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Kinematics of the Lumbar Spine and Hip Joints in People with Persistent Low Back Pain during Sit to Stand and Stand to Sit Activities

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Abstract

Background: To our knowledge, no study has examined the kinematics of lumbopelvic-hip complex of individuals with chronic low back pain (CLBP) who had lumbar flexion+rotation (F+R) syndrome during sit to stand (SiToSt) and stand to sit (StToSi) activities. Thus, this study aimed to examine movement patterns of the lumbopelvic-hip complex in participants with CLBP classified into F+R syndrome subgroup.

Methods: This was a cross sectional study. A 3-dimensional motion capture system was used to record movements of the lumbar spine and hips during SiToSt and StToSi. Participants were 20 patients with LBP classified in lumbar F+R subgroup, based on the movement impairment system model, and 20 asymptomatic individuals. The study was approved by Shahid Beheshti University of Medical Sciences (IR, SBMU.RETECH, and REC.1395.365).

Results: Greater and significant lumbar flexion, with SiToSt, and lumbar extension, with StToSi, were observed in the patients. In addition, the patients exhibited a greater magnitude of lumbar rotation during SiToSt. No significant difference was observed between the 2 groups in hip motions.

Conclusion: The patients with lumbar F+R syndrome tend to move their lumbopelvic region to a greater extent in sagittal and horizontal planes during SiToSt and StToSi compared with participants without low back pain.

Keywords: Low Back Pain, Lumbopelvic, Hip, Kinematics, Rotation

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Introduction

Low back pain (LBP) is the most prevalent musculoskeletal disorder that affects up to 80% of individuals in their lives (1, 2). The burden of treatment is challenging when a symptom of LBP persists for more than 3 months, which is known as chronic LBP (CLBP) (2, 3). In the dominant cases of CLBP, no specific pathological situation can be found that is identified as nonspecific CLBP (1, 4).

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↑What is "already known" in this topic:
Patients with LBP experience symptoms during many habitual activities. Two activities associated with pain, especially in those subcategorized in F+R subgroup, were SiToSt and StToSi. Previous studies showed that patients with F+R syndrome may benefit from decreasing lumbar flexion with trunk or limb movements.

→What this article adds:
The current data indicated an increase in lumbar spine motion of the patients with lumbar F+R during flexion phase of SiToSt and extension phase of StToSi tasks. The study also indicated that the patients used the lumbar rotation in a greater magnitude during SiToSt compared to healthy people.

It is well accepted by researchers and clinicians that mechanical risk factors are important in persistence and development of symptoms in individuals with nonspecific CLBP (5-9). Because of the close biomechanical and anatomical relationship between the hips and lumbar spine, abnormalities of lumbopelvic-hip rhythm, especially during the activities that need the lumbar spine and hip joints cooperation, are proposed as a possible potent contributing risk factor for LBP (10-13). Therefore, evaluation of lumbopelvic-hip rhythm in people who suffer from LBP symptom during performing habitual or functional activities could be an essential step in determining the main risk factors related to the problem.

Sit to stand (SiToSt) and stand to sit (StToSi) are essential functional activities that are frequently performed by individuals throughout the day (14). Completion of these activities are dependent on appropriate cooperation of the lumbar spine and the hip joints (15). Thus, impairments in the lumbopelvic-hip rhythm of an individual when he or she performs such activities may lead to LBP. Therefore, accurate evaluation of the lumbopelvic-hip movement patterns in people with nonspecific CLBP when they do these activities could be a key in revealing the cause of the problem. In addition, feeling pain in the lumbar spine region has always been reported by those with nonspecific CLBP when they performed such tasks. Thus, evaluation of the lumbar spine and hips in people with LBP and during SiToSt and StToSi activities was the focus of interest to some researchers in their studies (15-17). Nevertheless, several gaps have highlighted the need for further studies.

For example, although the movement of lumbopelvic-hip complex in people with CLBP has been evaluated during SiToSt or StToSi activities in some studies (16, 17), examination was limited only to the sagittal plane. Therefore, in the first step it was decided to examine people with CLBP during SiToSt and StToSi activities in the 3 planes of motion. In addition, it should be considered that CLBP is a heterogeneous group of patients with LBP, which should be placed in more homogeneous subgroups (8, 13, 18-20) and then compared with healthy people, which has been neglected so far in the previous studies (16, 17). The recent studies have also revealed patients with CLBP are a group of heterogeneous patients with dissimilar movement behaviors (8, 13, 21). Hence, considering the type of movement-based LBP subgroup is an important step when evaluating the lumbar spine and hip joints kinematics during SiToSt and StToSi. Therefore, we aimed to examine a homogeneous group of patients with CLBP who seemed to be more abundant in our society based on a valid and standard approach.

During the recent years, some authors have made an attempt to present advisable models of subgrouping for patients with LBP. One of these models, which has attracted the attention of various researchers, is the movement impairment system (MSI) model. This valid model subgroup of patients with LBP in 5 distinct subdivisions is based on the directions of the lumbar spine and is associated with LBP symptoms (22). One subgroup of the MSI model is flexion+rotation (F+R) syndrome subgroup. Patients with F+R syndrome subgroup are a common movement based LBP subgroup among patients with LBP (9). Also, in clinical conditions, we encounter a significant number of patients with low back pain who are in the F + R subgroup, and reporting low back pain symptoms during StToSi activities and vice versa is one of their main complaints. Therefore, this subgroup of patients were considered as the target of the study.

Overall, in the present study, we aimed to compare the movement pattern of lumbopelvic-hip complex in patients with lumbar F+R syndrome and healthy people during SiToSt and StToSi tests.

Methods

Participants

A total of 40 individuals (20 males with LBP and 20 males without LBP) aged 20-50 years participated in this cross-sectional observational study. The patients were individuals who (1) had nonspecific LBP on examination, performed by a physician, (2) had LBP symptoms more than the past 3 months, and (3) were placed in F+R subgroup of patients with lumbar spine pain syndrome based on the findings from a standardized examination (9, 23). The examination included taking history and physical examination. In taking the history, we focused on activities and positions that were related to LBP. Moreover, examination included primary and secondary tests. During the primary test, the participant assumed a position or requested to perform a movement. When the primary test provoked pain, a secondary test was done with a modified movement pattern that limited lumbar flexion and rotation/side flexion to examine whether the pain decreased or was eliminated. The tests for patients with lumbar F+R syndrome were considered positive if (1) lumbar spine tended to be flexed and rotated/side flexed relative to neutral, (2) lumbar spine tended to move toward the direction of flexion and rotation/side flexion during movements of the trunk or limbs, (3) pain was provoked or increased with the lumbar spine positioned in or moved into flexion and rotation/side flexion, and (4) pain decreased or eliminated with corrective strategies that restricted the lumbar spine flexion and rotation/side flexion. The principles to evaluate and diagnose subgroups were based on the model introduced by the movement system impairment model (19, 22, 24). In addition, the healthy participants with no clinical evidence of LBP were recruited from among the staff and students at Isfahan University of Medical Sciences.

Participants were excluded from the study if they had any neurological and rheumatological condition, leg length discrepancy, previous spinal or lower extremities surgery, degenerative joint disease in the lower limbs, obvious scoliosis or kyphosis deformity in the spine, and history of radiculopathy. For this purpose, a physician assessed the participants.

Prior to the conducting the study, ethical approval was obtained from Shahid Beheshti University of Medical Sciences (IR, SBMU.RETECH and REC.1395.365), and all the participants signed the written informed consent. Table 1 shows the participants' characteristic information.

Table 1. Participant Characteristics and demographic information

Variable	Patient N=20 Mean (SD)	Healthy N=20 Mean (SD)	95% confidence interval of the difference		P value
			Lower	Upper	
Age (yr.)	27.75 (7.59)	24.42 (2.87)	-7.08	0.42	0.080
Height (M)	1.74 (0.05)	1.78 (0.06)	-0.74	7.16	0.109
Weight (kg)	74.8 (5.6)	73.9 (8.9)	-5.78	4.07	0.726
Body Mass Index (BMI)	24.5 (2.49)	23.25 (0.02)	-2.72	0.21	0.094
Baecke score	7.36 (1.34)	8.38 (1.69)	-2.72	0.21	0.045
Oswestry disability index score	16.1 (8.29)	NA	NA	NA	NA
Duration of pain (month)	19.5 (16.8)	NA	NA	NA	NA

Significant value was identified with bold value.

Procedures

Self-reporting Questionnaire: All of the participants completed (1) a questionnaire on demographics and LBP history and (2) the Persian version of Baecke habitual physical activities questionnaire for identifying participants' level of physical activity. Its validity and reliability in measuring physical activities in Persian individuals have been determined previously (25). The patients were also asked to complete (1) a visual analog scale questionnaire, which demonstrates pain intensity as well as (2) the Persian version of Oswestry indexing questionnaire, which indicates LBP related level of disability (26). Information on the questionnaires is presented in Table 1.

Specific Test: Participants performed SiToSt and StToSi tests. To do so, they were asked to sit on a chair with no armrest or backrest. The chair was adjusted to each participant's height so that the knees were placed in 90° of flexion. The upper limbs rested freely on the sides of the body and the legs were shoulder-width apart. Participants were asked to rise freely with self-selected and comfortable speed and then maintain in erect posture for 3 seconds. Then, they were asked to sit on the chair at their own convenient speed. The tests were repeated in 3 trials with 30-second rests between the trials. Figure 1 shows the sequences of a sample test.

Data Recording and Processing: A 7-camera, 3-dimensional motion measurement system (Qualisys, Gothenburg, Sweden), located in the Rehabilitation Faculty of Isfahan University of Medical Sciences, was used to examine the kinematics of lumbar spine and hip joints during the tests. Retroreflective markers were placed on anatomical landmarks of the foot, leg, knee, thigh, pelvic, and spine as previously predetermined. The kinematic data recordings were performed at a sample rate of 120 Hz. After data collection, all data were filtered using a Butterworth filter with a cutoff frequency of 2.5 Hz.

During processing the data, initially, the start and end points of the motion of the tests were determined using a method employed in previous studies (16, 27). Each test began with concurrent flexion of the lumbar spine and hip joints (flexion phase) and continued to end with extension phase. The start of movement for each test was defined as a point of motion when the combined angle of hip and lumbar spine flexion changed 5° and reached 7% of its maximum velocity in that test, and the end point of movement for each test was identified when the combined angle of lumbar spine and hip extension reached 99.5% of the maximum angle in that test.

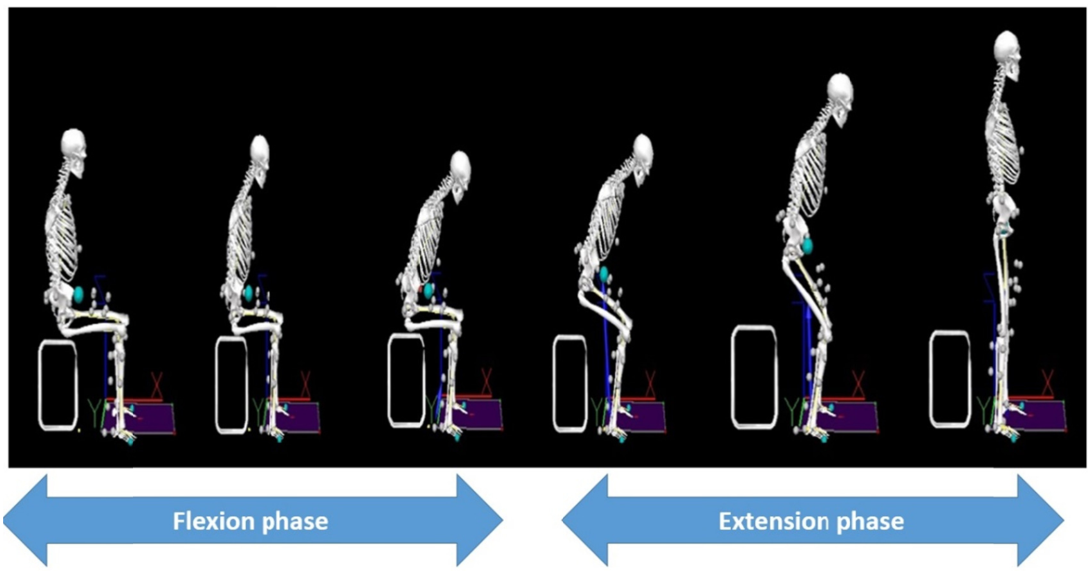

Fig. 1. Sequences of movement performance of the tests.

Then, peak flexion angles, displacements, and mean angular velocities of the lumbar spine and both hips were calculated during the flexion phases of SiToSt and StToSi tests. In addition, mean angular velocities of the lumbar spine and both hips were calculated during the extension phases of SiToSt and StToSi tests. Furthermore, the amount of maximum side bending and abduction/adduction of the lumbar spine and hips were calculated during each test. Moreover, maximum excursions of the segments were computed in the transverse plane for each test. Movement time was calculated as the duration between the start and end point of the test. Furthermore, the ratios of the lumbar spine to the dominant hip (LS/DH) and the lumbar spine to nondominant hip (LS/NDH) were computed for flexion and extension phases of the tests. These ratios are used to describe the relative contribution of the pairs' segments throughout the test.

Furthermore, the intraclass correlation coefficient (ICC) and standard error of the measurement (SEM) were used to index reliability. The values for each test, for SiToSt task, were found to be acceptable and reliable (Table 2). The kinematics values for the tests and lumbar and hip joints are reported in Tables 3, 4, and 5. Figure 2 shows the angles for lumbar spine and hip joint of a sample case in 3 planes of motion when a participant does the tests.

Statistical Analysis

For statistical analyses, SPSS, version 20, was used. Initially, normal distribution of the data was examined using Kolmogorov-Smirnov (K-S) test. After ensuring about the normality of distribution, independent sample t test was used to examine the differences between the groups (16). Significant level was set at $p<0.05$.

Results

Participant Characteristics

The results of the statistical analyses demonstrated that the mean values of participants' age, BMI, weight, and height were not significantly different between the 2 groups ($p>0.05$) (Table 1), but healthy individuals had a greater level of physical activity compared to the patient group ($p=0.045$) (Table 1).

Table 2. Mean, standard deviation (SD), intra-trial reliability interclass correlation coefficient (ICC) and standard error of the measurement (SEM) during SiToSt test

Variable (degree)	First management N=12		Second measurement N=12		Third measurement N=12		ICC
	Mean (SD)	SEM	Mean (SD)	SEM	Mean (SD)	SEM	
Lumbar flexion	8.21 (3.46)	1.1	7.04 (4.1)	1.3	8.65 (5.33)	1.6	0.882
Lumbar extension	24.59 (8.46)	2.6	23.8 (9.1)	2.8	23.97 (11.06)	3.4	0.959
Lumbar lateral flexion	3.81 (1.78)	0.5	3.41 (1.47)	0.4	3.36 (1.9)	0.6	0.927
Lumbar rotation	2.66 (1.78)	0.5	2.74 (1.64)	0.5	2.91 (1.62)	0.5	0.980
Hip flexion	31 (5.62)	1.6	30 (5.67)	1.7	29.7 (5.77)	1.6	0.902
Hip extension	75.16 (5.95)	1.7	74 (6.53)	1.8	75.45 (6.86)	1.6	0.950
Hip adduction	7.6 (5.66)	1.8	7.38 (4.51)	1.4	7.5 (4.85)	1.5	0.980
Hip rotation	9 (5.71)	1.8	8.35 (4.8)	1.5	8.7 (5.15)	1.6	0.984

Table 3. Amount of the sagittal ranges and velocities of the hips and the lumbar spine during sit-to-stand and stand-to-sit tests and also time spent to perform the tests

Variable	Region	Groups	Tests			
			Sit to stand Mean (SD)		Stand to sit Mean (SD)	
			Flexion phase	Extension phase	Flexion phase	Extension phase
Range of excursion (degree)	Lumbar	Patients	9.85 (5.48)	25.52 (9.05)	23.03 (8.38)	8.62 (4.25)
		healthy	6.55 (3.65)	21.83 (7.19)	19.68 (6.9)	5.05 (4.28)
			P=0.037	P=0.173	P=0.189	P=0.014
	Dominant hip	Patients	32.15 (10.23)	81.78 (11.5)	82.31 (14.38)	32.57 (9.37)
		healthy	32.05 (6.83)	81.63 (11.91)	80.36 (11.93)	31.73 (7.5)
			P=0.970	P=0.967	P=0.653	P=0.762
	Non-dominant hip	Patients	31.89 (10.57)	82.1 (12.32)	80.47 (11.94)	32.1 (8.88)
		healthy	31.78 (7.76)	83.63 (10.82)	78.42 (18.8)	34.3 (12.32)
			P=0.972	P=0.688	P=0.691	P=0.530
Velocity (degree/second)	Lumbar	Patients	10.59 (5.71)	22 (10.56)	19.87 (7.85)	5.92 (4.23)
		healthy	9.84 (5.37)	18.39 (5.75)	17.9 (6.21)	7.67 (5.1)
			P=0.676	P=0.192	P=0.390	P=0.251
	Dominant hip	Patients	37.07 (10)	68.35 (14.66)	72.43 (17.45)	35.08 (10)
		healthy	47.35 (12.37)	70 (13.68)	75.12 (22.61)	30 (10.38)
			P=0.007	P=0.706	P=0.679	P=0.131
	Non-dominant hip	Patients	36.97 (10.57)	68.68 (14.17)	70.23 (21.27)	37.84 (14.54)
		healthy	46.93 (13.11)	71.51 (12.71)	73.97 (21.66)	29.67 (9.5)
			P=0.014	P=0.517	P=0.589	P=0.068
Time (second)		Patients	2.2 (0.46)		2.3 (0.51)	
		healthy	1.8 (0.18)		2 (0.31)	
			0.01		0.04	

Sit to Stand

During SiToSt, in sagittal plane, hips and lumbar spine were firstly moved in flexion direction concurrently. The maximum angular displacements of lumbar spine, the dominant, and the nondominant hips in this phase of the test were 6.55°, 32.05°, and 31.78°, respectively, in the healthy group. Also, the obtained values for lumbar spine, dominant, and nondominant hips flexion for the patients in the flexion phase of SiToSt test were 9.85°, 32.15°, and 31.89°, respectively. Based on the results of statistical analyses, patients demonstrated greater magnitude of lumbar spine flexion during SiToSt task ($p=0.037$) (Table 3).

The second phase of SiToSt task is the extension phase, which begins soon after the loss of contact between the thighs and the chair. During this phase, lumbar spine and hips, which were in flexion, move in extension direction to the point that the individual could stand in upright position. The mean values of extension of lumbar spine, dominant, and nondominant hips in the participants with LBP were 6.5°, 32.05°, and 31.78°, and the mean values of the lumbar spine, dominant, and nondominant hips motions in extension direction for those without LBP were 9.85°, 32.15°, and 31.89°, respectively. With regards to hips and lumbar spine extension motion, no significant difference was observed between the groups during SiToSt task ($p>0.05$) (Table 3).

As shown in Table 4, during SiToSt activity, the lumbar spine displayed side flexion toward the dominant side and rotation to nondominant side. The value obtained for the maximum lumbar side flexion was not significantly different between the groups ($p=0.631$), but the patients group demonstrated a greater magnitude of lumbar rotation during SiToSt test ($p<0.001$).

According to the data obtained in Table 4, by performing SiToSt, from the moment of initiation up to the completion of the test, hip joints displayed adduction and internal rotation motions. The values obtained for the motions were not significantly different between the groups ($p>0.05$).

Moreover, the velocities of the movements during flexion phase of SiToSt significantly decreased for those with LBP when compared with those of the individuals without LBP ($p<0.05$). However, the velocities of the hips' movements during the extension phase of the test and velocities of the lumbar spine flexion and extension in the both tests were not found to be significantly different between the 2 groups ($p>0.05$) (Table 3).

For the patients and healthy group, the mean of the time to stand up from sitting position at a comfortable speed were 2.2 and 1.8 seconds, respectively, and the results of statistical analysis revealed that the difference between the 2 groups was significant ($p=0.010$) (Table 3).

During SiToSt, the mean ratios of lumbar/hip movements for the group with LBP were greater than those for the group without LBP although the difference was not statistically significant ($p>0.05$) (Table 5).

Stand to Sit

During StToSi, the movement patterns mirror was observed to take place for SiToSt, so that in sagittal plane hips and lumbar spine flex until thigh-seat contact occurred and then extended to the point that the participant sat upright. The flexion range of lumbar spine, dominant, and nondominant hips were 19.68°, 80.36°, and 78.42°,

Table 4. Range of excursion (degree) of the lumbopelvic-hips segments in the frontal and horizontal planes during the tests

Region	Groups	Tests: Sit to stand Mean (SD)		Tests: Stand to sit Mean (SD)	
		Frontal plane	Horizontal plane	Frontal plane	Horizontal plane
Lumbar	Patients	4.08 (1.32)	3.69 (1.57)	4.42 (2.44)	3.48 (1.37)
	healthy	3.8 (2.18)	2.18 (1.18)	3.6 (2.42)	2.73 (1.51)
		P=0.631	P=0.000	P=0.312	P=0.126
Dominant hip	Patients	8.3 (5.5)	10.3 (5.04)	8.3 (4.35)	6.95 (5.5)
	healthy	6 (2.6)	10.83 (3.09)	6 (2.65)	10.66 (2.99)
		P=0.068	P=0.694	P=0.056	P=0.617
Non-dominant hip	Patients	7.45 (4.03)	11.35 (5.37)	7.15 (3.51)	11.3 (5.86)
	healthy	6.94 (3.55)	11.66 (4.69)	7.38 (2.89)	11.11 (4.33)
		P=0.684	P=0.847	P=0.822	P=0.910

Table 5. Movement ratios for the lumbar to the hip joints during the tests

Test	Phase of the test	Variable	Patients Mean (SD)	Healthy Mean (SD)	P value
Sit to stand	Flexion	L[a]/DH[b]	0.31 (0.2)	0.22 (0.11)	0.101
		L/NDH[c]	0.32 (0.21)	0.22 (0.13)	0.124
	Extension	L/DH	0.3 (0.1)	0.28 (0.11)	0.551
		L/NDH	0.31 (0.1)	0.27 (0.1)	0.355
Stand to sit	Flexion	L/DH	0.28 (0.1)	0.26 (0.1)	0.585
		L/NDH	0.28 (0.1)	0.28 (0.14)	0.982
	Extension	L/DH	0.26 (0.14)	0.18 (0.14)	0.101
		L/NDH	0.27 (0.15)	0.18 (0.14)	0.078

[a] Lumbar
[b] Dominant Hip
[c] Non-Dominant Hip

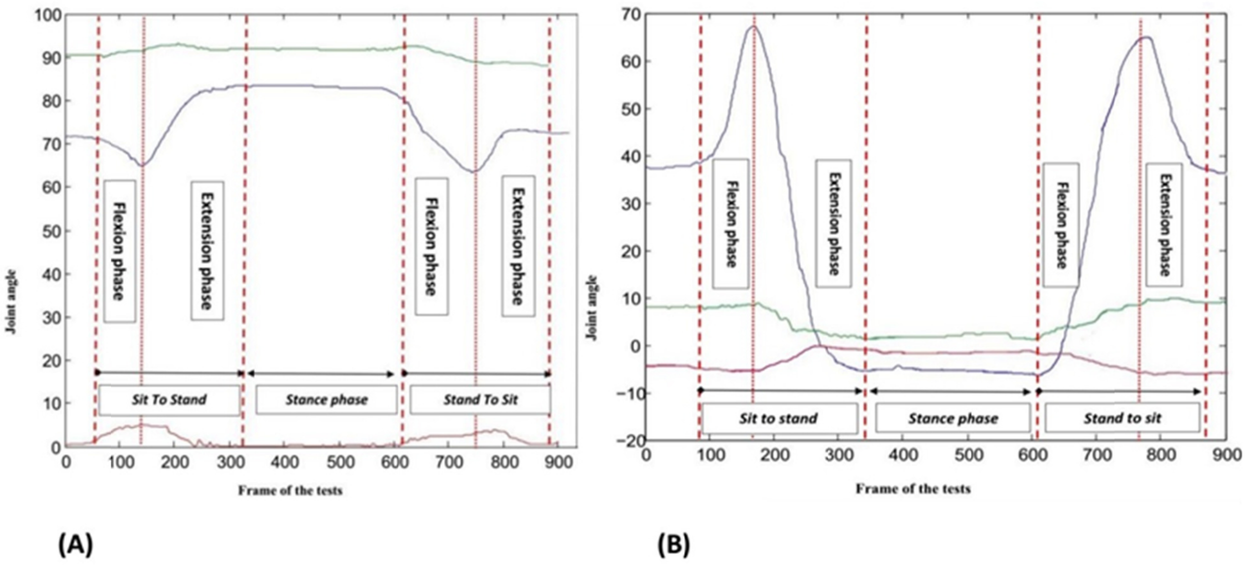

Fig. 2. Graphs of a sample lumbar (A) and Hip (B) movements in the sagittal (——), frontal (——) and horizontal (——) planes.

respectively, in healthy people, and 23.03°, 82.31°, and 80.47°, in the LBP people, in that order (Table 3). The data exhibited slightly more flexion motion of the segments in the patients with LBP, but the differences between the groups were not significant (p>0.05).

In the extension phase of StToSi, the values obtained for extension motion of lumbar spine, right hip, and left hip in participants with LBP were 8.62°, 32.57°, and 32.10°, respectively (Table 3). The mean values of lumbar spine, right hip, and left hip motion for the participants without LBP were 5.05°, 31.73°, and 34.31°, respectively, during extension phase of the test (Table 3). Based on the results, the group with LBP exhibited significantly more lumbar motion during extension phase of the StToSi test (p=0.014) (Table 3).

As data analysis revealed considering the velocities of the segments during the StToSi, no difference was observed between the groups (p>0.05) (Table 3).

In the horizontal plane based on Table 4, initially lumbar spine rotated toward the nondominant limb from the starting point of the test until the initiation of extension phase and then returned to the primary state. Although the maximum range of lumbar rotation in the patient group was more than that in the healthy group, the difference was not found to be significant (p=0.126) (Table 4). During the test, hips exhibited external rotation. The mean values of the hips' rotation were not different between the groups (p=0.617 for dominant hip and p=0.910 for nondominant hip) (Table 4). In the frontal plane, the lumbar spine moved toward the nondominate limb and hips exhibited abduction. No difference was observed in the maximum lumbar side flexion and hip abduction between the groups (p>0.05).

Furthermore, the mean of the time from standing positing to sitting position in the patients was 2.3 seconds, while participants without LBP performed the StToSi in 2 seconds (Table 2). Therefore, duration of StToSi in the patients was significantly longer than that in the healthy participants (p=0.040) (Table 2).

In addition, the ratios of lumbar/hip motion in the sagittal plane for the patients were slightly more, but the differences were not statistically significant (p>0.05) (Table 5).

Discussion

Low back pain is a common and prevalent musculoskeletal disorder among different human societies (4, 28, 29), and movement impairment related to lumbopelvic-hip complex has been proposed as a potent mechanical risk factor in occurrence and persistence of LBP symptoms (30, 31). SiToSt and StToSi are 2 important activities individuals frequently perform during their daily life (32).

Performing these activities depends on adequate hip-lumbopelvic interaction and coordination. It was clinically observed that a significant number of patients with low back pain, especially those who have lumbar F+R syndrome, reported LBP during SiToSt or StToSi activities. Based on our literature review, to date, no study has examined movement of lumbopelvic-hip complex in patients with lumbar F+R syndrome during SiToSt or StToSi activities. Hence, the present study aimed to compare the movement pattern of lumbopelvic-hip complex in individuals with lumbar F+R syndrome and those without LBP during SiToSt and StToSi tasks.

Kinematics data have the acceptable levels of reliability in the sessions of measurements. Therefore, the results of the test-retest reliability of this study are consistent with those obtained by Tully et al and Pourahmadi et al studies (16, 33). However, it seems necessary to assess intersession and interexaminer reliability of the data in transverse and frontal planes in future studies because in previous studies the assessment was limited to sagittal plane. Moreover, validity of the method used in this study must be investigated in futures studies.

Analysis of lumbar spine kinematics revealed that patients with lumbar F+R syndrome exhibited a greater range of lumbar flexion and extension during SiToSt and StToSi activities, respectively. Although the differences in the ranges of lumbar extension and flexion during SiToSt and StToSi were not significant between the groups, the mean values for the patients were to some extent greater. Thus, the results of this study demonstrated that patients with lumbar F+R had greater tendency of lumbar spine motion in sagittal plane compared to that of the individuals without LBP.

In a kinematic study performed by kim et al consistent results were obtained (34). They observed that patients with lumbar F+R syndrome have higher tendency of lumbar spine flexion during forward bending compared to healthy people. Similar results were also observed in Sadeghisani et al study (9). In their study, it was demonstrated that patients with F+R syndrome exhibited a greater magnitude of lumbar spine flexion during straight leg rising test compared to individuals who did not have LBP. Based on the evidence, the authors stated that that increase in the range of lumbar motion in patients with F+R syndrome may be related to the symptom (9, 34). Excessive lumbar motion in patients with LBP, in comparison to individuals without LBP, was also reported in other investigations (30, 35). The researchers of these studies had similar belief that lumbar spine motion abnormality in the form of the increase in the amount of motion could be a risk factor for LBP.

We also believe that greater tendency of lumbar spine for motion in sagittal plane and during SiToSt and StToSi activities could be associated with excessive loads applied on the lumbar spine, which is probably associated with soft tissue injury and eventually LBP symptoms in patients with F+R syndrome (36). Therefore, correcting strategies together with encouragement to limiting sagittal lumbopelvic motion during daily tasks may be recommended for the patients with F+R syndrome. Findings from the previous clinical studies also revealed that correcting strategies with emphasis on decreasing lumbopelvic motion proved to have positive results (24, 36, 37); however, more studies are needed to prove this hypothesis in patients with lumbar F+R syndrome.

One important finding of this study was related to the kinematic of lumbopelvic in transvers plane. In previous studies in which lumbopelvic-hip movement pattern was assessed during SiToSt (15-17, 33, 38), it was reported that kinematics data were limited only to sagittal plane. However, we examined the lumbar spine and hips in sagittal, frontal, and horizontal planes. As the results of the present study indicated, patients with lumbar F+R exhibited a greater and statistically significant rotation during SiToSt task compared to healthy individuals. Excessive lumbopelvic rotation was also observed in other people with LBP and was proposed as a contributing risk factor, which may lead to LBP (12, 39, 40). This kind of movement pattern in patients with lumbar F+R syndrome must be considered as an important feature in patients with lumbar F+R subgroup, and attempts should be made to correct this impairment in these individuals. Since most diagnostic and therapeutic procedures are focused on lumbopelvic movements in sagittal plane, movement impairments of lumbar spine in other planes are often neglected that could be associated with symptoms lasting in the patients. Our findings emphasize the importance of lumbar spine movement patterns evaluation in all 3 planes of motion, especially in patients with lumbar F+R syndrome.

Due to close anatomical and biomechanical links between the hip joints and lumbar spine, any impairment in each segment could be associated with impairment in the other segment (11, 41). Thus, some researchers believe that a greater tendency of motion in the lumbar spine could be due to a less tendency of motion in the hip joints (11, 12, 22, 42). Based on this hypothesis, limited hip motion in a specific direction would be compensated by lumbar spine motion in that direction, which eventually may lead to LBP (11, 43). Similar to this hypothesis, some investigators demonstrated that limited hip range of motion were associated with LBP (35, 44). However, the results of our study demonstrated no significant differences between the groups with regards to hips range of motion in 3 planes of movement. Therefore, the results of this part of the study were not consistent with those reported in previous studies. Nevertheless, in other subgroups of LBP and in patients with a higher level of pain or disability or during performing other activities other results may be obtained.

In this study, the ratios of the total movements of the lumbar spine to those of the dominant hip and to the non-dominant hip were determined in the sagittal plane. These variables provide kinematic indexes based on which the relative contributions of the joint pairs throughout the range of movements could be described (15). High values of this ratio indicate more relative cooperation of the lumbar spine and lower values of this ratio indicate lower relative involvement of the lumbar spine.. Findings of the present study showed although the differences in the mean values of the ratios were not significant, the mean values in the patients were slightly more than those in the participants without LBP. Therefore, in the patients with lumbar F+R syndrome, lumbar spine contributed more to total movements. Further investigations are needed to examine these ratios in other groups of patients with higher level of pain and disability and also other subgroups of patients based on movement impairment directions.

The mean time of SiToSt and StToSi obtained for the patients was 2.2±0.46 and 2.3±0.51 seconds, which were significantly longer than those obtained for the healthy group. Based on the literature, performing the tests by the 2 groups were slower compared to other studies performed on healthy participants who performed SiToSt (32, 45, 46). Since previous researchers used different starting foot and arm positions and, particularly, different identifications for the initiation and termination of the test, it would be difficult to compare durations of the tests between different investigations. However, in a study comparing SiToSt and StToSi durations between patients with LBP and people without LBP, patients were observed to do the tests more slowly (15).

There are some limitations related to the current study.

First, the study patients included F+R related LBP. However, it is unclear whether similar results are seen in other subgroups of low back pain whose symptoms of low back pain are related to extension or rotation patterns.Second, in this study patients with low level of pain and disability were included. Further studies may investigate lumbopelvic-hip kinematics in patients with higher intensity of pain and level of disability. Third, our study analyzed only SiToSt and StToSi tasks in patients with lumbar F+R syndrome, and more studies into activities of daily living such as squat, lifting an object, etc., are needed to examine lumbopelvic-hip movement patterns of the patients. Fourth, in this study, all participants were male and gender differences in lumbopelvic-hip kinematics during SiToSt and StToSi tasks were not investigated. Finally, the present study was limited to kinematics analysis and we did not measure kinetic variables. More studies should be performed to investigate kinetic variables, such as loads or moments of the trunk during SiToSt and StToSi tasks.

Based on the data obtained in the study, we must train the patients with lumbar F+R to decrease their lumbar spine to move in sagittal plane during flexion and extension phase of the SiToSt and StToSi activates, respectively. In addition, they must instruct to limit their lumbar rotation during SiToSt activities. These recommendations could be employed by the patients also during performing other habitual activities.

Conclusion

The kinematic parameters changes showed patients with lumbar F+R syndrome demonstrated more lumbar motion tendency in sagittal plane than the participants without LBP during SiToSt and StToSi activities. In addition, the patients group exhibited a greater range of lumbar rotation during SiToSt test. However, with regards to hips motions during the tests, no difference was observed between the patients with lumbar F+R syndrome and healthy participants. Finally, durations of performing SiToSt and StToSi in the patients, compared with the healthy group, were significantly longer.

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Conflict of Interests

The authors declare that they have no competing interests.

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