

Asymmetrical Movement Patterns of the Lumbopelvic Region During Active Hip Abduction Test in Individuals with Recurrent Low Back Pain

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Abstract

The active hip abduction test is used to assess movement control in the lumbopelvic region. Movement control of the lumbopelvic region during the active hip abduction test in patients with recurrent low back pain (LBP) has not been investigated. The aim of this study was to examine the asymmetry of pelvic wobble and asymmetry of the timing of lateral pelvic tilt during an active hip abduction test in individuals with recurrent LBP. Twenty healthy individuals and twenty individuals with recurrent LBP were recruited for this study. The active hip abduction test was performed at 15 °/s and at maximum speed. Pelvic acceleration was recorded to evaluate the pelvic wobble in the frontal and transverse planes. Asymmetry of the pelvic wobble and of the timing of lateral pelvic tilt during the active hip abduction test was calculated. Asymmetry of the pelvic wobble in the transverse plane at maximum speed and asymmetry of the timing of lateral pelvic tilt at 15 °/s and at maximum speed were greater in the recurrent LBP group than in the healthy group. Our results showed that individuals with recurrent LBP have less movement control of the lumbopelvic region.

1. Introduction

Low back pain (LBP) is the most common symptom of musculoskeletal disorders¹. Within the first month of the onset of LBP, most people show substantial recovery from disability and pain². However, 69% of these patients experience episodes of recurrent LBP within 1 year after recovery from acute LBP³. Recurrent LBP contributes to higher indemnity and medical costs through both additional care seeking and work disability than an initial LBP episode⁴.

Lumbopelvic stability is maintained by the active, passive, and neural control subsystems⁵. Two studies showed that individuals with chronic LBP demonstrated earlier and greater lumbar movement than that by healthy individuals during limb movement^{6,7}. Since these studies assessed patients with chronic LBP, changes in movement patterns might be due to the provocation of or protection from pain or the changes in

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movement pattern might reflect changes in movement control or the mechanics of the lumbopelvic region. The magnitude of residual and persistent changes in movement patterns after recovery from an episode of LBP is unknown.

The active hip abduction test is used to assess movement control in the lumbar and pelvic region during single leg hip abduction in the side-lying position, with both legs extended. This test assesses a patient's ability to maintain the trunk and pelvis in the neutral position in the transverse and frontal planes⁸⁾. The active hip abduction test predicts the development of transient LBP during prolonged standing in previously asymptomatic people⁹⁾. Individuals who developed transient LBP during prolonged standing demonstrated a decreased ability to maintain the neutral zone of the lumbopelvis and less symmetry in the timing of lateral pelvic tilt when compared with individuals who did not develop LBP^{9,10)}. The development of transient LBP during prolonged standing is effective in identifying asymptomatic individuals who are at risk of clinical LBP in future¹¹⁾.

Individuals with LBP show alterations in trunk muscle recruitment patterns that are related to delayed onset of the ipsilateral internal abdominal oblique muscle during the active hip abduction test¹²⁾. In addition, individuals in remission from recurrent LBP demonstrate delayed onset of the bilateral transversus abdominis/internal abdominal oblique and contralateral erector spinae compared to that of healthy individuals during the active hip abduction test¹³⁾. Tateuchi et al. reported that delayed deep trunk muscle activity was associated with excessive pelvic movement during dynamic leg movement in healthy individuals¹⁴⁾. Thus, in patients with recurrent LBP, there may be decreased movement control of the lumbopelvic region during the active hip abduction test. However, the movement control of the lumbopelvic region during the active hip abduction test in patients with recurrent LBP has not been investigated.

The aim of this study was to compare the movement control of the lumbopelvic region in individuals with recurrent LBP and healthy individuals during the active hip abduction test and to examine the association of the asymmetry of pelvic wobble and of the timing of lateral pelvic tilt with recurrent LBP. We hypothesized that individuals in remission from recurrent LBP would demonstrate an asymmetric movement pattern compared to healthy individuals.

2. Methods

2.1 Participants

We used an observational cross-sectional design for this study. Twenty healthy volunteers and twenty volunteers in remission from recurrent LBP were recruited through poster advertisements in the University. The following were the inclusion criteria: individuals with recurrent LBP that was localized to the area between the twelfth thoracic vertebrae and gluteal folds, limits to their sporting activities, and affects to their leisure and work^{15,16)} and those who have had at least two episodes of pain per year for at least 1 year¹⁵⁾. All participants were between the ages of 20 and 40 years and they were excluded if they had a passive hip abduction range of motion of less than 30°, a history of fracture or surgery in the spine or hip joints, or neurological disorders. All participants provided written informed consent.

2.2 Self-report measure

Participants with recurrent LBP completed the Oswestry Disability Index (ODI) questionnaire. The ODI was used to assess the degree of a participant's LBP-related disability. Scores of the ODI range from 0% (no disability) to 100% (maximum disability)^{17,18)}.

2.3 Procedure for the active hip abduction test

The participants were positioned in the side-lying on a yoga mat such that their knees were extended, hips were in a neutral alignment with regard to flexion and extension, and the lumbar spine was in a neutral alignment with regard to flexion, extension, and rotation. The top arm rested on the trunk with the hand on the chest to ensure that they did not use the arm to maintain balance. The investigator ensured

that the participants' shoulders, trunk, and bilateral lower extremities were in a straight line⁹. A target bar that was adjusted for each participant was used to control the angle of hip abduction (30°) during the active hip abduction test¹³. The active hip abduction test was performed on each leg three times at a speed of 15 °/s and at maximum speed (Figure 1). At the speed of 15 °/s, the participants were instructed to raise the test leg until it touched the target bar and returned to the starting position while minimizing any movement in the lumbopelvic region. A metronome was used as a guide for the speed of movement of the lower limbs in the active hip abduction test at 15 °/s. In the active hip abduction test at maximum speed, participants were instructed to raise the top leg as fast as possible until it touched the target bar.



Figure 1 Demonstration of the active hip abduction test

Participants were asked to raise their leg until it touched the target bar.

2.4 Measurement of pelvic wobble and asymmetry of lumbopelvic movement during active hip abduction

Tri-axis wireless inertial measurement units (MVP-RF10-AC; Microstone, Nagano, Japan) were attached 5 cm proximal to the dorsal ankle joint and the third sacral vertebra. Angular velocity and acceleration of the leg and pelvic movement were recorded at a 1,000-Hz sampling frequency. The acceleration of the leg and pelvis was recorded to determine the onset of leg and pelvic movements. The onset of leg and pelvic movement was defined as the point at which the angular velocity of the pelvic lateral tilt and hip abduction exceeds 5% of the maximal angular velocity¹⁴. The variable was the difference in time between the onset of the hip abduction movement and the onset of the pelvic lateral tilt movement (onsetdiff). The onsetdiff variable was calculated to index the relative timing of the onset of the lumbopelvic movement during the active hip abduction using the following equation.

The onsetdiff variable = the onset of the pelvic lateral tilt movement - the onset of the hip abduction movement.

Left to right asymmetry of the onsetdiff variable was calculated as the absolute value difference between the onsetdiff values on the left and right sides¹⁰. A value of zero indicated symmetry between the right and left sides. Larger values indicated significant asymmetry. The pelvic wobble has been used to assess the movement control of the lumbopelvic region during the active hip abduction test¹⁰. Therefore, the acceleration in the cranial-caudal and anterior-posterior directions of the pelvis was recorded to evaluate pelvic wobble in the frontal plane and transverse planes, respectively. The differences between the values of the maximum and minimum acceleration of the pelvis in each direction was calculated as an index of pelvic wobble in the frontal and transverse planes. Left to right asymmetry of the pelvic wobble was calculated as the difference between the pelvic wobble values on the left and right sides. A value of zero indicated meant symmetry between the right and left sides. Larger values indicated significant asymmetry.

2.5 Statistical analysis

All statistical analyses were performed using SPSS version 23 (IBM Corporation). Normality was assessed for all continuous variables using the Shapiro-Wilk test. Parametric or nonparametric analyses were performed as appropriate. Differences in participants' demographics, the onsetdiff variable, the amount of left-to-right asymmetry of the onsetdiff variable, pelvic wobble, and the amount of left-to-right asymmetry of the pelvic wobble between the recurrent LBP and healthy groups were compared using the independent samples student's t-tests or Mann-Whitney U-tests. The alpha level was set at 0.05 for all statistical tests.

3. Results

3.1 Demographics

Demographic characteristics of the recurrent LBP and healthy groups are shown in Table 1. No differences in age, height, body weight, and passive hip abduction range of motion were found between the two groups.

Table 1 Participant demographics

	Control group	LBP group	p-value
Sex (male : female)	17 : 3	17 : 3	
Age (years)	21.4 ± 3.3	21.9 ± 4.6	0.90
Height (cm)	171.2 ± 7.0	170.7 ± 5.3	0.79
Weight	63.2 ± 10.2	62.1 ± 6.4	0.70
Passive hip abduction range of motion of the right leg (degree)	34.1 ± 4.1	35.6 ± 5.1	0.31
Passive hip abduction range of motion of left leg (degree)	34.8 ± 4.7	36.9 ± 5.7	0.21
Oswestry Disability Index (%)		11.2 ± 7.4	

Values are presented as mean ± standard deviation. LBP: low back pain

3.2 Pelvic wobble and onsetdiff variable in active hip abduction test at 15 °/s

The pelvic wobble in the frontal and transverse planes and onsetdiff in the active hip abduction test at 15 °/s are shown in Table 2. No differences in pelvic wobble in the frontal and transverse planes and onsetdiff variables were found between the two groups.

Table 2 Pelvic wobble and onsetdiff variables in the active hip abduction test at 15 °/s

	Control group	LBP group	p-value
Pelvic wobble in the frontal plane of the right leg (m/sec ²)	2.1 ± 0.4	2.1 ± 0.5	0.83
Pelvic wobble in the transverse plane of the right leg (m/sec ²)	2.0 ± 0.4	1.9 ± 0.4	0.60
Onsetdiff variable of the right leg (ms)	269.6 ± 218.8	298.5 ± 139.1	0.16
Pelvic wobble in the frontal plane of the left leg (m/sec ²)	2.3 ± 0.5	2.3 ± 0.5	0.95
Pelvic wobble in the transverse plane of the left leg (m/sec ²)	2.2 ± 0.6	2.2 ± 0.5	0.55
Onsetdiff variable of the left leg (ms)	162.4 ± 220.6	90.9 ± 172.8	0.23

Values are presented as mean ± standard deviation. LBP: low back pain

3.3 Pelvic wobble and onsetdiff variable in active hip abduction test of maximum speed

The pelvic wobble in the frontal and transverse planes and onsetdiff in the active hip abduction test at maximum speed are shown in Table 3. No differences in pelvic wobble in the frontal and transverse planes and onsetdiff variables were found between the two groups.

Table 3 Pelvic wobble and onsetdiff variable in active hip abduction test at maximum speed

	Control group	LBP group	p-value
Pelvic wobble in the frontal plane of the right leg (m/sec ²)	3.7 ± 1.6	3.5 ± 1.6	0.64
Pelvic wobble in the transverse plane of the right leg (m/sec ²)	3.4 ± 1.4	3.5 ± 1.7	0.84
Onsetdiff variable of the right leg (ms)	76.4 ± 101.8	70.8 ± 64.3	0.86
Pelvic wobble in the frontal plane of the left leg (m/sec ²)	3.4 ± 1.6	3.2 ± 1.0	0.95
Pelvic wobble in the transverse plane of the left leg (m/sec ²)	3.1 ± 1.3	3.3 ± 1.3	0.43
Onsetdiff variable of the left leg (ms)	162.4 ± 220.6	90.9 ± 172.8	0.55

Values are presented as mean ± standard deviation. LBP: low back pain

3.4 Asymmetry of the pelvic wobble and asymmetry in the timing of the lateral pelvic tilt during active hip abduction

The asymmetry of the pelvic wobble and asymmetry of the onsetdiff variable are shown in Table 4. Asymmetry of the pelvic wobble in the transverse plane in the active hip abduction test at maximum speed was significantly greater in the recurrent LBP group than in the healthy group. Asymmetry of the onsetdiff variable in the active hip abduction test at both 15 °/s and at maximum speed were significantly greater in the recurrent LBP group than in the healthy group. There were no significant differences in the asymmetry of the pelvic wobble in the frontal and transverse planes in the active hip abduction test at 15 °/s. There were no significant differences in the asymmetry of the pelvic wobble in the frontal plane in the active hip abduction test at maximum speed.

Table 4 Asymmetry of the pelvic wobble and asymmetry of the onsetdiff variable

	Control group	LBP group	p-value
Active hip abduction test at 15 °/s			
Asymmetry of the pelvic wobble in the frontal plane (m/sec ²)	0.3 ± 0.2	0.4 ± 0.2	0.78
Asymmetry of the pelvic wobble in the transverse plane (m/sec ²)	0.4 ± 0.3	0.5 ± 0.4	0.23
Asymmetry of the onsetdiff variable (ms)	114.3 ± 97.3	239.0 ± 154.8	0.01*
Active hip abduction test at maximum speed			
Asymmetry of the pelvic wobble in the frontal plane (m/sec ²)	0.9 ± 1.1	1.1 ± 1.1	0.23
Asymmetry of the pelvic wobble in the transverse plane (m/sec ²)	0.5 ± 0.4	1.2 ± 1.1	0.03*
Asymmetry of the onsetdiff variable (ms)	40.3 ± 66.6	80.0 ± 61.3	0.01*

Values are presented as mean ± standard deviation. *p < 0.05; statistically significant difference. LBP: low back pain

4. Discussion

The aim of the present study was to examine the asymmetry of the pelvic wobble and the asymmetry of the timing of lateral pelvic tilt during the active hip abduction test in individuals with recurrent LBP compared to that in healthy individuals. We found that asymmetry of the pelvic wobble in the transverse plane during the active hip abduction test at maximum speed and asymmetry of the timing of lateral pelvic tilt (i.e., onsetdiff variable) during the active hip abduction test at 15 °/s and at maximum speed were greater in the recurrent LBP group than in the healthy group. These results support our hypothesis that individuals with recurrent LBP demonstrate an asymmetrical movement pattern compared to that demonstrated by healthy individuals, although the individuals with recurrent LBP had ODI scores of 11.2% (i.e., minimal disabilities).

In this study, asymmetry of the timing of lateral pelvic tilt was greater in the recurrent LBP group than in the healthy group. This agrees with the results of previous studies that found asymmetry in the timing of lateral pelvic tilt during active hip abduction in individuals who developed transient LBP during prolonged standing compared to individuals who did not develop LBP¹⁰. Movement control of the lumbopelvic region is required for local mobility¹⁹. Individuals with passive hip abduction range of motion of less than 30° were excluded from the study. In addition, there were no significant differences in the passive hip abduction range of motion between the groups. Therefore, we believe that the passive hip abduction range of motion did not influence the pelvic tilt in this study. In addition, because the participants in this study were individuals in remission from recurrent LBP, the results of this study were not influenced by pain. Some studies have reported that the onset time of the activities of the erector spinae and internal oblique muscles differs between left and right active hip abduction in individuals with LBP^{12,13}. Activation of the ipsilateral erector spinae muscle contributes to the lateral pelvic tilt observed during the active hip abduction test. The activation of the internal oblique muscle contributes to counterbalance of the rotational torque against the rotational torque of the lumbopelvic region during limb movement²⁰. Therefore, the significant asymmetry of the timing of lateral pelvic tilt and the asymmetry of pelvic wobble in the transverse plane in individuals with recurrent LBP may be due to differences in the onset time of the activity of the erector spinae and internal oblique muscles between left and right active hip abduction, although we did not examine the onset time of the activity of the trunk muscles. In addition, decreased use of lumbar proprioceptive inputs has been reported in individuals with recurrent LBP^{21,22}, and has been shown to be associated with poor pelvic movement control in individuals with LBP²³. Therefore, the significant asymmetry of the timing of lateral pelvic tilt and of the pelvic wobble in the transverse plane may be due to the decreased use of lumbar proprioceptive inputs. Repeated asymmetrical movement of the pelvic region may lead to a greater concentration of stress in the spinal tissue on one side of the spine compared to the other and can cause repetitive microtrauma to the spinal tissue, leading to recurrent LBP¹⁰.

This study has several limitations. First, the participants with recurrent LBP were young adults with minimal disabilities. Therefore, the results may not be generalizable to patients with severe disabilities and middle-aged and older adults. Second, the sample size was small. It remains a challenge for future research to determine whether interventions aimed at improving movement control of the lumbar and pelvic region can help prevent recurrent LBP.

In conclusion, asymmetry of the pelvic wobble in the transverse plane in the active hip abduction test at maximum speed and asymmetry of the timing of lateral pelvic tilt (i.e., the onsetdiff variable) in the active hip abduction test at 15 °/s and at maximum speed were greater in the recurrent LBP group than in the healthy group. Our results show that individuals with recurrent LBP have movement control of the lumbopelvic region, which differs from that had by healthy individuals. Our results suggest the need for early interventions for movement control in individuals with recurrent LBP.

Ethical considerations

This study was conducted in accordance with the Helsinki Declaration and was approved by the local ethics committee (20-002, 19-010) of Kawasaki University of Medical Welfare.

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