healthy participants were enrolled from the community through flyer postings and word of mouth. To be included in the healthy group, the participant had to have no history of low back pain in the previous 6 months. The CLI patients were recruited from women attending any one of three physical therapy clinics in Khon Kaen, Thailand. Inclusion criteria for the CLI group were: patients had LBP for more than 3 months, pain intensity was at least 3 as measured by a numeric rating scale¹⁵), and women were diagnosed with CLI from clinical subjective and objective examinations⁸). Exclusion criteria for both groups included: 1) any back or other joints disorders/deformities, 2) visual problems that were not corrected with glasses or contact lenses, 3) vestibular or brain disorders, or 4) systemic diseases, such as diabetes with neuropathy that could affect balance. There is no significant difference between Healthy and CLI for demographic characteristics of the participants (Table 1) and all data were normally distributed.

Postural control was measured with a force plate (Wii Balance Board; Nintendo, Kyoto, Japan)^{16, 17}). Postural sway was measured in double leg standing with eyes closed. To assume the test position of the quiet standing test, the participants were instructed to (i) fold their arms across their chest; (ii) stand feet shoulder width apart on the force plate; and (iii) remove their hands from their chest. The test was stopped if participants were not able to maintain the requirements of the test position. Measurements of standing tests were performed three times. The best value among the three successive trials in the test condition was recorded for further analysis.

All data were calculated as means and standard deviations (SD). The normality of all data distributions was tested using the Komogorov Smirnov Goodness of Fit test. The differences in characteristics and COP variables between healthy and CLI were analyzed using the unpaired t-test. The significance level was set at p-value <0.05.

RESULTS

Table 2 summarizes the COP variables in healthy individuals and CLI in quiet standing with eyes closed. All COP variables; path length, mean velocity and total area of excursion showed significant difference between healthy and CLI groups. The CLI group exhibited significantly larger path length excursion and significantly faster velocity than the healthy group (in all directions p<0.05). In addition, the CLI group revealed significantly larger area of excursion than the healthy group (p<0.05).

DISCUSSION

The present study revealed altered postural sway during quiet standing in women with clinical lumbar instability. During quiet stance, the CLI patients exhibited significantly greater path length excursion, mean velocity and total area of excursion compared with the healthy group when quiet standing with eyes closed. Lack of visual information influenced the body sway in the anterior-posterior and medial-lateral directions during quiet standing. Chronic LBP patients with CLI exhibit altered motion of the lumbar segment¹⁸) and trunk muscle activity⁶) that might influence the anterior-posterior and medial-lateral motion of postural control in standing, especially when visual information is deprived. Our findings are similar to the results from Mann et al. They demonstrated that younger women with chronic LBP who were deprived of visual information

Table 1. Characteristics of healthy individuals and clinical lumbar instability (CLI) patients

	Healthy (n=30)	CLI (n=15)
Age (years)	39.1 ± 9.8	37.7 ± 13.4
Height (m)	1.6 ± 6.2	1.6 ± 3.4
Weight (kg)	57.8 ± 9.0	54.5 ± 9.7
BMI (kg/m ²)	23.7 ± 3.1	22.4 ± 4.3

Values are presented as the mean ± SD; BMI: Body mass index.

demonstrated significantly increased postural sway in the anterior-posterior and medial-lateral directions when compared with healthy controls. Additionally, increased path length and mean velocity of COP excursion was seen in previous studies that compared postural sway between healthy and chronic LBP patients¹⁴).

Our findings demonstrated that without visual information, path length, mean velocity in the anterior-posterior and medial-lateral directions and total area of excursion increased in the CLI participants. It has been reported that postural sway is greater in chronic LBP patients than in healthy individuals when their visual system is deprived during standing^{14, 19}). These studies indicate an important relation between low back function and the role of the visual system during upright standing in humans. Vision is regarded as the sensory stimulus of highest confidence for the central nervous system in postural stability^{20, 21}).

A proprioception is the complex interaction between efferent and afferent fibers to control body movement and posture. The proprioceptive alteration in chronic LBP patients may thus be compensated for by visual function to provide postural stability¹⁴). In the case of chronic LBP with CLI presented trunk muscle dysfunction such as lumbar multifidus⁶) that causes impaired proprioception and induces poor postural control²²). When visual information was deprived in previous studies, postural instability was significantly increased in terms of the path length, mean velocity, and total area of excursion in healthy and chronic LBP groups because vision is so important for postural stability^{20, 21}). O'Sullivan et al.²³) stated that LBP patients with instability have impaired lumbosacral joint repositioning that reflects impaired proprioception. In addition, the chronic LBP patients probably rely more upon ankle proprioception than that of trunk¹¹), leading to increased postural sway in the anterior-posterior direction. Therefore, the chronic LBP patient caused by lumbar instability increased postural sway in the anterior-posterior direction.

In the anterior-posterior direction, the CLI group also exhibited greater postural sway compared with healthy participants with reduced visual information. The excessive postural sway in the anterior-posterior direction has been previously reported in CLI patients^{14, 19}). The postural sway in different directions is related to different control mechanisms. Winter²⁰) postulated that postural sway in the anterior-posterior direction is related to an ankle strategy while in the medial-lateral direction it is associated with a hip strategy to control balance during standing. Based on this difference in strategies, COP in the anterior-posterior and medial-lateral directions may each be differently influenced by the condition of lumbar stability in CLI patients.

The significant difference in sway between healthy participants and CLI patients in the medial-lateral direction during standing with vision deprived is possibly related to lumbar joint positioning error²³) and lumbopelvic muscle activities. It has been suggested that postural sway in the medial-lateral direction is related to the muscular activity of hip abductor /adductor muscles²⁴). Previous studies have reported altered muscle activities and movement control of the trunk in CLI patients²⁵). Patients with LBP present commonly hip dysfunction²⁶). Impairment of the hip abductor muscle likely affects the spinal stabilizing subsystem, such as the control of medial-lateral postural sway. Most CLI patients present with substantial damage of the stabilizing structures around the lumbar region, causing an excessive segmental motion of the lumbar spine²⁷). If the CLI patients are able to learn how to stabilize their trunk effectively, they should achieve better postural control.

Postural instability in chronic LBP patients with CLI may lead to this group being at risk of falls. Both healthy and CLI may face postural instability in the anterior-posterior and medial-lateral directions in visually deprived situations. The CLI patients may need to take care in environments with reduced visibility, for example when getting up at night to go to the bathroom or when using stairs in poorly lit situations.

Confounding factors that can cause COP variables, such as muscle activity and trunk motion were not considered for postural sway in CLI patients. To determine the possible mechanism of balance ability in CLI patients, further studies are needed to investigate postural sway in relation to the proprioceptive sense of the lumbar spine, trunk muscle activation and lower limb muscles during quiet standing.

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Table 2. The parameters of postural sway in healthy individuals and patients with clinical lumbar instability (CLI) in quiet standing with eyes closed

	Healthy (n=30)	CLI (n=15)
Path length in AP (cm)	31.07 ± 3.83	38.11 ± 5.33*
Path length in ML (cm)	41.38 ± 5.28	47.21 ± 9.23*
Mean velocity in AP (cm/sec)	1.04 ± 0.13	1.29 ± 0.19*
Mean velocity in ML (cm/sec)	1.39 ± 0.18	1.60 ± 0.32*
Total area of excursion (cm ²)	4.47 ± 2.31	9.76 ± 9.85*

Values are presented as the mean ± SD. AP: anterior-posterior direction; ML: medial-lateral direction. *p<0.05.

Conflict of interest

None.

REFERENCES

- 1) della Volpe R, Popa T, Ginanneschi F, et al.: Changes in coordination of postural control during dynamic stance in chronic low back pain patients. *Gait Posture*, 2006, 24: 349–355. [[Medline](#)] [[CrossRef](#)]
- 2) Henry SM, Hitt JR, Jones SL, et al.: Decreased limits of stability in response to postural perturbations in subjects with low back pain. *Clin Biomech (Bristol, Avon)*, 2006, 21: 881–892. [[Medline](#)] [[CrossRef](#)]
- 3) Brumagne S, Janssens L, Janssens E, et al.: Altered postural control in anticipation of postural instability in persons with recurrent low back pain. *Gait Posture*, 2008, 28: 657–662. [[Medline](#)] [[CrossRef](#)]
- 4) Braga AB, Rodrigues AC, de Lima GV, et al.: Comparison of static postural balance between healthy subjects and those with low back pain. *Acta Ortop Bras*, 2012, 20: 210–212. [[Medline](#)] [[CrossRef](#)]
- 5) Last AR, Hulbert K: Chronic low back pain: evaluation and management. *Am Fam Physician*, 2009, 79: 1067–1074. [[Medline](#)]
- 6) Panjabi MM: Clinical spinal instability and low back pain. *J Electromyogr Kinesiol*, 2003, 13: 371–379. [[Medline](#)] [[CrossRef](#)]
- 7) Abbott JH, McCane B, Herbison P, et al.: Lumbar segmental instability: a criterion-related validity study of manual therapy assessment. *BMC Musculoskelet Disord*, 2005, 6: 56. [[Medline](#)] [[CrossRef](#)]
- 8) Puntumetakul R, Yodchaisarn W, Emasithi A, et al.: Prevalence and individual risk factors associated with clinical lumbar instability in rice farmers with low back pain. *Patient Prefer Adherence*, 2014, 9: 1–7. [[Medline](#)] [[CrossRef](#)]
- 9) Cook C, Brismée JM, Sizer PS Jr: Subjective and objective descriptors of clinical lumbar spine instability: a Delphi study. *Man Ther*, 2006, 11: 11–21. [[Medline](#)] [[CrossRef](#)]
- 10) Ruhe A, Fejer R, Walker B: Is there a relationship between pain intensity and postural sway in patients with non-specific low back pain? *BMC Musculoskelet Disord*, 2011, 12: 162. [[Medline](#)] [[CrossRef](#)]
- 11) Brumagne S, Cordo P, Verschueren S: Proprioceptive weighting changes in persons with low back pain and elderly persons during upright standing. *Neurosci Lett*, 2004, 366: 63–66. [[Medline](#)] [[CrossRef](#)]
- 12) Davarian S, Maroufi N, Ebrahimi I, et al.: Trunk muscles strength and endurance in chronic low back pain patients with and without clinical instability. *J Back Musculoskeletal Rehabil*, 2012, 25: 123–129. [[Medline](#)] [[CrossRef](#)]
- 13) Palmieri RM, Ingersoll CD, Stone MB, et al.: Center-of-pressure parameters used in the assessment of postural control. *J Sport Rehabil*, 2002, 11: 51–66. [[CrossRef](#)]
- 14) Mann L, Kleinpaal JF, Pereira Moro AR, et al.: Effect of low back pain on postural stability in younger women: influence of visual deprivation. *J Bodyw Mov Ther*, 2010, 14: 361–366. [[Medline](#)] [[CrossRef](#)]
- 15) Farrar JT, Young JP Jr, LaMoreaux L, et al.: Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain*, 2001, 94: 149–158. [[Medline](#)] [[CrossRef](#)]
- 16) Clark RA, Bryant AL, Pua Y, et al.: Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. *Gait Posture*, 2010, 31: 307–310. [[Medline](#)] [[CrossRef](#)]
- 17) Bartlett HL, Ting LH, Bingham JT: Accuracy of force and center of pressure measures of the Wii Balance Board. *Gait Posture*, 2014, 39: 224–228. [[Medline](#)] [[CrossRef](#)]
- 18) O'Sullivan PB: Lumbar segmental 'instability': clinical presentation and specific stabilizing exercise management. *Man Ther*, 2000, 5: 2–12. [[Medline](#)] [[CrossRef](#)]
- 19) Popa T, Bonifazi M, Della Volpe R, et al.: Adaptive changes in postural strategy selection in chronic low back pain. *Exp Brain Res*, 2007, 177: 411–418. [[Medline](#)] [[CrossRef](#)]
- 20) Winter D: Human balance and posture control during standing and walking. *Gait Posture*, 1995, 3: 193–214. [[CrossRef](#)]
- 21) Brumagne S, Cordo P, Lysens R, et al.: The role of paraspinal muscle spindles in lumbosacral position sense in individuals with and without low back pain. *Spine*, 2000, 25: 989–994. [[Medline](#)] [[CrossRef](#)]
- 22) Brumagne S, Lysens R, Swinnen S, et al.: Effect of paraspinal muscle vibration on position sense of the lumbosacral spine. *Spine*, 1999, 24: 1328–1331. [[Medline](#)] [[CrossRef](#)]
- 23) O'Sullivan PB, Burnett A, Floyd AN, et al.: Lumbar repositioning deficit in a specific low back pain population. *Spine*, 2003, 28: 1074–1079. [[Medline](#)] [[CrossRef](#)]
- 24) Winter DA, Prince F, Frank JS, et al.: Unified theory regarding A/P and M/L balance in quiet stance. *J Neurophysiol*, 1996, 75: 2334–2343. [[Medline](#)] [[CrossRef](#)]
- 25) Puntumetakul R, Areeudomwong P, Emasithi A, et al.: Effect of 10-week core stabilization exercise training and detraining on pain-related outcomes in patients with clinical lumbar instability. *Patient Prefer Adherence*, 2013, 7: 1189–1199. [[Medline](#)] [[CrossRef](#)]
- 26) Prather H, Cheng A, Steger-May K, et al.: Hip and lumbar spine physical examination findings in people presenting with low back pain, with or without lower extremity pain. *J Orthop Sports Phys Ther*, 2017, 47: 163–172. [[Medline](#)] [[CrossRef](#)]
- 27) Leone A, Guglielmi G, Cassar-Pullicino VN, et al.: Lumbar intervertebral instability: a review. *Radiology*, 2007, 245: 62–77. [[Medline](#)] [[CrossRef](#)]