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Efficacy of Pelvic Repositioning Exercises on Pain, Hip and Shoulder Range of Motion and Disability of the Patients with Chronic Non-specific Low Back Pain: A Single Blinded Randomized Controlled Trial

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ABSTRACT

Background: Chronic non-specific low back pain (LBP) is one of the most controversial issues of experts. Positive Ober`s test was considered a contributing factor to LBP. Common intervention to address such problems was surgery or iliotibial band stretching. Recently, it was suggested that pelvic malalignment is the contributing factor to Positive Ober`s test. Pelvic repositioning exercises was argued as a solution for the treatment of chronic LBP followed by pelvic malalignment.
Methods: In this single-blinded randomized controlled trial, 18 patients participated and were assigned into the control and treatment groups using the block randomization method. One side Positive Ober`s test as an indicator of pelvic malalignment was used as an inclusion criterion to employ the patients who have pelvic malalignment and asymmetry. Patients were asked to complete the Oswestry disability questionnaire to assess their disability. Hip internal and external rotation and shoulder internal and external rotation ROM measured by a standard goniometer. An inclinometer measures hip adduction and abduction ROM. Outcome measures were reassessed after 12 days. Data were analyzed using the ANCOVA test to compare among groups.
Results: Patients in treatment group showed significant improvement of pain (P=0.01), ipsilateral hip adduction (P=0.00) and internal rotation (P=0.02) ROM and contralateral hip abduction (P=0.00) and shoulder internal rotation (P=0.00) ROM and Glenohumeral internal rotation deficit (GIRD) (P=0.001) compared with control group. There was no difference among groups for disability (P=0.34) and contralateral hip external rotation (P=0.06) and also there was no difference for contralateral shoulder external rotation (P=0.85) and ipsilateral shoulder internal (P=0.13) and external rotation (P=0.58).
Conclusion: Pelvic repositioning exercises are an effective treatment to reduce chronic LBP via improving pelvic alignment. These exercises improve GIRD and increase shoulder internal rotation ROM, contralateral to positive Ober`s test.

Introduction

Low back pain (LBP) is one of the most common health problems in the world, in addition to pain, limits physical activity [1]. About 80% of people experience LBP at least once in their life [2].

Many musculoskeletal impairments are considered possible mechanical causes of LBP in the literature like Sacroiliac dysfunctions [3], lumbar vertebral dysfunctions [4], movement impairments [5], and hip dysfunctions [6]. Positive Ober`s test indicating limited adduction of hip was considered a contributing factor

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of LBP by Frank Ober. He believed limited adduction of the hip put pressure on the lumbosacral region and sacroiliac joint, and via fascial expansions, put pressure on the sciatic nerve. He found out by surgical releasing of the iliotibial band (ITB) and tensor fascia lata, the patients with LBP would experience a decrease of pain and increase of Single leg raise test (SLR) range of motion (ROM) [7]. Later Kendall suggested stretching of ITB and tensor fascia lata instead of surgical release to eliminate the tightness [8]. However, a recent cadaver study showed 9075 N force is needed to change the length of ITB by 1%, and this amount of force is far outside of the physiologic range and cannot be applied in the clinical setting [9]. Recently it was argued that positive Ober`s test may be due to anterior and external rotation of hemipelvis which alters hip position rather than tightness of ITB and fascia lata [10, 11].

Diaphragm muscle plays an important role in postural stability in addition to respiratory function [12]. Decrease of the zone of apposition (ZOA) that is flattening the diaphragm dome; and insufficiency of transverse abdominal and oblique muscles may lead to Pelvic malalignment because they allow the ribs to be in an elevated and externally rotated position [13]. In the case of left hemi-diaphragm involvement, the anterior-superior pull of the diaphragm along with the anterior-inferior pull of iliopsoas exert an anterior directed force to the lumbar vertebra which increases lordosis [13] and induces lower thoracic and lumbar vertebral rotation to the right and left hemi pelvis to anterior rotation [11]. Because of the oblique orientation of the sacroiliac joint, anterior rotation of the pelvis will happen with abduction and external rotation [10, 13]. As there is a change in acetabulum orientation, there is compensation in the femur position [10], which makes it to be positioned in relative external rotation [13]. Diaphragm and pelvic floor muscles work synchronously and move parallel down and up when inhaling and exhaling, respectively [14]. Thus, unilateral dysfunction of the diaphragm may influence pelvic floor muscles symmetry and lead to the change of pelvic alignment. Ultra sonographic investigation has shown pelvic floor muscles asymmetry in people with lumbo-pelvic malalignment [15].

On the other hand, the diaphragm seems to have a crucial impact on the shoulder motion. Left ribs dysfunctions followed by left diaphragm hypertonicity and thoracic vertebral rotation may cause right ribs internal rotation and depression anteriorly and rib hump posteriorly, resulting in an inappropriate position of the scapula in a protracted, medially rotated, and anteriorly tilted position [13]. Normal function and effective motion of shoulder girdle is the result of interaction among lower extremity, pelvic girdle, and scapula [16]. As previous studies reported, limited hip internal rotation ROM is associated with compensatory contralateral shoulder external rotation ROM and torque and Glenohumeral internal rotation deficit (GIRD) [17]. While hip ROM is considered an important factor in shoulder ROM and torque production [17, 18], others believe pelvic alignment might be the underlying factor affecting hip mobility and contributing to shoulder dysfunctions [19]. It was reported that the patients with sacroiliac pain had an excessive anterior translation of the contralateral humeral head, and lumbo-pelvic dysfunctions may be an important factor in developing shoulder dysfunctions [18]. Pelvic alignment was shown to have a significant effect on shoulder internal rotation [19]. As suggested by Nourbakhsh et al. & Oliver et al., addressing lumbo-pelvic-hip complex as a global factor should be considered when treating shoulder GIRD and dysfunctions.

Some studies reported an immediate increase of hip adduction ROM after using pelvic repositioning exercises [11] and questioned the existing clinical reasoning for positive Ober`s test. Other studies reported longer-term efficacy of these exercises on hip adduction ROM either along with ITB stretching [20] or as an isolated treatment [19, 21-23]. Besides, some papers reported the effectiveness of pelvic repositioning exercises on reducing chronic LBP or the pain originating from sacroiliac joint and decreasing functional disability [10, 11, 21, 22, 24, 25]. Despite these findings, there is no paper investigating the effectiveness of pelvic repositioning exercises on both shoulder and lumbo-pelvic hip complex except one paper which targeted asymptomatic participants [19]. While, In the present study, the authors have recruited patients with LBP who had both pelvic girdle and shoulder ROM asymmetry, which shows a more extended pattern of asymmetry. A progressive series of exercises were used while previous trials used only one exercise.

This study aimed to investigate the effect of pelvic repositioning exercises on pain, hip and shoulder ROM, and disability of the patients with chronic non-specific LBP. We hypothesized these exercises using hamstring and hip adductors of ipsilateral side to positive Ober`s test, diaphragm, and abdominal muscles, would decrease the pain, functional disability, and GIRD and improve ipsilateral hip adduction, internal rotation ROM and contralateral hip external rotation and abduction ROM, and also contralateral shoulder internal rotation ROM compared to control group.

Methods

Study Design

This study used a single-blinded randomized controlled trial, pre-test post-test design. Each patient signed informed consent form.

The study was approved by the ethical board of university of social welfare and rehabilitation (Code IR.USWR.REC.1398.034); and was registered in Irct.ir with the number IRCT20201230049883N1.

Subject selection, randomization and blinding process:

Based on previous study (mean1=4.47, mean2=2.27, SD1=1.68, SD2=1.2), the sample size was calculated as 16 patients (power 0.8, α=0.05). Due to a possible drop in the subjects, 10 patients were considered in each group (total number=20). After physician referral, 35 patients with chronic LBP volunteered to participate in the study using a convenient sampling method. 16 patients didn`t meet the inclusion criteria. 19 patients were recruited with chronic non-specific LBP, meaning they didn’t have specific spine pathologies like spondylolisthesis, canal stenosis, and neurologic signs and symptoms. Their pain could not be attributed to a certain anatomical source. They should have aged between 20-45 years old to avoid degenerative changes. All patients should have a positive Ober`s test on one side, indicating the same side anteriorly and externally rotated innominate dysfunction and limited contralateral shoulder internal rotation. All examining and treatment processes were performed by a physiotherapist who was experienced in the musculoskeletal field. None of the patients was a professional athlete, but they were all involved in some recreational sports. Patients with bilateral positive Ober`s test, history of surgery in any part of the body were excluded. Patients were randomly assigned into control and treatment groups using the block randomization method. There were 5 blocks and 4 participants in each block that two of them belonged to the control group and two of them to the treatment group. Out of 20 patients that we had to recruit due to corona virus pandemic, we could recruit 19. Only Patients were blinded to group assignment and didn`t know in which group they were in (Figure 1). Only one patient of the treatment group left the study because of feeling pain in the hamstring because of previous hamstring strain, which was not reported to the therapist. All the procedure has been performed in a private physiotherapy clinic.

Testing Procedures

The measurement process included assessment of pelvic girdle alignment, shoulder, and hip ROM, pain, and disability.

ROM assessment: shoulder and hip passive ROM were bilaterally assessed using a standard goniometer and standard method of measurement [26]. Shoulder internal rotation ROM(ICC=0.94 & SEM=2.67) and external rotation ROM (ICC=0.87 & SEM=2.72) in supine position and hip internal rotation ROM(ICC=0.96 & SEM=1.91) and external rotation ROM(ICC=0.91 & SEM=2.82) were measured in sitting position [26]. An inclinometer was used to measure hip abduction ROM(ICC=0.78 & SEM=1.70) and adduction ROM (ICC=0.76 & SEM=1.89) in side-lying position [11]. Hip adduction ROM measured in Ober`s test was used as an indicator of pelvic girdle alignment [10]. Clinically, a horizontal line was used as a reference point indicating 0 degree of hip adduction. ROM more than this was assumed as a negative test. A positive test was indicative of malalignment of pelvic girdle, that is, anterior and external rotation of the same side innominate [10]. ROM measurements were done by the help of an assistant to ensure the precision of result. All ROM measurements were repeated 3 times, and the mean score was used for statistical analysis (Figure 2).

Pain assessment: visual analog scale (VAS) was used to evaluate the intensity of pain. VAS ranges from 0 to 10 scores.

Disability assessment: Oswestry disability questionnaire was used to evaluate the functional disability of daily living of the patients. It has ten parts, and each part consists of 6 statements, considering different levels of functional disability. Persian version of this questionnaire has excellent reliability (ICC=0.91) and good Construct Validity (Pearson correlation coefficients=0.66) with the physical functioning section of the SF-36 questionnaire and moderate concurrent validity with VAS (Pearson correlation coefficients=0.54)

Besides, outcome measures breathing type (diaphragmatic/ abdominal) and posture (scoliotic, kypholordotic, and so on) as a covariate was evaluated to see if they had any effect on the treatment. The physiotherapist evaluated the pattern of Breathing and posture through observation. Intervention procedure:

Treatment group: five Postural restoration exercises developed by Postural Restoration Institute [27] were used in the treatment group, all focused on the left (ipsilateral to positive Ober`s test) hamstring and adductors isometric contraction to neutralize anteriorly and externally rotated left hemipelvic by the use of Reverse action of hamstrings to pull the ischium caudally to generate posterior rotation of hemipelvis and reverse action of adductors to pull the ischium outward to generate hemipelvis internal rotation [11, 19]. Deep exhalation was used to recruit Abdominals and increase ZOA. Some exercises used the right gluteus maximus to generate right hip external rotation [10].

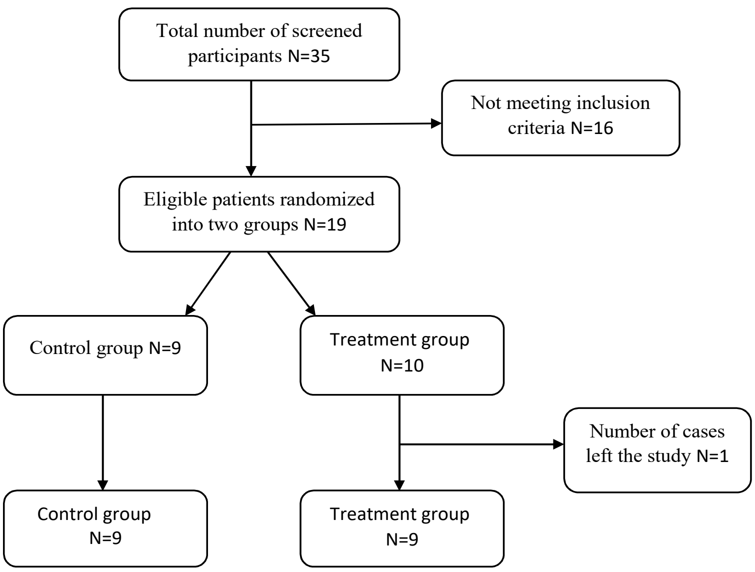

Figure 1: Flow chart for randomization

Figure 2: Measurement of hip adduction range of motion (ROM) using inclinometer

Figure 3: 90-90 Left hemibridge with ball and respiration

Figure 4: Right side lying left adductor pull back with respiration

Figure 5: Left side lying right Gluteus Max activation with respiration

Figure 6: Left side lying knee to knee with respiration

Figure 7: Wall supported squat with ball and respiration

Instructions

In the first session, 90-90 left hemibridge with ball and expiration exercise is used. Patients were asked to lie on their back with their heels on a box, and their knees and hips bent at a 90° angle. We placed a ball between their knees, their right arm in a 90° position. They were asked to push the left heel to the ground to recruit left hamstrings to generate posterior pelvic rotation and push the ball to recruit hip internal rotators, especially anterior fibers of the gluteus medius, and at the same time pull the left knee toward the ground, lower than right, to activate adductor magnus. While keeping above position, the patients were asked to exhale deeply and at the end, hold it for 4 seconds, then inhale without releasing abdominals. This cycle was repeated 4 sets of 4 breathe. The right arm was used as a reference point. The patient tried to rotate the upper thoracic to the right with each exhalation [11, 19] Figure 3.

The second exercise was performed similar to the previous one except that it was done in a right side-lying position, and patients focused on pulling back the thigh via the long axis of the femur to facilitate adductor magnus [12] Figure 4.

Third and fourth exercise was performed in a left side-lying position. Patients were asked to put their feet on the wall while knees and hips were in 90-90 position. They should have turned their right hip into external rotation and add a breathing part [10]. Figure 5. Left hip adduction was added to this position to address left and right pelvic musculature work at the same time Figure 6.

Finally, exercise performance was changed from non-weight bearing status to weight-bearing to make it a more functional position. The same procedure was performed as previous exercises Figure 7.

Control group: the patients in the control group performed five traditional exercises as follows: Double knee to chest 3 sets of 15, bridge, quadruped: apposite arm and leg raise (bird-dog), prone hip extension, and prone trunk extension all 10 sets of 10 seconds hold [28].

Patients were evaluated at the first session and then started their treatment based on their group. Each session, one exercise was added to the previous one and performed under the physiotherapist`s observation in both groups. They were visited 3 times in a week for 5 sessions, and two days after the fifth intervention session they have been evaluated again. Patients were asked to perform the exercises twice a day at home in addition to physiotherapy sessions.

Results

Statistical analysis was performed using SPSS 25. Chi-square analysis was used to evaluate the effect of quantitative variables (gender, posture, and breathe type) on the treatment. Shapiro-Wilk test was used to evaluate the normality of the data. ANCOVA test was used to evaluate and compare between groups of all quantitative continues variables considering the control variable (that is pre-test means here). Linear regression was used to assess the relative effect of left hip adduction ROM on contralateral shoulder internal rotation ROM.

Demographic information and descriptive statistics:

18 patients with chronic LBP aged between 20- 45 participated in the study. Descriptive data and contextual variables are presented in (Table 1). There was no significant difference between groups for age, sex, height. There was a significant difference between groups in weight and BMI (Table1). None of the gender (Table 2), posture (Table 3), and breathing type (Table 4) influenced the results based on 2×2 cross tables and chi-square test.

Effect of pelvic repositioning exercises on pain:

VAS score decreased in the control group from 5.77 to 4 (1.77 points) and in the treatment group from 5.77 to 2.55 (3.22 points). Using ANCOVA to compare means between groups revealed that reduction of pain was significantly higher in the treatment group (P=0.01). Eta squared was 0.33 (Table 5).

Effect of pelvic repositioning exercises on disability:

The amount of disability was measured by the Oswestry disability questionnaire and reported in percent. The amount of disability changed from 17.82% to 11.97% in the control group and from 18.55% to 10.55% in the treatment groups. Using ANCOVA, comparing the groups showed no significant difference between groups (Table 5).

Effect of pelvic repositioning exercises on hip ROM:

The ipsilateral hip adduction ROM changes from 2.18 degree to 12.73 degree in the treatment group. Using ANCOVA, comparing the groups showed a significant difference between groups (P=0.00). Eta squared was

Table 1: demographic information of participants (*Significant at P=0.05)

Variable(Unit of measurement)	Group	Range	Min	Max	Mean	SD	P value
Age(Year)	Control	25	20	45	29.11	8.97	0.55
	Treatment	17	20	37	31.33	6.59	
Height(centimeter)	Control	19	164	183	171	6.3	0.29
	Treatment	19	154	178	167.44	7.58	
Weight(kilogram)	Control	35	59	94	75	13.47	0.02*
	Treatment	29	51	80	61.78	8.02	
BMI(Kilogram per meter^2)	Control	12.9	20.4	33.3	25.58	4.12	0.03*
	Treatment	12.9	20	25.2	21.91	1.72	

BMI=Body Mass Index

Table 2: Chi-square test (group* gender)

Contextual variable	Gender				Chi-square	P value
	Group	Male	Female	Total		
Gender (number)	Control	2 (22.2%)	7 (77.8%)	9 (100%)	0.4	0.52
	Treatment	1 (11.1%)	8 (88.9%)	9 (100%)		
	Total	3 (16.7%)	15 (83.3%)	18 (100%)		

Table 3: Chi-square test (group* posture)

Contextual variable	Posture					Chi-square	P value
	Group	Normal	Scoliotic	Kyphosis-lordosis	Total		
Posture	Control	5 (55.6%)	1 (11.1%)	3 (33.3%)	9 (100%)	5.33	0.06
	Treatment	1 (11.1)	5 (55.6%)	3 (33.3%)	9 (100%)		
	Total	6 (33.3)	6 (33.3%)	6 (33.3%)	18 (100%)		

Table 4: Chi-square test (group* breathe type)

Contextual variable	Breathe type				Chi-square	P value
	Group	Abdominal	Diaphragmatic	Total		
Breathe type	Control	4 (44.4%)	5 (55.6%)	9 (100%)	2.1	0.14
	Treatment	7 (77.8%)	2 (22.2%)	9 (100%)		
	Total	11 (61.1%)	7 (38.9%)	18 (100%)		

Table 5: within group changes and between group comparisons of mean improvement of measured variables (*Significant at P=0.05)

Variable(unite)	Control group		Treatment group		Leven`s test	P value	Eta squared
	Mean±SD		Mean±SD				
	Pre test	Post test	Pre test	Post test			
VAS (score)	5.77±0.71	4±1.22	5.77±1.78	2.55±2.06	0.70	0.01*	0.33
ODI (percent)	17.82±5.37	11.97±4.26	18.55±10.54	10.55±7.82	0.08	0.34	0.06
LT Ober test (degree)	2.03±1.34	3.40±2.15	2.18±2.71	12.73±3.19	0.71	0.00*	0.77
LT Shoulder int.rot (degree)	70.84±9.38	72.29±7.80	64.81±7.89	74.10±9.59	0.12	0.13	0.14
RT Shoulder int.rot (degree)	51.84±7.87	59.03±7.88	45.44±9.50	69.47±9.07	0.53	0.00*	0.62
LT Shoulder ext.rot (degree)	105.62±12.99	106.96±12.40	102.44±14.21	103.06±13.07	0.29	0.58	0.02
RT Shoulder ext.rot (degree)	106.88±12.06	107.96±12.16	107.55±6.10	108.18±11.46	0.50	0.85	0.002
LT hip int.rot (degree)	35.59±9.22	39.21±9.73	42.03±8.01	49.92±5.33	0.14	0.02*	0.31
RT hip int.rot (degree)	41.99±12.61	47.07±12.61	47.73±5.27	50.84±6.16	0.24	0.99	0.00
LT hip ext.rot (degree)	51.58±5.11	51.92±6.07	45.99±7.11	52.81±4.53	0.79	0.11	0.15
RT hip ext.rot (degree)	48.03±9.82	49.29±6.28	44.29±6.34	50.70±4.55	0.22	0.06	0.21
RT hip abd (degree)	42.25±5.63	44.25±6.03	42.88±2.88	52.77±3.40	0.57	0.00*	0.60
LT hip abd (degree)	47.25±6.15	50.14±4.81	46.81±4.34	53.07±4.16	0.54	0.17	0.12
GIRD (degree)	19±7.13	13.25±3.95	19.36±6.18	5.66±4.25	0.11	0.001*	0.55

Right (RT), Left (LT), visual analog scale (VAS), Oswestry disability index (ODI), internal rotation (int.rot), external rotation (ext.rot), abduction (abd), Glenohumeral Internal Rotation Deficit (GIRD)

Table 6: The table of Regression (relationship between hip adduction range of motion (ROM) and contralateral shoulder internal rotation ROM) (*Significant at P=0.05)

Std error of the estimate	Adjusted R square	R square	R	Regression
8.489	0.256	0.30	0.548	

Predicting variable: post intervention left Ober`s test values

sig	F	Mean square	Df	Sum of square	Model
0.019*	6.852	493.815	1	493.815	Regression
		72.07	16	1153.134	Residual
			17	1646.949	total

Dependent variable: Right shoulder internal rotation ROM; Predicting variable: post left Ober`s test values

0.77 that showed intervention highly affected ipsilateral hip adduction ROM (Table 5).

Contralateral Hip abduction ROM significantly increased compared to the control group (P=0.00), and Eta squared was 0.6 that showed the high effect of the intervention on the contralateral (right) hip abduction ROM, while there was no significant difference between groups for ipsilateral hip abduction ROM (P=0.17) (Table 5).

The results showed ipsilateral hip internal rotation ROM significantly increased compared to the control group (P=0.02), and Eta squared was 0.31 showing a high effect of intervention. No significant difference was detected between groups for contralateral hip internal rotation ROM (P=0.99) (Table 5).

The analysis showed no significant difference between control and treatment groups for ipsilateral (P=0.11) and contralateral (P=0.06) hip external rotation (Table 5).

Effect of pelvic repositioning exercises on contralateral shoulder ROM:

Between groups, the comparison of shoulder ROM using ANCOVA revealed that contralateral shoulder internal rotation improved significantly in the treatment group (P=0.00) with high effect (Eta squared=0.62), while there was no significant change in ipsilateral shoulder internal rotation (P=0.13). Moreover, there was no significant change for external rotation of contralateral (P=0.85) or ipsilateral shoulder external rotation (P=0.58) (Table 5).

Glenohumeral internal rotation deficit (GIRD), defined as a side to side difference of shoulder internal rotation ROM changed from 19 degree to 13.25 degree in the control group and from 19.36 degree to 5.66 degree in the treatment group. Results showed treatment group experienced significant improvement of GIRD (P=0.001) compared to the control group. Eta squared was 0.55. About 13 degree of improvement in GIRD exceeded the minimal clinically important difference level that is 10 degree [19] (Table 5).

The linear regression model showed 30 % of improved contralateral shoulder internal rotation ROM was due to increasing ipsilateral hip adduction ROM (R^2=0.30) (Table 6).

Discussion

The effect of pelvic repositioning exercises on pain:

Our first hypothesis was that the improvement of pelvic alignment using pelvic repositioning exercises would decrease the pain in the patients with chronic non-specific low back pain. This study's results supported our first hypothesis. The results showed that pelvic repositioning exercises (treatment group) significantly reduced pain compared to the control group (P=0.01) beyond minimal clinically important difference level (MCID=2.5 points) [29]. The effect size of the intervention was high (Eta square=0.33). It is believed pelvic asymmetry may contribute to chronic pain [10, 12]. Asymmetry of pelvic may cause compression of the ilium to sacrum on the left side following left hemi pelvis anterior rotation, the distraction of right sacroiliac following posterior rotation of right hemi pelvic[30] or hip impingement [30], limited hip adduction and internal rotation. Pain also may be because of lumbar vertebral rotation [13].

Pelvic repositioning exercises using left hamstrings and abdominals, through posterior rotation of the left ilium by reverse action of hamstrings and recruitment of abdominals may reduce stress on the sacroiliac joints and ligaments and contribute to the decrease of pain. These exercises try to change acetabulum orientation by reverse action of adductors to achieve normal hip ROM and address hip impingement or excessive stress on the Acetabolu-femoral ligaments. Due to compensatory external rotation of the ipsilateral hip to the Ober`s test, there might be the adaptive shortening of posterior capsule or laxity of the anterior capsule of the hip that may contribute to hip impingement and causing sacroiliac instability or hip instability. All these conditions may produce low back pain [30]. It seems pelvic repositioning exercises and regaining neutral pelvic alignment is an effective way to decrease pain. Another possible mechanism for pain reduction using these exercises might be a neuromuscular improvement. Performing these exercises inhibit paravertebral and facilitates abdominal muscles which lead to a decrease of lumbar lordosis. On the other hand by positioning of hips at 90 degree, while performing the exercise, iliopsoas and tensor fascia lata are inhibited, and performing deep exhalation inhibits the diaphragm. Hence, they may contribute to a decrease of right lumbar rotation produced by over activity of diaphragm and iliopsoas that may be a possible source of pain [11].

This finding was in agreement with previous studies. Immediate effect [11] and long term [21, 22] effect of pelvic repositioning exercises were investigated in a single group [11, 25] or in comparison with iliotibial band stretching [21, 22], and all of them reported that these exercises affectively decreased pain [10, 24].

Effect of pelvic repositioning exercises on disability:

We hypothesized that pelvic alignment improvement would decrease the disability of the patients with chronic non-specific low back pain. We used the Oswestry disability index (ODI) to measure disability. The findings of the study didn`t support our hypothesis. There was no significant difference between treatment and control group in the reduction of disability measured by ODI (P=0.34), While, previous studies reported a significant decrease of disability using pelvic repositioning exercises. This difference may be due to the difference in the baseline disability of patients in the present study compared to previous studies. Patients participated in this study had low disability (mean ~ 18%) while it was medium (20-24%) [10] and high disability (40-60%) [22] in the previous reports [31]. Differences minimum 10 points (20%) reduction of disability is needed to consider the changes clinically significant [29]. Continuing the intervention for a longer time could decrease the amount of disability.

Effect of pelvic repositioning exercises on hip ROM:

Hip Adduction ROM:

We hypothesized that adduction ROM of the hip, ipsilateral to the positive Ober`s test, would increase significantly. According to the point that all the patients had positive Ober`s test on one side as an inclusion criterion, and all of them had limited left hip adduction ROM on the left. The results showed that pelvic repositioning exercises improved ipsilateral adduction ROM of the hip significantly (P=0.00) compared to the control group. The effect size of intervention was high (Eta square=0.77), showing that 77% of improvement of hip adduction ROM was because of the intervention.

The results were compatible with previous studies that reported ipsilateral hip adduction ROM improved significantly by pelvic repositioning exercises [11, 19, 20, 23]. Unilateral diaphragm dysfunction may lead to hemi pelvic anterior and external rotation [23]. Changing of acetabulum orientation following pelvic malalignment limits hip adduction ROM [10, 13]. Repositioning exercises via reverse action of hamstrings and adductors try to rotate the pelvic posteriorly and pull the acetabulum outward. Other components of the exercises like abdominal contraction and respiration help diaphragm and pelvic floor muscles to be in their optimal length to allow hemi pelvic to rotate posteriorly and internally [12, 13]. Placement of acetabulum in the neutral position prevents impingement of the neck of femur [11, 23] and allows the hip to freely adduct through full ROM.

Our findings showed a highly significant effect of improved pelvic alignment on Ober`s test and showed that it was probably pelvic malalignment as an underlying factor to limited hip adduction and positive Ober`s test [19, 23], not iliotibial band tightness [20]. Comparison of iliotibial band stretching with pelvic repositioning exercises showed that pelvic repositioning exercises were significantly more effective than iliotibial band stretching on positive Ober`s test [20].

Hip abduction ROM:

We hypothesized that hip abduction ROM, contralateral to the positive Ober`s test, would increase significantly. The results showed that pelvic repositioning exercises improved contralateral hip abduction ROM significantly (P=0.00). The effect size of intervention was high (Eta square=0.6), showing that 60% of improvement in the contralateral hip abduction was due to the intervention. There was no difference between groups for ipsilateral hip abduction ROM (P=0.17)

Despite the previous reports [23], our findings showed pelvic repositioning exercises effectively improved contralateral hip abduction ROM. The controversy might be due to the type of exercise that each study has used. In the current study, we employed exercises that emphasize right hemi pelvis and hip dysfunction and asymmetry [10]. When there is asymmetry of the pelvic, the right hemipelvic may rotate posteriorly and internally [23] along with the anterior rotation of the left hemipelvic. Because of tendency of patients to stand more on the right leg [13], a posterior directed force is exerted on the right ilium that makes the hip joint to be in the internal rotated and adducted position due to acetabulo-femoral internal rotation [23]. The activation of gluteus maximus and other external rotators which targeted on the exercises may facilitate hip external rotators and inhibit right adductor Magnus and internal rotators. Regaining the normal tone of the adductor magnus by using exercises may be the reason that allows the hip to abduct.

Hip internal rotation ROM:

We hypothesized pelvic repositioning exercises would significantly improve ipsilateral hip internal rotation ROM. The result showed pelvic repositioning exercises improved ipsilateral hip internal rotation significantly (P=0.02). The effect size was high (eta square=0.31) and the result showed there was no difference between groups for contralateral hip internal rotation ROM (P=0.99).

The result was not compatible with previous studies for ipsilateral hip internal rotation [19, 23]. Although there was the report of the improvement of side to side difference of ipsilateral hip internal rotation [23]. Pelvic repositioning exercises may have contributed in increasing hip internal rotation ROM through recruitment of ipsilateral hip internal rotators such as anterior fibers of gluteus medius and adductors. The activation of these muscles may have decreased external rotator tonicity via the reciprocal inhibition. Besides, the posterior capsule of the hip joint may have been stretched via adduction and internal rotation and led to an increase in internal rotation ROM.

Hip external rotation ROM:

We hypothesized pelvic repositioning exercises would significantly improve the contralateral hip external rotation. The results did not support our hypothesis and showed no significant difference between groups for ipsilateral (P=0.11) or contralateral (P=0.06) hip external rotation. The results were compatible with previous studies [19, 23], it seems pelvic repositioning exercises are not probably effective in increasing hip external rotation ROM.

Shoulder ROM:

We hypothesized that pelvic repositioning exercises would improve contralateral shoulder internal rotation and GIRD. The results showed pelvic repositioning exercises improved contralateral shoulder internal rotation ROM (P=0.00) with high effect size (eta square=0.62) and also improved GIRD significantly (P=0.001) with a high effect size (Eta square=0.55). The results showed no significant difference between groups for ipsilateral shoulder internal rotation ROM (P=0.13)

The results were compatible with the previous study [19], showing that pelvic alignment was a key factor for contralateral shoulder internal rotation ROM and GIRD. In some reports, the effect of limited hip ROM on the contralateral shoulder internal rotation has been discussed [17], but it seems that the effect of pelvic alignment as an underlying factor of hip ROM limitation was missed. Unilateral Pelvic anterior rotation along with unilateral diaphragm dysfunction may result some adaptive compensation toward the head such as contralateral trunk rotation, ipsilateral ribs external rotation and elevation, contralateral ribs internal rotation and depression [13], scapular dyskinesia [32], excessive anterior translation of humeral head [18] and contralateral shoulder mobility [19]. Our results were supported by a study that showed sacroiliac dysfunctions limit contralateral shoulder internal rotation. They explained that it was because of the altered function of the myofascial posterior chain [18]. They believed dominance of anterior sling to posterior sling would increase anteriorly directed force on the humeral head and limit shoulder internal rotation [18].

Considering the point that none of the participants performed shoulder stretching or ROM exercises, it seems pelvic repositioning exercises contribute to improve the internal rotation of the contralateral shoulder to the hip with Positive Ober`s test through improving pelvic alignment. Posterior rotation of ipsilateral hemipelvis using hamstrings, and internal rotation and depression of ipsilateral ribs using transverse and oblique muscles, increases ZOA and puts diaphragm in a more optimal position. The optimal position of the diaphragm makes it work more as a respiratory muscle [11]. On the other hand, increasing the activity of abdominals, posterior rotation of hemipelvis decreases the activity of iliopsoas [11]. These two factors altogether reduce the force exerted on the lumbar and lower thoracic vertebra and allow the vertebra to rotate back to the left. It helps retrieve the normal position of contralateral internally rotated and posteriorly humped ribs and so that normally oriented placement of contralateral scapula on the chest wall. Changing orientation of protracted, medially rotated, and anteriorly tipped scapula [13] via the alternation of muscle tones improves shoulder internal rotation ROM.

The results showed 30% of the increased internal rotation of contralateral shoulder ROM was because of improvements of ipsilateral hip adduction ROM (Ober`s test) that is indicator of pelvic alignment. (P=0.01, R^{2}=0.3) the result was very close to the findings of Nourbakhsh et al. (2018).

One of the limitations of the present study was that the authors didn`t have the opportunity to follow up on the results.

Conclusion

Pelvic asymmetry may cause LBP via the alternation of neuromuscular system or limiting joint motions. Pelvic repositioning exercises targeting pelvic asymmetry can decrease pain and increase hip joints ROM and functional ability in patients with chronic non-specific low back pain. Results of this study suggest pelvic repositioning exercises could be a treatment of choice to address ITB tightness.

The study also shows a distal to proximal link in the body and pelvic neutralizing exercises improve proximal asymmetries or dysfunctions such as shoulder ROM or GIRD.

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