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Examining the lumbopelvic-hip movement pattern in a subgroup of patients with low back pain during the active straight leg raise test

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ABSTRACT

This study aimed to investigate the differences in lumbopelvic-hip movement pattern between patients with lumbar rotation with flexion and people without low back pain (LBP). A total of 20 male patients with lumbar Flexion + Rotation, confirmed based on the movement system impairment model, and 15 men without a history of LBP were included in this study. The participants performed the active straight leg raise (ASLR) test and kinematic data related to hip-lumbopelvic-hip complex were collected with a motion capture system. Results: When the patients performed the ASLR test with their non-dominant limb, excessive posterior lumbopelvic tilt was observed in either the first half range of motion or the overall range. Amount of this motion was greater in comparison to that in healthy controls. Moreover, hip and lumbopelvic movements had a more synchronous pattern in patients with LBP than in healthy individuals. When patients with lumbar Flexion + Rotation syndrome perform the ASLR test with their non-dominant lower limb, lumbopelvic region exhibits a greater magnitude of posterior tilt in comparison to healthy people.

Keywords: low back pain; SLR; kinematic; lumbopelvic; rotation with flexion

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INTRODUCTION

Limb movements which apply force on the lumbopelvic region could be associated with motion in the region [1, 2]. It is suggested that with insufficient lumbopelvic control, the region may move earlier and/or in excessive range when a lower limb moves in a specific direction [3]. Since this form of motor behavior between the lumbopelvic region and lower limbs can exert extra load on lumbar spine tissues, repeated lower limb movements may produce lumbopelvic pain [3, 4] Evaluating lumbopelvic movement patterns during lower limb motion can thus be helpful in the identification of factors involved in pain development.

The active straight leg raise (ASLR) is a lower limb motion test often used for examining patients with low back pain (LBP), pelvic pain, and hip dysfunctions [5-7]. Previous investigations used the ASLR test to only assess the range of motion (ROM) of the hip. However, it is now well-known that limb movements would impose strain on the several anatomical structures attaching the lumbopelvic and hip joints and thus induce the lumbopelvic region to move in a specific direction [8]. Excessive and/or early lumbopelvic motion during a limb motion test can lead to soft tissue micro-trauma and eventually LBP [4, 9-12]. Clinical studies have reported that pain can be reduced by limiting pelvic motion during particular limb motions which cause LBP [13-15].

Therefore, we decided to examine the lumbopelvic movement pattern and hip joint ROM to clarify the relationship between the ASLR and LBP.

Today, it is known that mechanical LBP includes heterogeneous groups of patients with LBP [11, 16-18]. Based on clinical and laboratory evidence, the first step towards identifying LBP risk factors is recognizing the subgroup of LBP patients based on a standard model [10, 11, 15, 16, 19, 20]. Accordingly, several models have recently been introduced to classify LBP patients based on movement impairments leading to mechanical LBP symptoms. One of these models is the Movement System Impairment Model that classifies LBP patients into 5 subgroups based on the directions of the movements in which the movement of lumbar spine induces pain [18]. Based on clinical evidence, a subgroup containing a significant number of people with LBP presenting to medical centers is Flexion + Rotation subgroup. We decided to compare the lumbopelvic-hip movement pattern of these patients with healthy subjects during ASLR tests.

MATERIALS AND METHODS

Subjects

A total of 35 men participated in this study. The participants were allocated to two groups, i.e. those with chronic LBP (n = 20) and those without a history of LBP symptoms (n = 15). The patients who had non-specific chronic LBP were classified in the Flexion + Rotation subgroup based on the movement system impairment model [18]. In order to eliminate the confounding effects of gender, only male patients were recruited. All individuals' eligibility was assessed through the examinations made by a physician. The participants' age range was limited to 18-50 years. The exclusion criteria were pathological conditions, such as tumor, degenerative joint disease, disc herniation, infection, spondylolisthesis, or spondylolysis, related to the lumbopelvic region, remarkable kyphosis or scoliosis, a history of lumbar or lower limb surgery, pathological disorders in the lower limbs, and severe neurological or psychological illnesses. The subjects were provided with details about the objectives and experimental procedures of the study and asked to sign an informed consent form. The study was approved by the Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran.

Self-report questionnaire

All participants completed a demographic questionnaire containing items on age, weight, height, and body mass index (BMI). The patients' group also completed an LBP history questionnaire, the Oswestry Low Back Pain Questionnaire (OLBPQ) [21] and the Persian version of Baecke Habitual Physical Activity Questionnaire (PBHPAQ) [22]. The validity and reliability of the PBHPAQ and OLBPQ were evaluated for the Iranian population and found to be acceptable [21, 22]. The Oswestry Disability Index (ODI) was extracted from the OLBPQ. The patients also rated their pain on a visual analog scale (VAS) [23].

Clinical assessment

The patients with lumbar rotation with flexion were identified based on the method proposed by the movement system impairment model [18]. A standardized clinical procedure was hence used for this purpose [15, 18]. The examination included primary and secondary movement and alignment tests. During the primary test, the patients maintained a position or performed a trunk or limb movement.

During the secondary tests, which actually verified the sample selection in the desired subgroup, the subjects were asked to repeat the tests associated with LBP symptoms, but before repeating those tests, they were asked to maintain their lumbar flexion or reduce it and delay it in the tests that required lumbar flexion. The subjects were also asked to use modification strategies to reduce the lumbopelvic rotation or delay the motion in the lumbopelvic region during the tests in which lumbar rotation stimulated LBP symptoms. Sample selection was approved when the described modification strategies reduced or eliminated LBP symptoms. Principles to evaluate and diagnose subgroups were based on the model introduced by the Movement System Impairment [15, 18, 24].

Laboratory tests

After completing the questionnaires, the participants underwent kinematic measurements.

The measurements were performed while the participants were in the supine position with their head in a neutral position. The upper limbs were placed beside the trunk and the hands were positioned faced down. The lower limbs, pelvis, and upper trunk were in a straight line (Fig. 1). The participants were asked to perform the ASLR test with at their desired speed and to the extent they could (Fig. 2). The foot which first performed the test was selected randomly. The test was conducted in triplicate by each lower extremity.

Kinematic data recording and processing

A motion capture system with seven cameras, installed in Isfahan University of Medical Sciences, was used to record kinematic data at a frequency of 120 Hz. The static resonation for each camera was 1 mm/m^3. Prior to the tests, retro-reflective markers were attached to the anatomical landmarks of the pelvis, thigh, and knee of both sides. After performing the tests, the data collected by all markers were filtered by a dual pass, i.e. Butterworth filter, with an initial cutoff frequency of 2.5 Hz. The start and end points of pelvic and hip joint motion in the sagittal plane were identified based on previously described methods [10-12]. The start of hip flexion was defined as the point at which the angular velocity exceeded 5% of the maximal angular velocity for the thigh. The start of posterior pelvic tilt was defined as the point at which the angular velocity exceeded 15% of the angular velocity for the segment. The end of movement for each segment was defined as the point at which the angle of motion displacement reached 99.5% of its maximum.

Dependent variables

Sagittal plane hip and pelvis motions were calculated from the beginning of the test to the maximal angle of the lower limb movement. The degree of posterior pelvic tilt was also determined from the start point of the motion to the point where the lower limb reached its mid-range. Finally, the angular displacement of the hip joint from the start point of the hip motion to the point where pelvic motion initiated was calculated as an index of hip-lumbopelvic timing during the ASLR test.

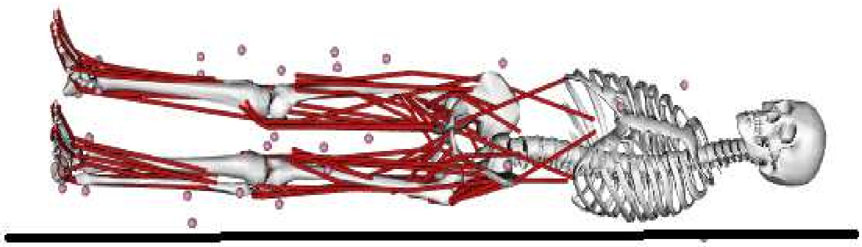

Figure 1: Start position of the test

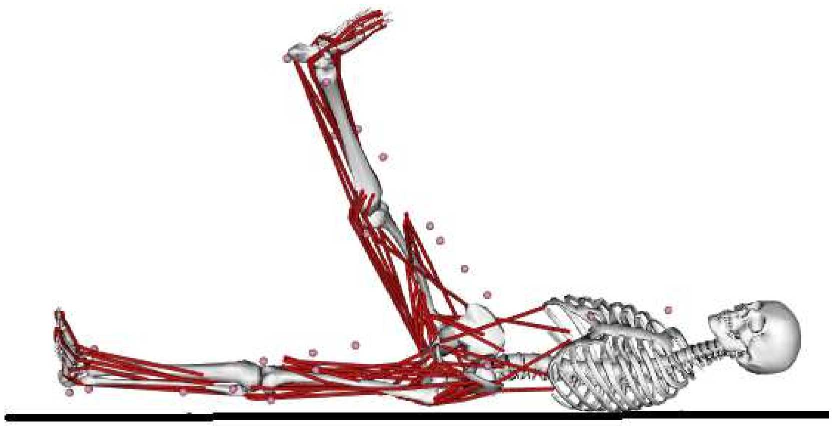

Figure 1: End position of the test

Statistical analysis

The Kolmogorov-Smirnov (K-S) test was applied to assess the normal distribution of the descriptive and dependent variables. Descriptive statistics were then used performed for relevant characteristics of the participants. Independent t-tests were conducted to compare the groups in terms of different characteristic. All statistical analyses were performed using SPSS 21 (SPSS Inc., Chicago, IL, USA).

RESULTS

Table 1 shows the results of the differences between the two groups with regard to participants, LBP related and activities characteristics. Based on these evidences, no significantly differences was observed between the groups with regard to age, height and body mass index (P>0.05). But, the healthy participants had greater level of physical activities (P=0.045).

Table 2 and 3 exhibit the results of the differences between the groups with regard to kinematic variables. As the results shows, when the patients performed the test with the non-dominant limb, lumbopelvic posterior rotation take place in a greater magnitude in total and the first half range of the test (P<0.05); but, hip/pelvic timing of motion and range of the hip flexion weren't significantly different between the groups (P>0.05).

During the test with the dominant side, no significantly differences were observed between the groups in regard to kinematic variables (P>0.05) (Table 2).

DISCUSSION

While the occurrence and persistence of LBP, as the most prevalent musculoskeletal disorder, is affected by different biological, psychological, and social factors, biomechanical factors are considered as the most prominent risk factor of the condition [10, 25]. Previous research has, in

Table 1: subjects' characteristics

	Group without LBP (N=15) Mean(SD)	Group with LBP (N=20) Mean(SD)	Mean difference (95%CI)	Degrees of freedom (df), P-value
Age	24.7(2.7)	26.7(5.1)	-2	df=33 , **p=0.181**
Weight	74.8(8.9)	74.8(5.6)	0	df=33 , p=1.000
Height	178(6)	174(6)	2	df=33 , p=0.127
BMI	23.5(2.1)	24.5(2.5)	-0.96	df=33 , p=0.238
PBHPAQ score	8.4(1.6)	7.3(1.3)	1.02	df=33 , p=0.045
OLBPQ score	NA	16.1(8.3)		
VAS score	NA	<4		

Table 2: results of the kinematic analysis during the test with the non-dominant limb

	Group without LBP (N=15) Mean(SD)	Group with LBP (N=20) Mean(SD)	Mean difference (95%CI)	Degrees of freedom (df), P-value
pelvic rotation angle	7.6 (3.4)	11.2 (4.9)	-3.6	df=33 , **p=0.034**
Hip flexion angle	61.4 (12.6)	63.2 (8.6)	-1.7	df=33 , p=0.672
Timing of pelvic rotation	24 (17.7)	12.1 (10.3)	11.2	df=33 , p=0.074
Pelvic rotation in first half of motion	1.8 (1.3)	4.1 (3.2)	-2.3	df=33 , p=0.011

**Value presented in degrees*

Table 3: results of the kinematic analysis during the test with the non-dominant limb

	Group without LBP (N=15) Mean(SD)	Group with LBP (N=20) Mean(SD)	Mean difference (95%CI)	Degrees of freedom (df), P-value
pelvic rotation angle	7.2 (3. 9)	10 (4.4)	-2.87	df=33 , **p=0.075**
Hip flexion angle	66.7 (10.2)	64.6 (8.7)	2.1	df=33 , p=0.540
Timing of pelvic rotation	21.1 (19.2)	15.3 (8.01)	5.8	df=33 , p=0.431
Pelvic rotation in first half of motion	10.6 (2.2)	4.2 (3.66)	6.3	df=33 , p=0.495

fact, identified several biomechanical characteristics to be related with the initiation and development of LBP. Numerous studies in this field have recently 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, would exert excessive load on the lumbopelvic region and ultimately lead to LBP [1, 10, 11, 26, 27]. Therefore, understanding the patterns of lumbopelvic-hip movements can help clinicians better identify the causes of LBP.

The ASLR is a limb movement test for the examination of patients with LBP [5, 18]. However, no studies have evaluated the lumbopelvic-hip movement in patients with LBP during this test. Therefore, this study assessed the lumbopelvic-hip movement pattern in patients with lumbar rotation with flexion during the ASLR test. According to our findings, when the participants performed the test with their non-dominant limb, the lumbopelvic region of the patients had a wider ROM in the sagittal plane than that of the healthy group. Some authors reported similar results in patients with LBP [4, 10]. Scholtes et al. compared a group of healthy individuals with patients with LBP and found that in patients, the lumbopelvic region had a greater tendency to display motion during the knee flexion and hip external rotation test [4]. Likewise, Sadeghisani et al. detected an excessive lumbopelvic motion during a lower limb motion test [22]. This finding may thus be a potent contributing factor in the development of tissue damages. In fact, lumbopelvic motion in a wider-than-usual range applies greater stress on the lumbar spine and repetition of such stresses during daily activities might cause LBP. Clinical evidence has also shown that restricting lumbopelvic motion during lower limb motions could decrease LBP symptoms [13-15].

Impairment in hip extensor muscles, such as hamstring tightness, has been proposed to justify such lumbopelvic movement impairments. We thus hypothesized hamstring tightness may increase posterior pelvic rotation and eventually limit hip flexion ROM. Consistent with this hypothesis, some studies found limited hip ROM in people with LBP [28]. However, we did not observe any significant differences in hip flexion ROM between the two groups.

In order to evaluate lumbopelvic-hip movement behavior during functional activities, the two groups in this study were compared in terms of two kinematic variables, i.e. the degree of pelvic rotation during the first half range of the test and hip/pelvic timing [9-11]. Based on the obtained results, the patients with LBP moved their lumbopelvic region in a greater extent during the first half range of the test. Although the timing of hip/pelvic motion was not significantly different between the two groups, statistical analyses suggested that the pelvis and hip moved in a more synchronous pattern in the patients.

This study had a number of limitations. First, only a subgroup of patients was compared with healthy controls. Therefore, future studies should recruit different subgroups of patients. The second limitation of this study was comparing the two groups only based on the ASLR test. Further studies are thus warranted to examine lumbopelvic movements during other limb motions. Moreover, since the ASLR test is a non-functional test, future studies are recommended to include functional activities as well. Finally, our examinations were limited to the sagittal plane. It is hence essential for future studies to evaluate lumbopelvic motion in other planes.

CONCLUSION

The current evidences exhibited that an excessive lumbopelvic posterior rotation during ASLR take place in the patients with lumbar Flexion Rotation syndrome, which can be an important factor contributing to the development or persistence of a LBP problem in this group of patients. Future studies should identify [1] the contributing factors that are related to the movement impaired, [2] whether such similar evidence could be seen during other limb tests.

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