Manipulation Effect on Lumbar Kinematics in Patients with Unilateral Innominate Rotation and Comparison with Asymptomatic Subjects

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ABSTRACT

Background: Lumbar motion analysis is used as a clinical method in the diagnosis and treatment of low back pain (LBP). So far, no studies have shown if manipulating the sacroiliac joint (SIJ) will change spinal kinematics.

Objective: The main objectives of this study were to investigate the effects of SIJ manipulation on the lumbar kinematics in subjects with innominate rotation and to compare lumbar kinematics among experiment and control groups.

Material and Methods: This study was a quasi-experiment-control trial study. 21 LBP patients with anterior or posterior innominate rotations in experiment group and 22 asymptomatic subjects in control group were evaluated. Lumbar kinematic variables (LKV) include lumbar range of motion (ROM) and speed, lumbar lateral flexion and rotation asymmetry were evaluated using Qualysis Track Manager (QTM) twice within two days in control group, and these parameters with pelvic asymmetry and disability were tested before and after intervention in the experiment group.

Results: While pre-intervention experiment group exhibited significantly lower lumbar lateral flexion ($p=0.0001$), rotation ($p=0.008$) ROM and lower lateral flexion speed ($p=0.014$), post-intervention experiment group exhibited significantly lower lumbar lateral flexion ($p=0.01$) ROM in comparison with control group. Pelvic asymmetry ($p=0.049$) and disability ($p=0.01$) significantly decreased in the experiment group after manipulation, but LKV did not change significantly after the intervention ($p>0.05$).

Conclusion: Experiment groups had different lumbar kinematics in comparison with control group before and after SIJ manipulation. Despite the changes in pelvic asymmetry and disability, intervention had no effect on lumbar kinematics.

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Introduction

Low back pain is one of the most important social problems [1] and one of the most common forms of chronic pain, a major cause of disability and expenditure in industrial societies [2, 3]. Evaluation of spinal motion is used as a clinical method in the diagnosis and treatment of back pain [4]. Several studies suggest that unilateral low back pain is accompanied by asymmetric movements in lateral bending in the frontal plane and rotation in the transverse plane [5-9]. Al-Eisa et al. showed that abnormalities of the pelvic anatomical structure are related to change mechanics in the lumbar spine in such a way that lumbar movement asymmetry in frontal and transverse planes is related to pelvic asymmetry in the same plane. Although asymmetric movement in the back has been reported, factors that might lead to such an asymmetry in either normal or patient populations are not well understood [4, 5].

Considering the variability in the lumbar range of motion as a result of measuring tools and methods [10] or biological differences of the people because of their age [11], it is possible to consider the movement asymmetry in frontal and transverse planes as the measuring scale of the kinematic impacts of intervention. Analysis of movement patterns in subgroups of low back pain subjects during body movement in different directions is highly important because it may help therapists determine movement disorders in these subjects and use purposeful interventions including manual therapy and active rehabilitation [12].

Among conservative methods, manual treatments including manipulation and mobilization have been prescribed as effective treatment methods for acute and chronic LBP [13, 14]. Several studies have reported the therapeutic effects of spinal manipulation as an intervention on pelvic asymmetry [15], ROM improvement [16, 17] or unimproved ROM [18, 19]. According to Millan et al, non evaluation of the ROM as a variable is because of no ROM change following manipulation; there might be changes in spinal kinematics and quality of movement after manipulation [20]. Two variables of ROM and speed of movement as possible trends in future clinical trial studies show the effectiveness of orthopedic manual interventions in ROM and speed of movement in comparison with the simple effect on pain and disability [12].

Regarding the lack of evidence on the effects of SIJ manipulation in subjects with unilateral anterior or posterior rotations of the pelvis on lumbar kinematics in frontal and transverse planes, this study was conducted to evaluate the effects of SIJ manipulation on lumbar kinematics such as movement asymmetry, total ROM and speed in unilateral LBP subjects caused by innominate rotation and to compare the results with a control group.

Material and Methods

In the current quasi-experiment-control trial study, informed consent was obtained from the participants, and the study protocol was approved by the Ethics Committee of Iran University of Medical Sciences (code: 5787) and also registered in the Clinical Trial Center (registration code: 201502187057N4).

Eighty-two people with LBP were initially recruited from the clinics of Iran University of Medical Sciences in the experiment group, of whom 21 subjects who had the inclusion criteria entered the study voluntarily. Twenty-two asymptomatic subjects with no history of LBP during the past one year were recruited as the control group.

The inclusion criteria were age between 20 to 60 years, unilateral Lumbosacral referral pain to the knee without a radicular origin, and a diagnosis of unilateral anterior or posterior innominate rotation. If there was any kind of manipulation contraindication including fracture, herniated disc, rheumatoid arthritis, surgery, malignancy, pregnancy, osteoporosis or nerve root involvement, the subjects were excluded from the study.

Sample size was calculated based on the pelvic asymmetry changes by SIJ manipulation in the Child et al. [15] study, with the following formula [$N=7.78\times2(SD/\text{change mean})^2$].

For detecting innominate rotation in this study, three clinical tests including Standing flexion, Gillet and Prone knee bend tests were used. Some studies have shown moderate to substantial intra- and inter-examiner reliability for clusters of motion palpation tests [21, 22]. The lumbar spine was assessed through palpating the transverse processes by the therapist to ensure the absence of any dysfunction in this region.

Variables included pelvic asymmetry, lumbar lateral flexion, rotation asymmetry, mean speed of lumbar lateral flexion and rotation before and two days after the intervention session. The Oswestry Disability Index questionnaire (ODI) was employed to evaluate the impact of the intervention on the level of functional disability after two weeks. Ten reflective markers were recorded three-dimensionally using QTM (Qualysis Medical AB, Gothenburg, Sweden) which consists of six video cameras. Each marker could be seen by at least two cameras anywhere during the motion. Data were processed at 100 Hz using Open Sim techniques by a biomechanical engineer and the accuracy of the Qualysis device has been reported [23]. For the measurement of pelvic asymmetry, ASISS and PSISS were palpated and markers with a diameter of eight millimeters were placed on them. Then, the height of ASISS and PSISS from the floor and their distances from each other (pelvic width) in the standing position were characterized by the cameras of the motion analysis system. The height difference of the ASISS divided by their distances from each other as well as the height differences of PSISS divided by their distances from each other multiplied by 100 showed pelvic asymmetry ration which defines the slope between ASISs and the slope between PSISs [24]. For the measurement of lumbar lateral flexion and rotation asymmetry in frontal and transverse planes, ten markers were used. The markers were placed on the first and fifth lumbar vertebrae, PSISs, the apex of the sacrum, ASISs and the clavicle. A pair of markers were placed 7cm from the first lumbar vertebra. Trunk movements including lumbar lateral flexion and rotation were measured in the standing position. Each movement was repeated three times and movement characteristics included maximum ROM to the right, maximum ROM to the left and the entire ROM from left to right. To quantify lumbar movement asymmetry, lateral flexion or rotation difference between the right and left divided the entire range of motion from right to left and its percentage was calculated. The speeds of lumbar lateral flexion and rotation movements were recorded in an arbitrary and non-imposed manner. The mean speed was calculated by the sum of the maximum speed of the lumbar right and left lateral flexion or rotation divided by two. Functional disability was evaluated before and two weeks after using ODI in experiment group.

In experiment group, the manipulation technique to correct the right posterior innominate rotation was done in the following way: with the subjects lying on the right side and the therapist standing in front of them palpating the lumbosacral region, the therapist turned the subject's trunk to the left to the lumbosacral region and extended the subject's lower limbs until the base of the sacrum began to move forward and the subject's left knee was placed in the right popliteal fossa. While the right arm of the therapist fixed the subject's trunk and the left sacroiliac joint was parallel to the bed, he put his right hand's pisiform on the left side of the subject's PSIS and tried to turn the left pelvis (innominate bone) forward by applying a thrust through his right forearm [25]. Two days after the intervention, all measurements were repeated in the experiment group like pre-intervention. The measurements were performed in the control group twice within two days without any intervention.

Data were analyzed using SPSS software version 19. The Shapiro-Wilk test was used to determine the normal distribution of variables in this study, which showed the variables were normally distributed ($P>0.05$). Changes in the experiment group including total ROM, movement asymmetry, mean movement speed, ODI and pelvic asymmetry were assessed before and after the intervention using paired t-test. The Effect size was calculated to compare the magnitude of the difference between before and after intervention in experiment group. Using MANOVA, differences in the three parameters including total ROM, movement asymmetry and the mean movement speed among experiment and control groups were evaluated. The Effect size was calculated to compare the magnitude of the difference among populations. Based on Bonferroni method, an alpha of 0.05 was divided by the number of dependent variables. According to three variables in the MANOVA, 0.05 was divided by 3 and the new alpha was 0.017. Due to the small sample size in this study, Pillai's trace test was the strongest among 4 selected tests. The significance level for other variables apart from MANOVA was set at 0.05.

Results

There was no significant difference between the two groups in demographic data (p>0.05). The primary characteristics of control subjects and patients with innominate rotation are shown in Table 1.

MANOVA demonstrated significant differences between the pre-intervention experiment and control groups in the lumbar lateral flexion speed, movement asymmetry and total ROM (F=8.24, P=0.0001). Moreover, there was significant difference between the post-intervention experiment and control groups in the lumbar lateral flexion parameters (F=3.53, P=0.03). There was a significant difference in lumbar rotation speed, movement asymmetry and total ROM between the pre-intervention experiment and control groups (F=3.18, P=0.03); while, there was no significant difference between the post-intervention experiment and control groups in lumbar rotation parameters (F=3.18, P=0.057). A review of variables that were different among pre-intervention experiment and control groups in the lumbar lateral flexion revealed that the mean speed (P=0.014) and total ROM (P=0.0001) were lower in the experiment group, while lateral flexion asymmetry did not have a significant difference (P= 0.10). In lumbar rotation, the total ROM (P=0.008) was less in the pre-intervention experiment group, but the mean speed (P=0.12) and rotation asymmetry (P=0.14) did not have a significant difference between the two groups. In lumbar lateral flexion, the total ROM (P=0.01) was less in the post-intervention experiment group, but the mean speed (P=0.76) and rotation asymmetry (P=0.54) did not have a significant difference between the two groups. In lumbar rotation, the total ROM (P=0.06), the mean speed (P=0.29) and rotation asymmetry (P=0.08) did not have a significant difference between the two groups. The difference between the control and experiment groups in principal motion is shown in Tables 2 and 3.

Paired t-test showed a significant difference in ODI (P=0.0001) and pelvic asymmetry (P=0.01) in the experiment group before and after treatment. There was no significant difference in movement asymmetry, total ROM and the speed of lumbar lateral flexion and rotation before and after the treatment in experiment group. Intra-group analysis before and after intervention in experiment group is shown in Table 4.

Table 1: Primary characteristics of control subjects and patients with innominate rotation.

Primary Characteristics	Control	Experiment	P Value
Male, Female	10.12	8.13	0.29
Age, year, mean(SD)	38(10)	42(11)	0.24
Weigh, kg, mean(SD)	72.3(7.8)	76.7(14.4)	0.22

Independent test

Discussion

The results of this study due to effect size showed that there was no difference between control and pre-intervention experiment groups in comparison with control and post-intervention experiment groups in lumbar lateral flexion and rotation kinematic variables. It indicates that the intervention in the experi-

Table 2: MANOVA results for the differences between the control (n = 22) and pre intervention experiment groups (n = 21) in principal motion.

Principal motion	Group	Range (◦)		Mean Speed (◦.s)		Asymmetry (%)	Group
		Mean (±SD)	P	Mean (±SD)	P	Mean (±SD	P
Lateral flexion	Control	38.1±7.1	0.0001*	22.5±4.4	0.014*	2.8±2.7	0.1
	LBP	28.7±6.6		18.6±5.2		5±3.5	
Axial rotation	Control	31.2±9.4	0.008*	53.2±15	0.14	2.9±2.4	0.12
	LBP	24.3±5.8		47±11.2		5.1±2.9	

*Significant difference

Table 3: MANOVA results for the differences between the control (n = 22) and post-intervention experiment groups (n = 21) in principal motion.

Principal motion	Group	Range (◦)		Mean Speed (◦.s)		Asymmetry (%)	Group
		Mean (±SD)	P	Mean (±SD)	P	Mean (±SD)	P
Lateral flexion	Control	36.9±7	0.01*	21.2±4.1	0.76	2±1.8	0.54
	LBP	28.8±5.5		20.5±5.1		2.6±2.5	
Axial rotation	Control	29.6±8	0.06*	52.1±14.4	0.29	3.3±1.4	0.08
	LBP	23.4±4.9		45.3±12.3		5.2±2.7	

*Significant difference

Table 4: Intra-group analysis before and after intervention in experiment group.

	SIJ Manipulation			
Outcome measures	Before	After	P Value	Effect size
OD	22.2±12.6	16.2±13.9	0.013	0.28
PA	6.9±2.7	4.7±2	0.049	0.3
TLF	28.7±6.6	27±6	0.14	0.1
TAR	24.8±5.9	24.9±6.6	0.97	0.001
MSLF	18.6±5.2	18±4.9	0.55	0.01
MSAR	46.6±11.1	45.5±17.5	0.75	0.004
LFA	5±3.5	3/9±2/3	0.19	0.08
ARA	5.1±2.9	5.05±3.2	0.92	0.001

PA=pelvic asymmetry, TLF=total lateral flexion, TAR=total axial rotation, MSLF=mean speed lateral flexion, MSAR=mean speed axial rotation, LFA=lateral flexion asymmetry, ARA=axial rotation asymmetry ment group is ineffective in the creation of lumbar kinematic variables. Of course, we did not find any significant change in lumbar kinematic variables after SIJ manipulation.

Al-Eisa et al. reported a significant difference between subjects with unilateral lumbosacral pain and control subjects in lumbar lateral flexion asymmetry; in contrast, Hidalgo et al. did not find any significant differences in lumbar lateral flexion between the groups and believed that lumbar lateral flexion was not a valuable variable to determine the kinematic pattern in LBP subjects. Regarding the differences among the results reported by these authors in the lumbar lateral flexion, it can be said that Hidalgo applied markers over the spinous processes of L3 and S2, while Al-Eisa placed markers on L1, L5 and sacral apex. It seems the use of marker on L5 by Al-Eisa is more logical because the fifth lumbar vertebra is the center of rotations and bending movements in the lumbar region [26]. Accordingly, normal and patient populations differ in lumbar lateral flexion and the results of our study and the study by Al-Eisa are consistent in this regard. Similarly, Gomez et al. also found a significant difference in lumbar lateral flexion asymmetry and no significant difference in lumbar rotation asymmetry between experiment and control subjects. Although Gomez only examined lumbar movement asymmetry, in the present study there were significant differences in ROM and mean speed of lumbar lateral flexion between experiment and control groups, while there was only significant difference in lumbar rotation ROM. Another study reported that Lumbar lateral flexion measurements, obtained using the Spine Motion Analyzer, are sufficiently reliable to be used for group comparisons but lumbar rotation measurements in the horizontal plane cannot be used for group comparisons [27]. To our knowledge, markers have less visibility by video cameras during lumbar rotation than lumbar lateral flexion, and the possibility of their removal is more during lumbar rotation. It seems that the evaluation of lumbar rotation kinematics would require a higher degree of accuracy.

In our study, due to no change in the total ROM, mean speed, movement asymmetry, improvement of the pelvic asymmetry and disability after the manipulation, it can be concluded that there is no relationship between lumbar movement parameters and disability, as indicated by other studies [28, 29]. In a review study, Millan et al. showed that vertebral and SIJ manipulations did not affect the lumbar and hip joint ROM. Harvey et al. also did not observe any significant change in the lumbo-pelvic kinematics after manipulation. Lehman et al. reported a high variability in the ROM including increase, decrease or no change in the ROM after the manipulation. Giles et al. showed that manipulation twice a week could cause significant changes in flexion of the lumbar spine after 2, 5 and 9 weeks. Lumbar kinematics may gradually improve over several weeks with repeated manipulation, but doing one manipulation is unlikely to improve lumbar kinematics. The results of the present study are in agreement with results of some studies that reported spinal manipulation did not affect lumbar kinematics [20, 30].

Considering the asymmetrical distribution of muscle tone around pelvis and its impact on lumbar movement asymmetry, it is better to use interventions that can help restore the asymmetrical muscle tone around the pelvis and lumbar regions. Therefore, it is necessary that future studies use targeted interventions on the pelvic and lumbar regions to correct movement asymmetry on the side of motion restriction.

Conclusion

Considering the fact that there was not difference between control and pre-intervention experiment groups in comparison with control and post-intervention experiment groups in lumbar kinematic variables, SIJ manipulation is ineffective in lumbar kinematics; but it returns unilateral innominate rotation and improves disability.

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Conflict of Interest

None

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