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RESEARCH ARTICLE

EFFECT OF OPEN CHAIN VERSUS CLOSED CHAIN SEGMENTAL CONTROL ON SPINOPELVIC ANGLES IN ASYMPTOMATIC SUBJECTS

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ABSTRACT

Open Chain Segmental Control, Closed Chain Segmental Control, Spinopelvic Angles, Asymptomatic Subjects.
Purpose: This study aimed to measure of spinopelvic angles after application of open chain segmental control exercises versus closed chain segmental control exercises, pre and post application. Method: Twenty eight participants were randomly divided into two groups, groups A and B. Group A (n=15) received open chain segmental control exercises for four weeks. Group B (n=13) received closed chain segmental control exercises for four weeks. X-Ray and Corel draw software were used to evaluate participants' pelvic angles, pre and post-treatment. **Methods:** spinopelvic angles were measured before and after treatment in both groups. Spinopelvic angles were pelvic tilt (PT), pelvic incidence (PI), sacral slope (SS) and lumbar lordosis (LL). **Results:** There were changes in angles of spinopelvic parameters in both groups. The significant difference in pelvic tilt was shown in group "A" while there was a significant difference in pelvic incidence angle in group "B". **Conclusion:** Both open chain segmental control exercises and closed chain segmental control exercises showed a significance difference before and after application in spinopelvic angles.

INTRODUCTION

Maintaining a mechanically efficient posture necessitates proper spine-pelvic alignment. In order to achieve sagittal symmetry, the trunk and pelvis must be aligned with the hip joint. Since sagittal imbalance is influenced by spine-related factors (e.g., lumbar lordosis, thoracic kyphosis, pelvic parameters, and hip/knee joint contractures). In order to better analyze sagittal equilibrium, it is essential to determine spinal-pelvic parameters, which have been shown to have a close relationship. Pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) are pelvic parameters, whereas lordosis and kyphosis angles are spinal parameters. To measure spinal and pelvic motion, lateral radiography of the spine and pelvis in the standing position is needed(1). The current study's goal was to compare spinopelvic angles before and after open chain segmental control workouts against closed chain segmental control activities. The relationship between the pelvis and the lumbar spine is determined by: lordotic angle of the lumbar spine: The angle formed by the first lumbar and first sacral vertebral bodies' upper plates(2), Incidence of Pelvic angle is measured via the point where the line perpendicular to the sacral plate at its midpoint intersects with the line connecting the point to the femoral head's middle axis(3), Sacral slope is determined by the intersection of lines parallel to the sacral plateau and parallel to the ground(4), and pelvic tilt is determined by the intersection of lines parallel to the sacral plateau and parallel to the ground. The intersection of the lines that cross the midpoints of both femoral head centers and the midpoint of the sacral plateau with the line perpendicular to the ground is used to determine it. (5)

Closed chain segmental control: Using weight bearing closed chain exercises retain local muscle synergy contraction while gradually advancing load cues through the body. Weight bearing load should be gradually increased, with any weight bearing muscle at any kinetic chain segment being activated to provide adequate antigravity support and secure load transfer.

Open chain segmental control: Maintain local segmental control while increasing load through open kinetic chain movement of neighboring segments to facilitate progression,

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ensuring that all muscles are officially integrated into functional movement activities. This allows for the detection of any loss of segmental control during high-load tasks, ensuring that no compensation is required. Asymmetry of joints adjacent to the lumbopelvic area should also be treated to ensure that loss of mobility range does not compromise lumbopelvic flexibility during movement[6]

METHODOLOGY

In this study, the spinopelvic angles were measured before and after the administration of open chain segmental control exercises vs closed chain segmental control workouts in asymptomatic participants.

Design of the study: Pretest- posttest study design. The independent variables were open chain segmental control exercise and closed chain segmental control exercise. The dependent variables were spinopelvic angels. Twenty eight subjects were divided into two groups, from both sexes (15 females and 13 males) with age range from 18 to 22 years. Their weights and heights were collected for body mass index calculation. The subjects were divided into two groups.

Group A: this group consists of 15 subjects (10 females and 5 males) received open chain segmental control exercises for four weeks, 3 sessions per week.

Group B: this group consists of 13 subjects (5 females and 8 males) received closed chain segmental control exercises for four weeks, 3 sessions per week. The subjects were participated in the study under the following criteria; *Inclusion Criteria:* Asymptomatic subjects, the subject's age were ranged from 18 to 22 years, Body Mass Index was ranged from 19 to 33 kg/m², the subjects were chosen from both sex. All subjects were medically stable and do not suffer from any other diseases which might affect the trial results. *Exclusion criteria;* history of previous back surgery; acute and sever inflammatory conditions; neurological deficit; history of diabetes, circulatory or sensory disorders; symptoms of vertigo or dizziness and cardiopulmonary disease with decreased activity tolerance.

Treatment Procedures: Lumbopelvic x ray from lateral view for all subjects from standing position [X-Ray: Siemens Heathcare GmbH, Henkestr. 127 , 91052 Erlangen, Germany, model (240) 10092614, manufactured December 2017 was used. X-rays are highly penetrating, ionizing radiation used to take pictures of dense tissues such as bones[7]. Put each X ray on lighting unit and take a photo by HUAWEI Y7 prime 2018 camera to take a soft copy for each x ray picture. Put all soft copies of X ray pictures on a computer and measure the spinopelvic angels (sacral slope, lumber lordosis, pelvic incidence and pelvic tilt) by using CorelDraw graphic suits X7 software program and record the data.

Group A: this group consists of 15 subjects(10 females and 5 males) received open chain segmental control exercises. [Exercises in open chain, high velocity and high load. The goal was to maintain each position for 10 seconds and 10 repetitions for the following exercises]:

Transversus abdominis (TrA) activation: Hollowing- in maneuver “draw in the abdominal wall”. Participants were instructed to “take a relaxed breath in and out, hold the breath out and then draw in your lower abdomen without moving your spine" holding for 10 seconds and the goal was 10 repetitions.

Lumbar multifidus (LM) activation: Multifidus was activated from sitting to lumbar neutral position. Participants were instructed to look for neutral position while being in sitting. Holding for 10 seconds and the goal was 10 repetitions.

Lower limb abduction: From side lying position participants were instructed to abduct the upper leg then lower it down holding the abduction for 10 seconds and the goal was 10 repetitions.

Knee extension in supine position on roller: The participants were instructed to lie on a roller at supine position, flex one knee resting the foot on the bed and extend the other knee holding the knee extension for 10 seconds and the goal was 10 repetitions.

Group B: this group consists of 13 subjects (5 females and 8 males) received closed chain segmental control exercises, [Exercises in closed chain, low velocity and low load. The goal was maintaining each position for 10 seconds and repeating 10 times]. The following exercises were performed three sessions per week for a period of four weeks.

Closed chain lunge exercises, with the addition of hand weights: The participants were instructed to perform lunge exercise while holding an additional weight (1 kilogram) on each hand, holding for 10 seconds and repeating 10 times.

Bridge in prone position: The participants were instructed to begin lying face down on the floor with both legs fully extended. Lift his upper body from the floor and place both elbows on the floor, holding the position for 10 seconds and repeating 10 times.

Bridge in supine position: The patient was instructed to lie on the back with flexed knees and feet flat on the floor. Then, lift hip off the floor, holding the position for 10 seconds and repeating 10 times.

Lateral bridge: The patient was instructed to begin in side lying position with both legs fully extended. Then, lift his body from the floor being supported on the elbow and the feet, holding the position for 10 seconds and repeating 10 times. After application of the exercises apply lumbopelvic X ray from lateral view for the 2 groups again. Measure the spinopelvic angels again to compare the results between the 2 groups.

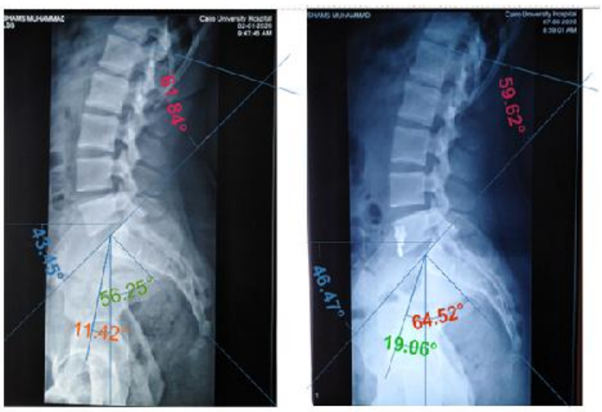

Figure 1. A: Before application of open kinetic chain exercises (S.S: 43.45°, L.L: 61.84°,P.I: 56.25° , P.T: 11.42°). B: After application of open kinetic chain exercises (S.S: 46.47°, L.L: 59.62°, P.I: 64.52°, P.T: 19.06°)

Data collection and statistical analysis

Descriptive analysis and **Inferential statistics including** Paired t-test to determine the significance within group, Independent t-test to determine the significance between groups, and the level of significance will be set < of 0.05. All statistical analysis will be conducted through the statistical package for social studies (SPSS) version 19 for windows (IBM SPSS, Chicago, IL, USA)

RESULTS

Spinopelvic angles were measured pre and post application of segmental chain exercises. Group "A" received open chain segmental control exercises and group "B" received closed chain segmental control exercises.

Table 1. Spinopelvic parameters in group A, before and after application of open kinetic chain program

	SS	LL	PI	PT
Pre	36.32±7.45	60.46±11.55	56.26±9.44	14.31±5.2
Post	35.8±5.57	56.58±8.95	51.52±7.32	17.6±3.4
t-test	1.71	1.1	1.8	-1.9
P	0.4	0.3	0.07	0.03
Sig	NS	NS	NS	S

SS: Sacral Slope, LL: Lumbar Lordosis, PI: Pelvic Incidence, PT: Pelvic Tilt, NS: Not significant, S: Significant

Table 2. Mean values of spinopelvic parameters in group B, before and after application of closed kinetic chain program

	SS	LL	PI	PT
Pre	37.52±8.93	54.59±8.56	51.68±9.51	11.41±5.14
Post	41.84±8.86	53.27±10.25	60.4±9.91	12.32±4.57
t-test	1.72	2.11	-2.13	0.44
P	0.13	0.37	0.02	0.33
Sig	NS	NS	S	NS

SS: Sacral Slope, LL: Lumbar Lordosis, PI: Pelvic Incidence, PT: Pelvic Tilt, NS: Not significant, S: Significant

Results of group "A"; in table (1) showed that the sacral slope angle was 36.32±7.45 degrees before treatment and decreased (35.8±5.57) after treatment with no statistical difference (p=0.3). As well lumbar lordosis and pelvic index showed no statistical difference after application of segmental open kinetic chain exercises. On the other hand; pelvic tilt angle was 14.31±5.2 degrees before treatment and increased significantly after treatment 17.6±3.4 degrees. These results are illustrated in Figure (2).

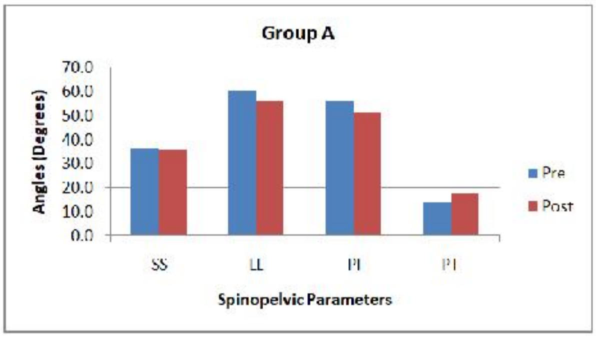

Figure 2. Spinopelvic parameters of group A before and after application of open kinetic chain exercises

Results of group "B"; in table (2) showed that the sacral slope angle was 37.52±8.93 degrees before treatment and increased (41.84±8.86) after treatment with no statistical difference (p=0.3). As well lumbar lordosis and pelvic tilt showed no statistical difference after application of segmental open kinetic chain exercises. On the other hand; pelvic index angle was 51.68±9.51 degrees before treatment and increased significantly after treatment 60.4±9.91 degrees. These results are illustrated in Figure (3).

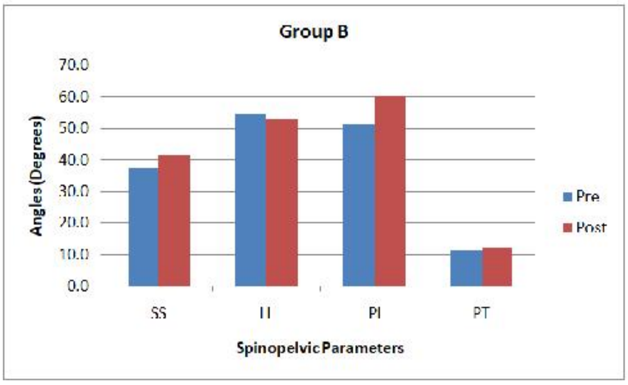

Figure 3. Spinopelvic parameters of group B before and after application of closed kinetic chain exercises

DISCUSSION

Our results showed that among the pelvic parameters, PI showed a statistically significant difference in the lumbar spondylolisthesis and failed back surgery syndrome patients as compared to a healthy asymptomatic group, whereas SS and sagittal vertical axis (SVA) offset did not show any statistically significant difference. These results were comparable to the study conducted by Barrey *et al*[8] Lim and Kim[9] also reported that PI is based on the morphology of the pelvis, and they found significant differences in PI between lumbar spondylolisthesis and lumbar spinal stenosis. They reported that the PI in patients with lumbar spondylolisthesis was significantly greater than that of lumbar spinal stenosis and asymptomatic participants in concordance with our study. In addition to PI, PT also showed a significant difference between the asymptomatic and in patients with lumbar spine disorders. The PI initially described by Duval-Beaupère *et al.*[10] is the important determinant of sagittal spine balance in an individual. It is an important anatomical parameter that reflects the configuration of the pelvis and greatly influences the sagittal balance of the whole spine[11]. Oh *et al.*[12] demonstrated the spinopelvic parameters in the Korean population which showed that PI is positively correlated with SS and PT and in patients with large PI, PT, and SS are also high in concordance to the present study. The role of PI in the sagittal spine balance has been well established with PI being higher in lumbar spondylolisthesis patients, and high PI is associated with poor clinical outcome following surgery.[13-15]

The values of the spinopelvic parameters were found to be high in obese individuals, which means that Body mass index (BMI), waist circumference (WC) may influence on the spinopelvic parameters, especially in females. Further, in individuals with abdominal obesity, the sagittal spinopelvic alignment is likely to change as a result of hyperlordosis and forward inclination of the pelvis, but there is little effect on the coronal spinopelvic alignment[7]. In study of Rezaee *et al.* (2020); we tried to determine the normal range of spinopelvic parameters. Our data showed that PT and PI-LL are significantly lower in women, while, PT, PI and PI-LL increase and LL decreases in older ages[16].

Yukawa and his coworkers have established normative data for spinopelvic sagittal parameters, gender related and age-related changes in asymptomatic subjects in age from 3rd to 8th decade. The average values are 49.7 ± 11.2 for LL, 53.7 ± 10.9 for PI, 14.5 ± 8.4 for PT, and 39.4 ± 8.0 for SS. Advancing age cause an increase in CL, PT, and a decrease in LL and SS. There was a significant gender differences[17]. Spinopelvic alignment changes were considered to have a significant impact on the progression of hip osteoarthritis (HOA). In the treatment of HOA, it is important to prevent the complication of spondylolisthesis and consider the changes in sagittal spinopelvic alignment[18]. There was a statistically significant difference between groups in terms of LL-SS ratio. In patients with degenerative disc disease and disc hernias, there is a more flat spine, characterized by decreased thoracic kyphosis and decreased LL. In these individuals, PI appears to be lower than normal population[19]. Rose *et al.* suggested that the sum of thoracic kyphosis, LL and pelvic indices should be less than 45 degrees for a healthy spinopelvic balance[20] Yang *et al.* observed that PI was lower in patients with lumbar degenerative disc, and that the angles of the SS and PT were decreased, and finally, that flatter LL and thoracic kyphosis developed[21].

In our study of low back pain patients, neither lumbar stabilization exercises nor sling exercises had a significant effect on the lumbar lordosis angle, lumbosacral angle, or sacral slope compared to pre-intervention measurements[22]. Similarly, in a study by Oh *et al.* (2017), lumbar stabilization exercise did not significantly affect the lumbar lordosis angle in women in their 20–30s. Therefore, our findings are consistent with those from other studies in that lumbar stabilization and sling exercises did not affect sagittal lumbar lordosis in patients with chronic back pain[23]. A Retrospective Study in a Population of East China Age, T1 sagittal angle, maxLL, PT, and PI are primary contributors to determining sagittal balance in asymptomatic subjects from East China. SVA is a golden global parameter for whole sagittal balance that has been found to be significantly correlated with several spinal and pelvic parameters[24]. It was found in our study that SVA was correlated with age, T1 sagittal angle, maxLL, PT, and PI. Lumbar lordosis decreased with aging possibly due to disc degeneration, whereas PT increases to restore sagittal balance as a compensatory mechanism. Sagittal disturbances such as increased SVA and pelvic compensatory backward rotation (increased PT) result in twisting mobilization within the sacroiliac joint, which might increase PI with aging. Janusz *et al.* in (2016) studied rotation of the pelvis in the coronal plane during acquisition of radiographs influences PI, PT and SS measurements. Substantial error of PI, PT and SS measurements occurs with pelvic rotation in the coronal plane of more than 20_. The LLD up to 5 cm appeared to have a negligible influence on PI, PT and SS measurements.

Pelvic rotation in the coronal plane while acquiring the radiograph may be calculated by use of the distance between the centers of the femoral heads on anteroposterior radiograph and the vertical distance between the centers of the femoral heads on the lateral radiograph. Further evaluation of influence of pelvic rotation in coronal plane on spinopelvic parameters with larger sample would be valuable[25]. The results of Hu *et al.* study confirmed that the increased global kyphosis (GK) in patients with ankylosing spondylitis (AS) leads to an increase in pelvic tilt (PT) and a decrease in the sacro-femoral-pubic (SFP) angle. The SFP angle was strongly correlated with PT and that PT could be assessed by the SFP angle according to the formula PT = 72.3 − 0.82 ×(SFP angle) in patients with AS with thoracolumbar kyphosis[26].

Conclusion

Both open chain segmental control exercises and closed chain segmental control exercises showed a significance difference before and after application in spinopelvic angles

Conflict of interest: There is no conflict of interest.

REFERENCES

1-Lee SH, Lim CW, Choi KY, (1) *et al.* (2019). "Effect of Spine-Pelvis Relationship in Total Hip Arthroplasty". Hip Pelvis 31(1): 5

2-Lee ES, Ko CW, Suh SW, (3) *et al.* (2014): "The effect of age on sagittal plane profile of the lumbar spine according to standing, supine, and various sitting positions"; J Orthop Surg Res. 2014; 9: 11.

3-Boulay C, Tardieu C, Hecquet J (7) *et al.* (2006). "Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis." Eur Spine J. 154. 415.

4-Le Huec JC, S. Aunoble S, Philippe L (1) *et al.* (2011). "Pelvic parameters: origin and significance". Eur Spine J. 20 Suppl 5. S564.

5-Endo K, Suzuki H, Nishimura (3) *et al.* (2012). "Sagittal lumbar and pelvic alignment in the standing and sitting positions". J Orthop Sci. 176. 682.

6-Luque-Suárez AE, Díaz-Mohedo I, Medina-Porqueres (1) *et al.* (2012) . " Stabilization Exercise for the Management of Low Back Pain" Norasteh A. Low Back Pain. 1st ed. Ch 12: 261.

7-Zhang J, Yang G, Cheng Y (5) *et al.* (2005): "Stationary scanning X-ray source based on carbon nanotube field emitter". Applied Physics Letters. 86(18): 1841041-7)

8-Barrey C, Jund J, Noseda O, (1) *et al.* (2007). Sagittal balance of the pelvis-spine complex and lumbar degenerative diseases. A comparative study about 85 cases. Eur Spine J.;16:1459–67.

9-Lim JK, Kim SM. (2014). Comparison of sagittal spinopelvic alignment between lumbar degenerative spondylolisthesis and degenerative spinal stenosis. J Korean Neurosurg Soc.;55:331–6.

10-Duval-Beaupère G, Schmidt C, Cosson P. (1992). A barycentremetric study of the sagittal shape of spine and pelvis: The conditions required for an economic standing position. Ann Biomed Eng.;20:451–62.

11-Johnson RD, Valore A, Villaminar A, (2) *et al.* (2013). Sagittal balance and pelvic parameters – A paradigm shift in spinal surgery. J Clin Neurosci.;20:191–6.

12-Oh SK, Chung SS, Lee CS. (2009). Correlation of pelvic parameters with isthmic spondylolisthesis. Asian Spine J.;3:21–6.

13.Labelle H, Roussouly P, Berthonnaud E, (4) *et al.* (2004). Spondylolisthesis, pelvic incidence, and spinopelvic balance: A correlation study. Spine Phila Pa 1976);29:2049–54.

14.Legaye J, Duval-Beaupère G, Hecquet J, (1) *et al.* (1998). Pelvic incidence: A fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. Eur Spine J.; 7: 99–103.

15.Lee CS, Chung SS, Kang KC, (2) *et al*. (2011). Normal patterns of sagittal alignment of the spine in young adults radiological analysis in a Korean population. Spine Phila Pa 1976); 36:E1648–54.
16-Rezaee H, Bahadorkhan G, Ehsaei M, (3) *et al*. (2020). "Spinopelvic Parameters among Healthy Volunteers in Iran" 85), The archives of bone and joint surgery, Iran, PP 623.
17-Yukawa Y, Kato F, Suda K, (3) *et al*. (2018). Normative data for parameters of sagittal spinal alignment in healthy subjects: an analysis of gender specific differences and changes with aging in 626 asymptomatic individuals. European Spine Journal.; 272. 426-32.
18-Warashina H, Kato M, Kitamura S (2) *et al*. (2019). " The progression of osteoarthritis of the hip increases degenerative lumbar spondylolisthesis and causes the change of spinopelvic alignment",16, J Orthop, Japan, PP 278.
19-Kircelli A, Coven I, Sen P (1) *et al*. (2019). " The Effects of Spinopelvic Parameters Such As Lumbar Lordosis and Sacral Slope Angles in the Development of Lumbar Disc Degeneration" 7 1), Bezmialem science, Turkey, PP 25.
20-Rose PS, Bridwell KH, Lenke LG, (4) *et al*. (2009). Role of pelvic incidence, thoracic kyphosis, and patient factors on sagittal plane correction following pedicle subtraction osteotomy. Spine Phila Pa 1976); 34:785-91.
21-Yang X, Kong Q, Song Y, (3) *et al*. (2014). The characteristics of spinopelvic sagittal alignment in patients with lumbar disc degenerative diseases. Eur Spine J; 23:569-75.
22-Ko K, Ha G, Yook Y (1) *et al*. (2018). "Effects of 12-week lumbar stabilization exercise and sling exercise on lumbosacral region angle, lumbar muscle strength, and pain scale of patients with chronic low back pain" 30 1), The J of Phys Ther Sc, Korea, PP 21.
23-Oh JS, Choi DG, Kim YS: (2017). The effect of lumbar stability exercise program on sedentary life female, lumbosacral region angle, muscular strength, physical fitness and pain scale. Korean J Sports Med, , 35: 15–24.
24-Yang M, Yang C, Zhai X (3) *et al*. (2017). "Analysis of Factors Associated With Sagittal Balance in Normal Asymptomatic Individuals" 424), Spine, China, PP E223.
25-JanuszP, Tyrakowski M, Monsef J (1) *et al*. (2016). " Influence of lower limbs discrepancy and pelvic coronal rotation on pelvic incidence, pelvic tilt and sacral slope" Eur Spine J, Heidelberg 2511. 3622-3629.
26-Hu J, Ji M, Qian B (5) *et al*. (2014). " Can Pelvic Tilt be Predicated by the Sacrofemoral-Pubic Angel in Patients With Thoracolumbar Kyphosis Secondary to Ankylosing Spondylitis?" 3923), Spine, China, PP E1350-E1352.

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