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Original Article

Comparison of Lumbopelvic Movement Patterns in People with and Without Low Back Pain During Stair Descending Task

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ABSTRACT

Background: Decreased lumbar spine control may be associated with early and/or excessive lumbopelvic motion with trunk and lower extremity movements during functional and daily activities. This study investigated differences in lumbopelvic movement patterns in people with and without low back pain (LBP) during a stair descending (SD) task.
Methods: A total of 36 subjects, 18 females with non-specific chronic low back pain (NSCLBP) and 18 healthy females, participated in this study. A three-dimensional motion capture system was used to record kinematics during the SD task.
Results: The results showed that in the LBP group, the start-time of the lumbar muscles occurred early in the movement (P=0.015). Additionally, subjects with LBP showed excessive lumbar spine and pelvic movement during the SD task (P<0.05).
Conclusion: LBP patients make early and excessive lumbopelvic movements during a SD task, and this can be an important factor contributing to the development or persistence of their LBP problem. This finding should be considered by clinicians when evaluating functional tasks as part of movement-based examinations and rehabilitation programs for people with LBP.

Introduction

Low back pain (LBP) and lumbopelvic dysfunction are the most common causes of musculoskeletal impairment and one of the primary reasons for doctors' visits in the United States [1]. Motor control impairments and lumbopelvic instability have been implicated by many as causes of LBP [2, 3]. Decreased lumbar spine control may be associated with early and/or excessive lumbopelvic motion with trunk and lower extremity movements during daily routines and functional activities [1, 4]. While LBP patients typically do not exhibit obvious abnormalities in static conditions, spine abnormalities, potentially revealed by range of motion (ROM) in dynamic conditions, can lead to incoordination, compensation movement, and early coupling motion [5]. Therefore, to improve and facilitate LBP treatment strategies for restoring the normal movement of the spine, quantitative assessment of low back functional dynamic motion is critical [6].

Stair climbing (SC) is a common functional activity of daily living that requires the recruitment of different muscles and more effort than level walking; thus, the ability to climb stairs with relative ease is important to one's quality of life [5-7]. Stair descending (SD) and stair ascending are two parts of the SC task [5]. Impairment

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during SC can contribute to functional limitation, disability, and pain in people with LBP [6]. Thus, a better understanding of the biomechanics of lumbopelvic motion during this activity is important for the planning and evaluation of treatment programs for patients with LBP and lower limb problems.

Several authors have suggested that people with LBP demonstrate a greater total amount of lumbopelvic motion during hip movement in an open kinematic chain than people without LBP [1-4, 8-12]. Much clinical and laboratory evidence shows that excessive and/or early lumbopelvic motion is problematic, because as particular trunk or limb movements are performed repeatedly, such as with functional activities, stress may accumulate in specific lumbar or pelvic region tissues and, over time, may lead to tissue damage and pain [1, 2, 12, 13]. The relationship between increased or early lumbopelvic motion during trunk or limb movements and LBP has been evaluated in many studies [1-4, 9, 10, 12]; however, prior works have been limited by the reliance of the majority of them on nonfunctional tasks. The examination of lumbopelvic movement patterns during functional activities, such as the SD task, is essential in evaluating LBP people.

The current study aimed to compare the effects of LBP on lumbopelvic kinematic patterns during the SD task. In this study, it was hypothesized that subjects with LBP have less lumbopelvic control during the SD functional task.

Methods

For this study, 18 female patients (mean age=38.67±10.29 years) and 18 healthy women (mean age=33.89±9.62 years) were recruited. Subjects in the control group were matched to subjects with LBP in the patient group for age, gender, height, weight, and activity level. Inclusion criteria included nonspecific chronic LBP (NSCLBP), symptoms lasting longer than six months, and the ability to perform SC without aid [14]. Those subjects with a history of a serious spinal medical condition, spinal surgery, fracture/dislocation of the vertebral column, inflammatory joint disease, neurological signs, and people who had cancer at the time of the study, were pregnant, unable to perform fundamental movements of the spine and extremities, undergoing physical therapy treatment, or unable to perform SC [14-16] were excluded from the study. Owing to the kinematic differences between males and females and to eliminate the confounding effects of gender, only female subjects were enrolled in the study [3, 8].

The present study was conducted at the Musculoskeletal Rehabilitation Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Written informed consent was obtained from all participants. This study was reviewed, accepted, and approved by the Ethical Committee of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

A self-report questionnaire was used to obtain each participant's demographic characteristics and history of LBP. Subjects with LBP were asked to rate the severity of their pain on the day of testing using a numeric pain rating scale (NRS) (scale ranged from 0–10, with 0=no pain and 10=worst imaginable pain) [14, 16]. Disability levels were assessed and quantified using a reliable and valid Persian version of the Oswestry Disability Index (ODI) questionnaire [14]. In both groups, levels of physical activity were examined using the Persian version of the Baecke habitual physical activity questionnaire (BHPAQ) [17].

The ODI questionnaire, the golden standard for low back functional outcomes, comprises 10 questions (each question answered on a scale from 0 to 5) and measures LBP disability in different activities of daily living. LBP patients were asked to mark the best answer according to their state in each section. Then, the scores were measured. Scores on the ODI ranged from 0% to 100%, with 0% indicating no disability and 100% indicating maximum disability [18].

The BHPAQ is a tool for evaluating an individual's habitual physical activities over the previous 12 months. This questionnaire consists of 16 questions within three main domains of physical activities (occupational, sport, and recreational). Individual physical activities are measured by calculating the sum of the scores obtained from all three categories [17].

Laboratory Measurements

A 7-camera, three-dimensional optical motion capture system (Qualisys Medical AB, Gothenburg, Sweden) was used to measure kinematics data during the SD task. The sampling rate of each camera was 120 Hz [19]. Initially, a physical therapist palpated and placed 30 retro-reflective markers on the bilateral posterior superior iliac spine (PSIS), bilateral anterior superior iliac spine (ASIS), bilateral acromion, spinous process of T3, T12, L3, and L5, and 4 cm to the right and left of the spinous process at L1 and L4. Three markers were placed bilaterally on the thigh, knee, and foot [14, 15, 20].

Prior to conducting each SD trial, a static calibration trial was captured to define spine, pelvis, and lower extremity segments and to measure the standing alignment of each segment. The pelvis segment was defined by markers on the bilateral PSIS and ASIS [14, 20]. The lumbar spine model was tested for reliability and validity and found to be acceptable [14, 15, 20]. The start and end points of lumbar and pelvic motion were identified based on previously described methods [1, 10, 12]. SD movement initiation was defined as the instant of heel-off of the leading limb. Lumbar and pelvis movement start times were calculated by considering SD movement initiation as the reference time. Segment movement initiation was scored when its velocity first exceeded 10 percent of the maximum velocity. Segment excursion was defined as the difference between the minimum and maximum axial angle for each segment during the task [14-16].

The experimental staircase consisted of three steps (step height=18 cm, width=100 cm, and depth=30 cm) [19]. Each subject completed 6 trials of the SD functional task at their own pace. The test movement was repeated three times leading with the right foot and then three times leading with the left foot. The subjects performed three trials of the SD movement task for both leading foots, and the mean of the three trials was used for data analysis. Subjects were not provided specific instructions on how to accomplish the task or to control the descent. All subjects were instructed to place only one foot on each step and to perform at the speed at which they felt most comfortable (natural speed) [14, 16].

Marker data was post-processed without knowledge of group membership in the Qualisys Track Manager and exported to Visual 3D software (C-motion Inc., IUMS Biomechanics Lab, Iran). The coordinates were digitally filtered using a fourth-order, zero-lag Butterworth 6 Hz low-pass filter. The results were saved in ASCI format and transferred to Excel and SPSS for statistical analysis [16]. Preliminary analysis revealed no effect of SD side (right vs. left) for lumbar spine and pelvic kinematics between groups; therefore, the data was averaged for the right and left SD trials.

Data was analyzed using SPSS version 22, and the criterion threshold for significance was set at $\alpha=0.05$. Mean and standard deviations by group were calculated for all variables. Normality of the data was initially assessed using the Kolmogorov-Smirnov (K-S) test. Independent t-tests were conducted to compare the groups in terms of different characteristics.

Results

Table 1 represents the participants' demographic information. The results showed no significant difference in mean age, height, weight, or activity level between two groups (all $P>0.05$).

As a result of kinematics differences, when subjects in the LBP group performed the SD test, lumbar-start-time took place early in the movement time ($P<0.05$). There were no statistical differences between the groups in pelvic start time during the SD task ($P>0.05$) (Table 2).

Differences in pelvic and lumbar axial rotation between the two groups were statistically significant ($P<0.05$) (Table 2).

Discussion

The purpose of the current study was to examine and compare lumbopelvic rotation and lumbar movement in the axial plane during an SD task in people with LBP and healthy subjects.

The SD task is a common activity in daily life and may be compromised by the presence of LBP. Clinicians should be aware of the relevant variables in order to offer the most appropriate advice on such activities as part of the primary care management of LBP [21]. The current study has demonstrated that individuals with LBP display greater ROM in the axial plane in the pelvic and lumbar spine than the control group during the SD functional task. These findings are consistent with those of some prior literature that evaluated lumbopelvic motion during nonfunctional tasks [1, 2, 4, 9-11, 22, 23].

Another variable measured in this study was the timing of lumbar and pelvic motion. Subjects in the LBP group displayed earlier lumbar movement during the SD task than control subjects. This early and faulty movement can cause injury to lumbar spine tissue and, subsequently, LBP symptoms [1]. Based on a previous study, repeated early and excessive lumbopelvic motion during trunk and limb movement may contribute to LBP by causing cumulative tissue stress, tissue damage, and pain [1, 10, 23, 24]. Clinical evidence has also shown that restricting lumbopelvic motion during lower limb motion could decrease LBP symptoms [1, 10]. Therefore, it is believed that limiting lumbopelvic motion thought to be associated with LBP symptoms is likely an important component of

Table 1: Subject characteristics and self-reported measures in LBP and control groups; mean±SD

Variable	Control (n=18)	LBP (n=18)	Degrees of freedom (df), P value
Age (yrs)	33.89 (9.62)	38.67 (10.29)	df=34, P=0.159
Height (cm)	161.67 (4.85)	161.89 (5.64)	df=34, P=0.900
Weight (kg)	66.61 (8.05)	69.89 (7.35)	df=34, P=0.211
NRS on test day	N/A	1.28 (1.79)	-
Duration of LBP (yrs)	N/A	8.22 (3.30)	-
ODI score	N/A	25.22 (7.42)	-
BHPAQ_Work	2.81 (0.40)	2.62 (0.32)	df=34, P=0.136
BHPAQ_Sport	2.31 (0.46)	2.05 (0.45)	df=34, P=0.094
BHPAQ_Leisure	2.20 (0.44)	2.04 (0.31)	df=34, P=0.204

NRS: Numeric Rating Pain Scale; ODI: Oswestry Disability Index; BHPAQ: Baecke Habitual Physical Activity Questionnaire

Table 2: Mean differences in kinematic variables during SD task.

Variable	Control (n=18)	LBP (n=18)	Degrees of freedom(df), P value
Lumbar_start_time (seconds)	-0.41 (0.19)	-0.57 (0.16)	df=34, P=0.015*
Pelvis_start_time (seconds)	-0.26 (0.17)	-0.28 (0.11)	df=34, P=0.823
Lumbar rotation angle (degree)	6.12 (1.94)	8.34 (1.56)	df=34, P=0.043*
Pelvic rotation angle (degree)	13.05 (2.92)	17.94 (5.15)	df=34, P=0.023*

*Significant differences are reported in bold with the significance value set at P<0.05.

the treatment for LBP [22]. The assessment of the pelvis relative to the lumbar spine will need to be considered by therapists as this is likely to influence the positioning of the trunk. Intervention should also be focused around not only postural, but functional re-education of lumbopelvic movement [25].

The results of the present study are consistent with those of Pearcy et al., who reported that LBP patients showed significantly more lateral bending and rotation in lumbar-flexion movement than asymptomatic subjects did [26]. Pearcy et al. reported that the increase in lateral bending and rotation of the lumbar spine during lumbar flexion was due to the involvement of unilateral ligaments or muscles and, thus, was asymmetric when patients moved [22, 26-28]. Many clinical studies have suggested that various factors, such as strength, tension, or length of muscles or ligaments, may be affected in static or dynamic postures of the pelvis and lumbar spine [22, 24, 27, 28].

Numerous recent studies have focused on lumbopelvic and hip movement impairments and found that increased lumbopelvic motion in a specific direction during the movements of the trunk and/or lower limbs exerts an excessive load on the lumbopelvic region and ultimately leads to LBP. Therefore, understanding the pattern of lumbopelvic movements can help clinicians better identify the causes of LBP [12]. If the lumbopelvic motion during active and passive limb movement takes place in a range greater than the neutral zone, it can be expected that lumbopelvic motion will occur in a greater range during functional physical activities [1, 4, 10].

Sadeghisani et al. detected excessive lumbopelvic motion during the active straight leg raise test and reported that when patients with LBP perform this test, the lumbopelvic region exhibits a greater magnitude of posterior pelvic tilt in comparison with healthy people. This result is consistent with that of the current study [10].

The current study had a number of potential limitations. First, all participants were female subjects, because it was assumed that specific differences in movement patterns could occur between genders. Therefore, the results of the study also may not be generalized to all people. Another limitation of the present study is that electromyography was not used to assess muscle activity during the tests [4]. Therefore, future studies should examine muscle activation patterns of the lumbopelvic region during functional tasks. Finally, the limitation in the accuracy of using surface markers to measure kinematics should be noted.

Conclusion

The findings from this study point to relevant kinematic differences between people with LBP and healthy subjects. They suggest that people with LBP displayed earlier and excessive lumbopelvic rotation during the SD task, which can be one of the causes of symptoms in this group of patients. Exploration of abnormal movements in people with LBP may help focus the evaluation and treatment of movement impairments. Future research should examine the various characteristics of motor pattern and muscle recruitment in LBP subjects, which might explain the mechanism of LBP altering the lumbar spine and pelvis during functional activities of daily living.

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Conflict of interest: None declared.

References

1. Sadeghisani M, Namnik N, Karimi M, et al. Evaluation of differences between two groups of low back pain patients with and without rotational demand activities based on hip and lumbopelvic movement patterns. Ortopedia, traumatologia, rehabilitacja. 2015;17(1):51-57.
2. Hoffman SL, Johnson MB, Zou D, Van Dillen LR. Differences in end-range lumbar flexion during slumped sitting and forward bending between low back pain subgroups and genders. Manual therapy. 2012;17(2):157-63.
3. Hoffman SL, Johnson MB, Zou D, Van Dillen LR. Gender differences in modifying lumbopelvic motion during hip medial rotation in people with low back pain. Rehabilitation Research and Practice 2012;2012.
4. Sadeghisani M, Manshadi F, Kalantari K, et al. Correlation between Hip Rotation Range-of-Motion Impairment and Low Back Pain. A Literature Review. Ortopedia, traumatologia, rehabilitacja. 2015;17(5):455-62.
5. Lee JK, Desmoulin GT, Khan AH, Park EJ. Comparison of 3D spinal motions during stair-climbing between individuals with and without low back pain. Gait & posture. 2011;34(2):222-26.
6. Lee JK, Park EJ. 3D spinal motion analysis during staircase walking using an ambulatory inertial and magnetic sensing system. Medical & biological engineering & computing 2011;49(7):755-64.
7. Riener R, Rabuffetti M, Frigo C. Stair ascent and descent at different inclinations. Gait & posture. 2002;15(1):32-44.
8. Gombatto SP, Collins DR, Sahrmann SA, Engsberg JR, Van Dillen LR. Gender differences in pattern of hip and lumbopelvic rotation in people with low back pain. Clinical Biomechanics .2006;21(3):263-71.
9. Hoffman SL, Harris-Hayes M, Van Dillen LR. Differences in activity limitation between 2 low back pain subgroups based on the movement system impairment model. PM&R 2010;2(12):1113-18.
10. Sadeghisani M, Rezvani M, Rahmani P, Tabesh H, Nikouei F. Examining the lumbopelvic-hip movement pattern in a subgroup of patients with low back pain during the active straight leg raise test. Journal of Research in Medical and Dental Science. 2017;5(3):4-10.
11. Sadeghisani M, Sobhani V, Kouchaki E, Bayati A, Asna Ashari A, Mousavi M. Comparison of Lumbopelvic and Hip Movement Patterns During Passive Hip External Rotation in Two Groups of Low Back Pain Patients with and without Rotational Demand Activities. Ortopedia, traumatologia, rehabilitacja. 2015;17(6):611-8.
12. Sadeghisani M, Manshadi FD, Kalantari KK, et al. A Comparison Of The Lumbopelvic-Hip Complex Movement Patterns In People With And Without Non-Specific Low Back Pain During An Active Hip Test. Journal Of Mechanics In Medicine And Biology. 2017;17(01):1750004.
13. Sahrmann S. *Diagnosis and treatment of movement impairment syndromes*: Elsevier Health Sciences, 2002.
14. Hernandez A, Gross K, Gombatto S. Differences in lumbar spine and lower extremity kinematics during a step down functional task in people with and people without low back pain. Clinical Biomechanics. 2017;47:46-52.
15. Gombatto S, Brock T, Delork A, et al. Lumbar Spine Kinematics During Walking In People With And Without Low Back Pain. journal of Orthopaedic & Sports Physical. 2015;45(1):A120.

16. Mitchell K, Porter M, Anderson L, et al. Differences in lumbar spine and lower extremity kinematics in people with and without low back pain during a step-up task: a cross-sectional study. BMC musculoskeletal disorders. 2017;18(1):369.
17. Sadeghisani M, Manshadi FD, Azimi H, Montazeri A. Validity and reliability of the Persian version of Baecke habitual physical activity questionnaire in healthy subjects. Asian journal of sports medicine. 2016;7(3).
18. Mousavi SJ, Parnianpour M, Mehdian H, Montazeri A, Mobini B. The Oswestry disability index, the Roland-Morris disability questionnaire, and the Quebec back pain disability scale: translation and validation studies of the Iranian versions. Spine. 2006;31(14):E454-E59.
19. Protopapadaki A, Drechsler WI, Cramp MC, Coutts FJ, Scott OM. Hip, knee, ankle kinematics and kinetics during stair ascent and descent in healthy young individuals. Clinical biomechanics. 2007;22(2):203-10.
20. Marich AV, Hwang C-T, Salsich GB, Lang CE, Van Dillen LR. Consistency of a lumbar movement pattern across functional activities in people with low back pain. Clinical Biomechanics. 2017;44:45-51.
21. Shum GL, Crosbie J, Lee RY. Symptomatic and asymptomatic movement coordination of the lumbar spine and hip during an everyday activity. Spine. 2005;30(23):E697-E702.
22. Scholtes SA, Gombatto SP, Van Dillen LR. Differences in lumbopelvic motion between people with and people without low back pain during two lower limb movement tests. Clinical Biomechanics. 2009;24(1):7-12.
23. Van Dillen LR, Gombatto SP, Collins DR, Engsberg JR, Sahrmann SA. Symmetry of timing of hip and lumbopelvic rotation motion in 2 different subgroups of people with low back pain. Archives of physical medicine and rehabilitation. 2007;88(3):351-60.
24. Shum GL, Crosbie J, Lee RY. Effect of low back pain on the kinematics and joint coordination of the lumbar spine and hip during sit-to-stand and stand-to-sit. Spine. 2005;30(17):1998-2004.
25. Hemming R. Regional spinal kinematics and muscle activity in non-specific chronic low back pain during functional tasks: evaluation of a sub-classification approach. Cardiff University, 2015.
26. Pearcy M, Portek I, Shepherd J. The effect of low-back pain on lumbar spinal movements measured by three-dimensional X-ray analysis. Spine. 1985;10(2):150-53.
27. Kim M-h, Yoo W-g, Choi B-r. Differences between two subgroups of low back pain patients in lumbopelvic rotation and symmetry in the erector spinae and hamstring muscles during trunk flexion when standing. Journal of Electromyography and Kinesiology. 2013;23(2):387-93.
28. Kim S-h, Kwon O-y, Park K-n, Kim M-H. Comparison of erector spinae and hamstring muscle activities and lumbar motion during standing knee flexion in subjects with and without lumbar extension rotation syndrome. Journal of Electromyography and Kinesiology. 2013;23(6):1311-16.