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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

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SUMMARY

Background. Because different groups of people with low back pain (LBP) engage in different tasks, their lumbopelvic-hip complex may move in different ways in those groups. The purpose of this study was to quantify the differences in lumbopelvic movement pattern during the passive hip external rotation (PHER) test in LBP patients with and without rotational demand activities (RDA).

Material and methods. A total of 30 subjects with LBP, including 15 patients with-RDA and 15 patients without-RDA were enrolled. A passive hip external rotation test was performed. Pelvic and hip rotation over the full range of the test, timing of hip and pelvic motion, and pelvic rotation in the first half of the movement were measured using a 3-D motion analysis system.

Results. Passive pelvic rotation during the test in the group with RDA was significantly greater than in the other group. However, there was no significant difference between the groups in other kinematic variables, including hip external rotation, timing of hip and pelvic motion and pelvic rotation in the first half of the movement ($p > 0.05$).

Conclusions. 1. A greater lumbopelvic rotation ROM during the PHER existed in LBP patients who regularly participated in RDA. 2. Different groups of patients with LBP who engage in different specific activities may have a specific lumbopelvic movement pattern impairment. Therefore, each group of LBP patients in regard to their specific activities may need a different, specific plan of treatment.

Key words: low back pain, passive hip external rotation, rotation-related sports activities, lumbopelvic movement

BACKGROUND

Movement control of the lumbar spine and its stability depends on passive, active, and neural elements of this region [1]. Any impairment in any of these elements may result in lumbar spine control deficits during postural and functional movements [1]. 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 [2,3]. If movement in the lumbopelvic region has a greater range and/or begins earlier than normal, abnormal stresses will be exerted on lumbar tissues. This faulty lumbopelvic movement can be associated with microtrauma and tissue injury and, subsequently, LBP symptoms [2,3]. Therefore, as long as lumbopelvic motion frequency has a greater range or occurs earlier, tissue stress, microtrauma and LBP symptoms will persist [4,5].

Increased lumbopelvic motion with limb and trunk movements has been observed in previous studies in patients with LBP [6-10]. Increased and/or early lumbopelvic motion during lower limb movements was associated with increased pain symptom provocation, while restriction of the lumbopelvic motion was associated with a decrease in the pain intensity [11,13-15]. Accordingly, the assessment of the lumbopelvic movement pattern during lower limb movements is an important part of the clinical examination of patients with LBP.

Both active and passive lower limb movements could be used in the examination of lumbopelvic movement patterns in patients with LBP. Testing passive movements provides information about passive tissue characteristics such as relative flexibility and passive stability of the lumbar spine [3,16]. Based on the movement system impairment (MSI), increased flexibility of the lumbopelvic tissues, resulting from repeated lumbopelvic motion in a specific direction, contributes to the development of LBP [3]. Therefore, examination of lumbopelvic movements during passive lower limb motion can help identify the direction in which the lumbopelvic region predominantly tends to move and whether there is more flexibility or less stability. Lumbopelvic motion has been previously examined during active limb tests in LBP people, but as yet the lumbopelvic movement pattern has not been examined during passive lower limb motion [17,18]. Therefore, one purpose of the current study was to examine lumbopelvic movement during passive lower extremity motion.

The MSI theory has also proposed that different groups of patients may have different lumbar spine impairments, because different groups of patients may engage in different activities [3]. If this is the case, we could expect differences in lumbopelvic movement patterns between different LBP patients in regard to their specific activities during lower limb movements. However, differences in lumbopelvic movement between two groups of patients with LBP who perform different specific activities have not been examined to date. So, the second purpose of the study was to clarify whether the lumbopelvic region moves in a different way in people with LBP who perform specific activities than in other people with LBP who do not perform those activities.

Hip external rotation is a lower limb motion which is used in the examination of people with LBP [3,12,13]. This limb motion was associated with pain stimulation in some LBP patients performing rotational demand activities (RDA), i.e. activities which involve regular trunk and hip rotation motion [4,5,13]. Hence, lumbopelvic motion in patients with RDA during hip external rotation has been examined in some studies [4,5,17].

To date, differences in lumbopelvic rotation during hip external rotation have been evaluated between males and females, people with and without LBP and two groups of people with LBP sub-classified based on the MSI [4,5,17]. But, all of those studies relied on testing active movement and lumbopelvic and hip movement patterns during passive hip external rotation (PHER) were not investigated.

Furthermore, increased lumbopelvic motion was observed in different groups of patients involved with LBP regardless of whether they performed or did not perform RDAs [7-10]. Accordingly, it seems that lumbopelvic movement impairment is a common finding in patients with LBP. It has not been clarified whether insufficient control of lumbopelvic in a specific direction is task-specific or not. If this is true, patients performing RDAs must exhibit more and/or early lumbopelvic rotation than patients who do not perform RDAs. However, to date lumbopelvic movement pattern differences between LBP patients involved or not involved with rotational demand activities during PHER have not been investigated.

Therefore, this study was designed to compare lumbopelvic movement patterns during PHER between LBP patients with and without sport-related rotational demand activities.

We hypothesized that LBP people with and without RDA would exhibit different patterns of lumbopelvic movement during the PHER test. We also hypothesized that, compared to LBP people without RDA, people with LBP who did RDA, would demonstrate a greater tendency towards lumbopelvic region movement in the horizontal plane.

MATERIAL AND METHODS

Participants

Thirty patients with non-specific chronic LBP referred by a physician participated in this study [19]. Those participants who met the inclusion criteria were asked to participate in the study and signed a consent form approved by the Shahrekord University of Medical Science, Iran. The group consisted of fifteen participants with LBP (mean age =31.57.7 years) who participated regularly in sporting activities such as squash, tennis and golf and 15 patients with LBP (mean age = 32±7.8) who did not participate in any RDA. Patients with any of the following conditions were excluded from participating in the study: 1) acute flare up of LBP [20], 2) lumbar spine pathology such as infection, tumor, rheumatological disease and degenerative joint disease 3) intervertebral disc bulging, 4) leg length discrepancy, 5) lower extremity injury and dysfunction, 6) neurological and psychological illnesses, 7) radiculopathy.

Outcome measurements

A self-report questionnaire was used to obtain information relating to demographic characteristics and history of LBP. A Visual Analogue Scale (VAS) was used to assess pain intensity, while LBP-related disability was examined using the Persian version of the Oswestry disability questionnaire [21,22]. The level of physical activity in the patients with LBP was measured by using the Baecke habitual physical activities questionnaire whereas fear avoidance behavior was evaluated by the Persian version of the fear-avoidance belief questionnaire [23,24].

Special lower limb movement test

The test that we used in our study was the PHER test [3]. The patients were in the prone position, with their arms positioned on both sides of the body and the lower extremities in a neutral position with regard to abduction/adduction and internal/external rotation, and the head rotated to one side as was comfortable for the patient. Then, the examiner conducted PHER tests on both hips of each participant but the first hip to be tested was selected randomly. The examiner was blinded with respect to participant assignment to a subgroup. At the beginning of the test, the knee joint was held by the examiner in 90° flexion and the hip joint was in a neutral position with respect to rotation and abduction/adduction. The patients were asked relax as much as they could during the test. During the test the examiner held the distal part of the participant’s leg, proximal to the lateral and medial malleolus, then externally rotated their hip joint to the end point of hip external rotation range of motion (ROM) and returned to the starting position. Three attempts were made for each side in every patient (Fig. 1 shows the starting position and Fig. 2 shows the terminal position for the test).

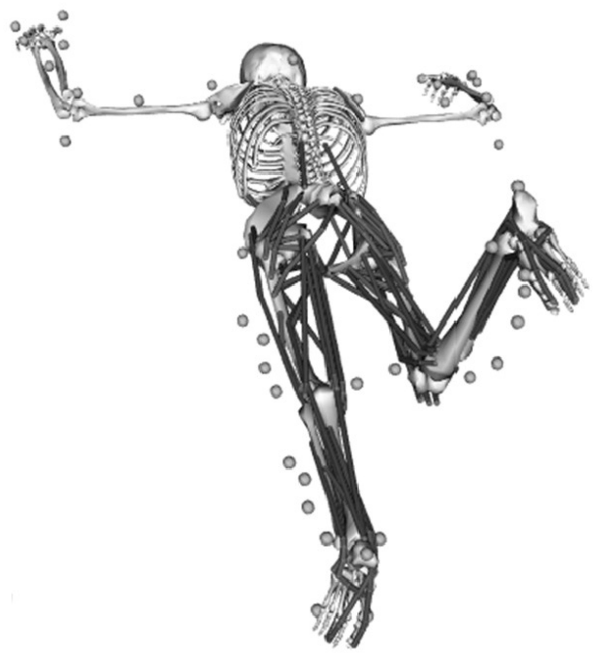

Fig. 1. Shows the starting position for the test

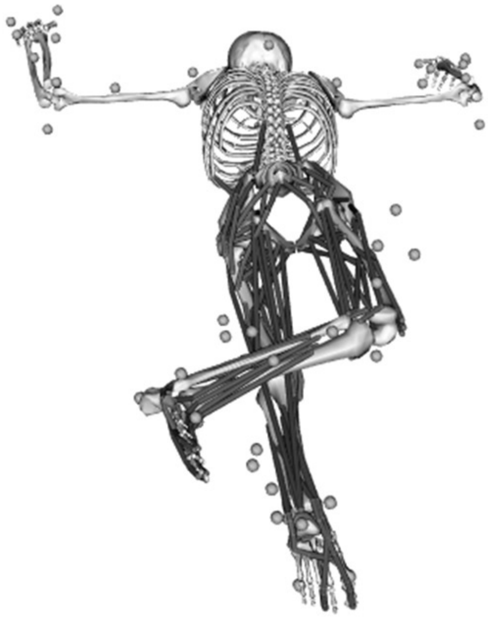

Fig. 2. Terminal position for the test

Kinematic measurements

Kinematic measurements were carried out using a 3-D motion analysis system with 7 cameras. Reflective markers were attached to 7 anatomical landmarks: the second sacral spinous process (S2), bilateral posterior superior iliac spines, and bilateral lateral knee joint lines and lateral malleoli [25]. The static resolution for each camera was 1mm/m^3 and the sampling rate was 120 Hz. Data were collected in the Isfahan University of Medical Sciences lab.

Data processing

All data were filtered at the 2Hz cutoff frequency with a dual-pass Butterworth filter [25]. Besides the vectors derived from PSIS of both sides at the initial and terminal points of movement, angular rotation ROM and angular velocity of the pelvic segment were calculated [25]. The vectors between the lateral knee joint line and the lateral malleolus markers were employed for the calculation of lower limb external rotation ROM and its angular velocity [4,25]. The initial and terminal points of movement were determined based on previous similar studies [4,5]. Because the examiner performed the test movement at self-selected speeds, the raw data were re-filtered by a trail-specific cut-off frequency [4,5,25]. Subsequently, pelvic rotation in the horizontal plane and hip external rotation ROM for the full range of the test, pelvic rotation from the starting point of limb movement to the mid-range of lower limb rotation and timing of the motion between the lower limb and the pelvic motion were calculated by MATLAB software. To determine the timing of hip and pelvic rotation, the amount of hip external rotation completed prior to the start of lumbopelvic rotation was calculated [4,5]. A large value of the timing variable would indicate less synchronized hip/pelvic motion and vice versa.

Statistical analysis

All statistical analyses were performed with SPSS 20 software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY). Normality of the data was initially evaluated by the K-S test. Due to the parametric nature of the data collected, group comparisons were made using the independent t-test.

RESULTS

Our results show that there were no significant differences in mean age, body mass index (BMI), duration of LBP, weight and height between the groups (all p-values>0.05) (Table 1). In addition, pain intensity was not significantly different between the two groups ($p > 0.05$).

LBP-related disability and fear-avoidance behavior in the group without RDA were significantly greater than in the group with RDA ($p < 0.05$). At the same time, the level of habitual physical activities in the group with RDA (9.231.3) was significantly gre-

Tab. 1. Subject characteristics

	Group without rotational activities (n=15) Mean (±SD)	Group with rotational activities (n=15) Mean (±SD)	Mean difference(95%CI)	Degrees of freedom (df), P-value
Age (years)	32 (±7.8)	31.5 (±7.7)	-0.53 (-6.3 – 5.3)	df=28, p=0.853
Height (m)	1.76 (±0.07)	1.77 (±0.06)	0/006 (-0/037 – 0.049)	df=28, p=0.776
Weight (kg)	76.8 (±11.5)	80.5 (±11.4)	3.7 (-4.8 – 12.2)	df=28, p=0.384
BMI (kg/m²)	24.8 (±3.28)	25.6 (±3.7)	1 (-1.7 – 3.7)	df=28, p=0.458
LBP duration (month)	19.06 (±13.6)	20 (±18.2)	0.4 (-11.6 – 4.12)	df=28, p=0.946
Average pain	4.7 (±1.2)	4.5 (±1.2)	-0.2 (-1.1 – 0.74)	df=28, p=0.668
Most pain	5 (±1.4)	5 (±1.8)	0 (-1.2 – 1.2)	df=28, p=1.000
Current pain	2.1 (±2.4)	2.2 (±2.0)	0.06 (-1.6 – 1.7)	df=28, p=0.936
Oswestry score	22.1 (±7.6)	15.2 (±9.7)	-6.9 (-13.4 – -0.39)	df=28, p=0.038*
Fear-avoidance during physical activity	19.7 (±4)	14.2 (±5.6)	-5.5 (-9.2 – -1.8)	df=28, p=0.005*
Fear-avoidance during work	21.1 (±10.3)	16.6 (±8.5)	-9.5 (-16.6 □-2.4)	df=28, p=0.010*
Habitual physical activity	5.8 (±1.4)	9.2 (±1.3)	3.4 (2.4 – 4.4)	df=28, p=0.000*

Tab. 2. Mean differences in kinematic variables during bilateral passive hip external rotation test

variables	Group without rotational activities (n=15) Mean (±SD)	Group with rotational activities (n=15) Mean (±SD)	Mean difference (95%CI)	Degrees of freedom (df), P-value
pelvic rotation angle (degree)	9.7 (±2.37)	11.8 (±2.7)	2.07 (0.16 – 3.9)	df=28, p=0.034*
Hip rotation angle (degree)	49.4 (±6.54)	48.1 (±4.06)	-1.27 (-5.3 – -2.8)	df=28, p=0.527
Timing of pelvic rotation (degree)	7 (±7.5)	6.4 (±6.39)	-0.61 (-5.8 – 4.6)	df=28, p=0.811
Pelvic rotation in first half of motion (degree)	4.4 (±2.58)	3.9 (±2.82)	-0.48 (-2.5 – 1.54)	df=28, p=0.631

*Values expressed in degrees

ater (p=0.00) in comparison to the group without RDA (5.81.4) (Tab. 1).

As a result of kinematic differences between the two groups, the mean hip external rotation ROM was 48.1±4.06 in the group with RDA and was 49.4±6.54 in the group without RDA. This variable was not significantly different between the two groups (p=0.527). Pelvic rotation in the group with rotation (11.8 ±2.7) was significantly greater than the group without rotation (9.7 ±2.37) (p=0.034). There were no differences between the two groups in timing and pelvic rotation during the first half of the movement (p> 0.05) (Tab. 2).

DISCUSSION

Comparison of participant characteristics and clinical measurements

As shown in Table 1, there were no differences in age, weight, height, BMI and duration of LBP between the two groups. Although mean pain intensity was not significantly different between the two groups, LBP-related disability was greater in the group without RDA than in the other group. One reason behind this difference may be related to differences in the level of fear-avoidance between the groups. Several studies have established that psychological factors, such as the level of fear-avoidance, are related to disability in patients with LBP more than pain intensity [26,27]. For example Crombez et al. study clearly showed that fear-avoidance beliefs were more disabling than pain intensity alone and fear-avoidance belief had a prominent role in determining LBP-related disability [26].

In our study, lower levels of disability in the group with RDA may be due to their regular participation in recreational activities, such as sporting activities, and this may decrease the negative effect of fear-avoidance and help the participants perform their activities with greater confidence.

Kinematics comparison

There are anatomical and functional relationships between the hip joints and the lumbar spine [4]. Therefore, the role of hip rotation ROM impairments in the development and persistence of LBP symptoms has been studied in previous research and was also investigated in our study [28-33]. Most previous studies have investigated the relationship between active, passive and total hip internal/external rotational ROM and low back pain without taking into account the lumbopelvic movement pattern. A limited hip rotational ROM has been reported in patients with and without RDA in comparison to respective healthy control groups [28-33]. However, differences between patients with and without rotational activities were not considered in any these studies. Thus, current study compared passive hip external rotation ROM between LBP patients with and without RDA. Our results cleared that there were no differences between the two groups in these variables. A decreased hip external rotation ROM was not reported in the other LBP participants with and without RDA in comparison with the healthy groups. Impaired hip rotation range of motion may be an important contributing factor in LBP, especially in people who regularly participate in sport and functional activities that need repeated near-full-range hip and trunk rotation [33]. The reason is that they perform their specific activities with full or nearly full range of trunk and hip joint rotation. Any decreased rotational ROM in each of these segments causes compensatory rotational motion in other segments. There is a hypothesis that assumes that a decreased hip rotation ROM leads to compensatory rotational motion in the lumbar spine and, in time, results in tissue microtrauma, injury and eventually low back pain symptoms [33]. One reason why we did not detect any differences in hip external rotational ROM between our groups may be due to our study using the mean values of left and right hip ROM.

The purpose of the study was to examine and compare lumbopelvic rotation, i.e. motion in the horizontal plane, during the PHER test between two groups of LBP patients with and without RDA. Limb movements are associated with lumbopelvic motion [17]. If the lumbopelvic motion during active and passive limb movement take place in a greater range than the neutral zone and occurs earlier, it can be expected that lumbopelvic motion will occur in a greater range and/or earlier during functional physical activities [3]. This faulty movement in the lumbopelvic region can cause injury to lumbar spine tissues and, subsequently, LBP symptoms. Lower limb movement, such as prone hip rotation, is no exception. Thus, the investigation of lumbopelvic movement patterns during active and passive limb movement tests such as hip external rotation is extremely important. Previous studies have relied exclusively on active lower limb testing to investigate lumbopelvic motion [4,5,17, 25]. However, evaluation of lumbopelvic movement during the PHER could provide information about the characteristics of passive tissues. For example, an increase in the flexibility of lumbar spine tissues would manifest itself as an increase in lumbar spine motion during lower limb motion [3]. We hypothesized that people engaged in RDA would exhibit a greater tendency to lumbopelvic rotation during the PHER test. As the result shown, pelvic rotation ROM in the patients with RDA was significantly greater than in the patients without RDA. The result of the study, with regard to pelvic rotation, was consistent with the results of a study by Scholtes et al. [17]. They observed that LBP people with RDA had a greater magnitude of lumbopelvic rotation than the healthy group. As already mentioned, increased lumbopelvic movement during limb motion cloud be related to increased flexibility in the lumbopelvic region [3]. The pattern of lumbopelvic region movement in the patients with RDA may represent decreased lumbopelvic stiffness in the direction of the rotation.

Furthermore, increased and/or early lumbopelvic motion during trunk and lower limb movements has been reported in different groups of patients with LBP [6-9,18]. In a study by Shum et al., participants with low back pain had greater lumbar spine rotational motion during putting on socks [34]. In Burnett et al., cyclists with low back pain had greater spinal flexion and rotation during cycling [6]. Therefore, based on the previous studies, excessive lumbopelvic motion during trunk and limb motion is a common finding in people with LBP. However, it was not clear whether repeated movement could affect the lumbopelvic movement pattern in relation to motion needed for performing those tasks. Consequently, one aim of the current study was to determine whether lumbopelvic movement configuration in people with LBP was task-related. If this were true, patients with RDA would show more obvious impairment of lumbopelvic rotation than people without RDA.

Our results also demonstrated that the patients with RDA had more lumbopelvic movement impairment, in the form of excessive lumbopelvic rotation, in the transverse plane. The results of the current study corroborate the findings of previous research in providing evidence that different subgroups of people with LBP may exist based on the lumbopelvic movement pattern and kinesiological model [5,35, 36]. Therefore, a standard classification of chronic low back pain needs to be developed for future study and, furthermore, every group of patients may require a specific and customized treatment plan.

Most everyday physical activities performed in the early and mid-ranges of lumbar and hip joints movement instead of at the extreme of ROM [4,37]. Most lower back pain and symptoms occur during or after performing such activities [4]. Therefore, lumbopelvic movement examinations in the mid-range of hip rotation and timing of hip/pelvic motion have been performed in previous studies. Evidence demonstrated that patients with RDA had a greater magnitude of lumbopelvic rotation in mid-range during a hip rotation test and greater simultaneous pelvic/hip rotation during an active hip rotation test. However, our result shows that there were no differences between groups in pelvic rotation during the first half of movement and timing of pelvic/hip rotation. Accordingly, we assume that this may be due to the fact that passive stiffness is dominant in the end-range of motion and we examined lumbopelvic movement patterns in early to mid-range of movements.

Limitation: There were several limitations to our study. As a passive test was used for lumbopelvic movement examination, we could not determine any possible differences between the two groups during the active test. We did not use electromyography for assessing muscle activity during the test. The test was nonfunctional and, in future studies, lumbopelvic movement differences between two groups during functional activities should be considered. In addition, it was unknown how many patients in each group had any impairment in rotational direction. The study also involved patients practicing a variety of types of rotational demand sports activities. The lumbopelvic movement pattern was examined in the early and first 50% range of the test. It is recommended that, in future studies, lumbopelvic motion should be examined in the 2nd half of the test. One more significant limitation of the study was the small size of the groups.

CONCLUSIONS

1. A greater lumbopelvic rotation ROM during the PHER existed in LBP patients who regularly participated in RDA.
2. Different groups of patients with LBP who engage in different specific activities may have a specific lumbopelvic movement pattern impairment.
3. Therefore, each group of LBP patients in regard to their specific activities may need a different, specific plan of treatment.

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