Original Article

4D ANALYSIS OF SPINO-PELVIC ALIGNMENT IN PATIENTS WITH CHRONIC SCIATICA

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Abstract

Background: Chronic sciatica is a frequent neurological disorder caused by nerve root dysfunction that may be due to mechanical compression from lumbar disc herniation. It may affect the spino-pelvic alignment.

Objective: This study aimed to evaluate the impact of chronic unilateral discogenic sciatica on spino-pelvic alignment (lumbar lordosis, sagittal imbalance, coronal imbalance, pelvic obliquity and torsion)

Methods: A cross-sectional observational study was accomplished over seventy subjects of both genders aged between 30 to 40 years. The subjects were distributed into 2 groups: Study group (GI): forty subjects with chronic unilateral discogenic sciatica (L4-L5/L5-S1) with duration of illness more than three months and Control group (GII): thirty healthy subjects matched with age and sex. Formetric DIERS 4D (Rasterstereography) was used to assess the effect of chronic sciatica on spino-pelvic alignment. The Arabic version of Oswestry Disability Index (ODI) was utilised to assess disability in chronic sciatica patients. **Results:** The results of the current study reported a significant increase of the mean values of the sagittal imbalance, pelvic obliquity and the pelvic torsion in the study group compared to the control group, and there was no significant difference in the lordotic angle and coronal imbalance between the groups. Regarding ODI, the study revealed non-significant correlation between ODI and all measured variables in the study group. **Conclusion:** Considering the outcomes of the current study, it can be proved that chronic sciatica has a significant effect on spino-pelvic alignment, as there was a significant increase in sagittal imbalance, pelvic obliquity and pelvic torsion. So, these findings should be considered in the rehabilitation of individuals with chronic sciatica.

Keywords: Lumbar disc herniation; Sagittal imbalance; Sciatica; Spino-pelvic alignment; Pelvic obliquity; Pelvic torsion.

Introduction:

Sciatica is the most obvious symptom of lumbar disc herniation (LDH). About 1% of the general population is affected by symptomatic LDH causing low back pain (LBP), sciatica and gait difficulty **[1].**

Discogenic sciatica caused by LDH represents nearly 90% of sciatica cases and has a significant financial burden due to loss of work and healthcare cost **[2].**It is characterized by pain radiation to the posterior or posterolateral leg combined with sensory and motor manifestations caused by lumbosacral nerve roots compression that may be compensated by spinal imbalances as sagittal and coronal trunk tilt **[1,3].**

Abnormal sagittal spinal alignment is linked with spinal deformities. Spino-pelvic malalignment is a key structural feature of spinal degeneration and chronic LBP **[4,5].**

Spino-pelvic sagittal parameters analysis is necessary to optimize the management of lumbar degenerative diseases **[6]**. Formetric Diers 4D (Formetric Rasterstereography) provides accurate noninvasive objective and reliable analysis of the spinal anatomy. It generates a 3D analysis of the spine and provides postural assessment over time without the possible adverse effects that may occur from radiation exposure **[7,8].** Thus, this study aimed to assess the spino-pelvic alignment (lumbar lordosis, sagittal imbalance, coronal imbalance, pelvic obliquity and torsion) in patients with chronic unilateral discogenic sciatica.

Materials and Methods:

Study design:

A Cross-sectional observational study was undertaken to assess and explore the impact of chronic unilateral discogenic sciatica on spino-pelvic alignment (lumbar lordosis, sagittal imbalance, coronal imbalance, pelvic obliquity and torsion). The study was conducted at the Faculty of Physical Therapy, Cairo University and Fizik Center for Physical Therapy and Rehabilitation, Cairo, Egypt from the period of July 2021 to March 2022. The protocol was prospectively approved by the Faculty of Physical Therapy's Research Ethics Committee, Cairo University, Egypt (NO:P.T.REC/012/003561).

Participants and Randomization

70 subjects were enrolled in the study and randomized by opaque sealed envelopes into 2 groups: **Study group (GI):** 40 patients with chronic unilateral discogenic sciatica (L4-L5/L5-S1) and **Control group (GII):** 30 healthy subjects matched with age and sex.

The patients enrolled if they met the inclusion criteria; age between 30-40 years, both sexes, body mass index (BMI) ranged between 18.5 and 25 kg/m^2, chronic unilateral discogenic sciatica with lower lumbar herniation (L4-L5 and L5-S1) and duration of illness more than three months. Subjects were excluded if they have upper lumbar radiculopathy (L1-L3), BMI more than 25 kg/m^2, pregnancy, leg length discrepancy**,** congenital deformities and previous spinal surgeries. From each participant, signed informed consent was gained.

Subjects with leg length discrepancy were screened out using tape measurement of the patient's legs in supine lying position from the anterior superior iliac spine (ASIS) to the medial malleolus of the ankle joint **[9].** Participants' BMI was in the normal average to exclude the effect of BMI on spino-pelvic alignment so, after measurement of the weight and height of the subjects, the BMI was measured through the following equation: BMI= Body Weight per kg/ (Height per meter)^2**[10].** A detailed examination sheet was registered for to every patient including personal, past and present history.

Sample Size Calculation:

The sample size was obtained using a power of 80% and α= 0.05. The proper sample size was 70 subjects. For the calculations, G* Power version 3.1.9.2 (Franz Faul, Uni Kiel, Germany) was utilized.

Assessment procedure of the spino-pelvic alignment by Formetric device (DIERS DICAM 4D).

a. System positioning:

The patients were standing in upright relaxed posture at a distance of 2 m in front of 4D scanning system and photo cameras. The patient back was bared skin (including half of the buttocks). Metals in the space as necklaces and watches were removed. Subject's hair was raised upward to expose C7.

Taking into account the subject's height, the camera column was modified. The green crosshairs were directly below the scapula and the spine was in the centre. The image recording started once the patient standard position is assumed. The "project stripes" button was pressed to turn the lights on. The best image capture was taken with slight expiration.

Examination room light was turned off so that raster lines were visible on subject's back. The examiner then clicked "start recording" to start the measurement. The scanning time was less than 30 ms in order to eliminate movement artifact. Once 5 second motion image capture was completed, the lights turned off automatically. The steps were repeated after 2 minutes for another 2 times. Every trial was processed by Formetric software individually.

b. Measurements:

- From the sagittal profile:

1) The lordotic angle was calculated by the equipment as the angle between inflectional point of the curvature from the thoracic spine to lumbar spine and the inflectional point of the curvature from lumbar spine to sacral spine **[11]**.

2) The sagittal imbalance (trunk inclination) was calculated as Plumb line deviation from vertebral prominence of C7 to the dimple in the middle of the sacrum in the sagittal plane **[2]**.

3) The pelvic torsion represents the torsion between left side and right side pelvic bones. It is measured as the degree of coronal shift of the pelvis in relation to the plumb line which defines the orientation of the right hip bone in relation to the left on **[2].**

- From the frontal profile:

1) The coronal imbalance was calculated as the plumb line deviation from vertebral prominence of C7 to the dimple in the middle of the sacrum in the frontal plane **[2]**.

2) The Pelvic obliquity (lateral pelvic tilt) was calculated by the equipment as the amount of tilt in millimeters or degrees from the horizontal line between the two lumbar dimples (from left dimple to right dimple). A positive value denotes that right dimple is higher than the left one and a negative value denotes that left dimple is higher than the right one **[12].** A mean pelvic obliquity in the neutral standing position was defined when the right posterior superior iliac spine is higher by a value > 4mm which is denoted (+), or the left is higher than the right by a value >4mm which is denoted (-) **[13].**

c. Outcome measures

The Arabic version of Oswestry Disability Index (ODI) was utilised to measure the amount of disability caused by chronic sciatica, a disease-specific measure that indexes a patient's activity limitation due to low back pain via a 10-item self-assessing questionnaire, with each item having six possible responses ranging from zero (not at all disabled) to five (extremely disabled). The percentage of disability can vary from 0% (no disability) to 100% (completely disabled) **[14].**

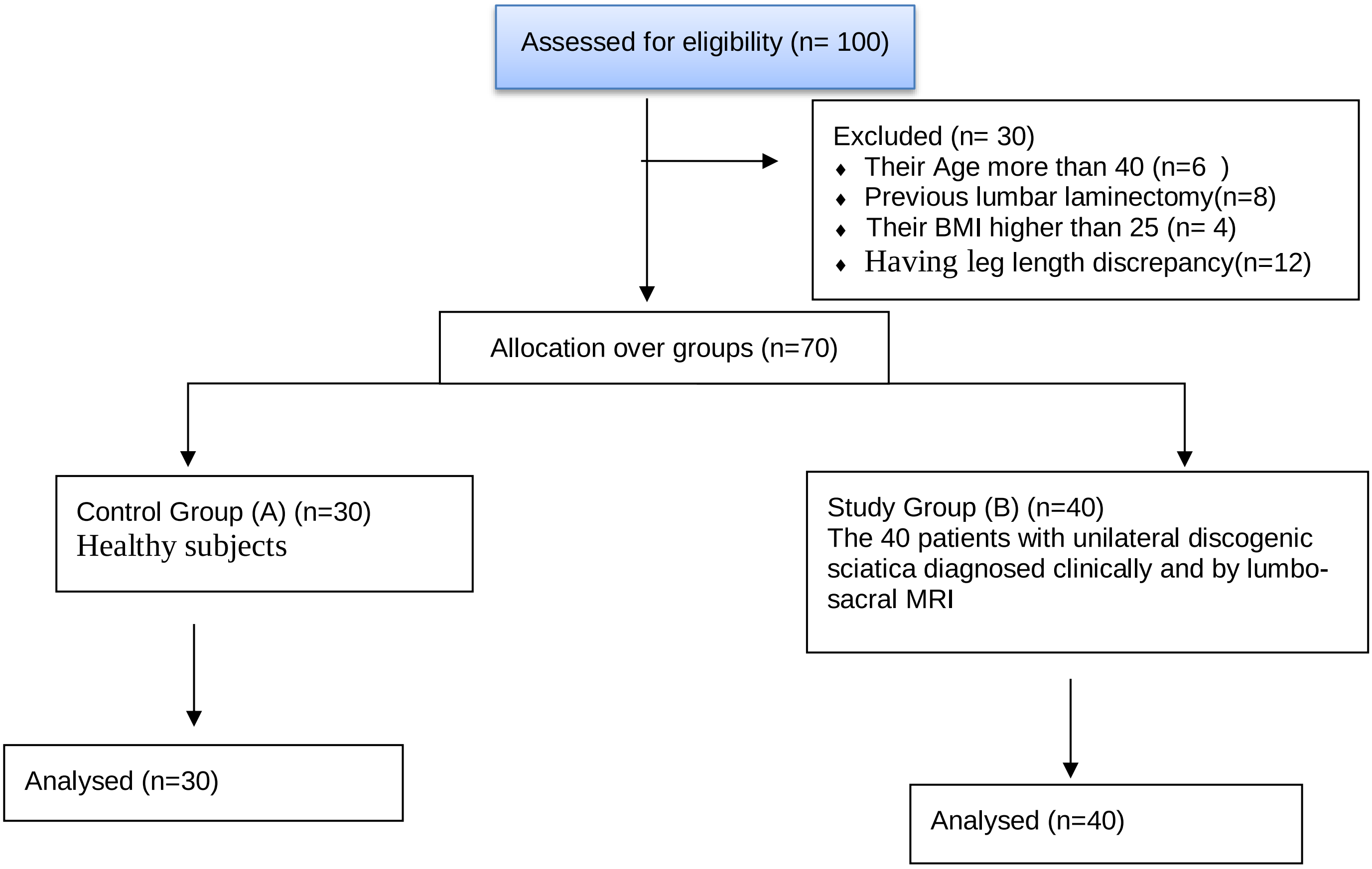
Statistical analysis:

The statistical package for social sciences (SPSS) version 25 for Windows was utilized to analyse the data (IBM SPSS, Chicago, IL, USA). The features of the participants were compared between groups using an unpaired t test. To compare the gender distribution between groups, the Chi-squared test was utilised. The Shapiro-Wilk test was utilised to ensure that the data was distributed normally. Levene's test was used to determine group homogeneity. To compare spino-pelvic alignment between groups, an unpaired t test was used. To study the relationship between ODI and spino-pelvic alignment, the Pearson correlation coefficient was used. The level of significance was set at $p < 0.05$ for all statistical tests.

Results:

70 subjects participated in this study, 40 patients with chronic sciatica due to LDH and 30 healthy subjects. All subjects were matched regarding age and sex. The following diagram of the study cases is shown in **fig (1).**

Figure 1. Consort Flow diagram



General characteristics of the participants:

Study group (GI):

This group includes forty individuals with persistent discogenic sciatica. Their averages for age, weight, height, and body mass index (BMI) were respectively 34.4 6.86 years, 68.95 9.07 kg, 172 8.82 cm, and 22.62 3.41 kg/m^2 as shown in **table (1)** .

Control group (GII):

There were 30 healthy participants in this group. Their mean SD values for height, weight, and BMI were 174.03 cm, 71.33 kg, 32.96 years, and 23.33 kg/m^2, respectively as shown in **table (1)** .

Comparing the demographic characteristics of the individuals in both groups found no significant difference in mean age, weight, height, or BMI (p > 0.05).

Table (1). The mean values of age, weight, height, and BMI of the study and the control groups.

	Study group	Control group	MD	t-value	p-value	Sig
	$\bar{X}$ ± SD	$\bar{X}$ ± SD				
Age (years)	34.4 ± 6.86	32.96 ± 3.16	1.44	1.06	0.29	**NS**
Weight (kg)	68.95 ± 9.07	71.33 ± 9.27	-2.38	-1.07	0.28	**NS**
Height (cm)	172 ± 8.82	174.03 ± 9.43	-2.03	-0.92	0.35	**NS**
BMI (kg/m²)	22.62 ± 3.41	23.33 ± 1.11	-0.71	-1.09	0.27	**NS**

$\bar{X}$: Mean **SD: Standard deviation** **MD: Mean difference**

t value: Unpaired t value **p value: Probability value** **NS: Non significant**

Sex distribution:

The sex distribution of study group reported that there were 19 (47%) females and 21 (53%) males. The sex distribution of control group reported that there were 10 (33%) females and 20 (67%) males. There was no significant difference in sex distribution between both groups (p = 0.23). **(Table 2)**.

Table (2): The frequency distribution and chi squared test for comparison of sex distribution between of study and control groups.

	Study group	Control group	χ^2 value	p-value	Sig
Females	19 (47%)	10 (33%)	1.41	0.23	**NS**
Males	21 (53%)	20 (67%)			

χ^2 : Chi squared value **p value: Probability value** **NS: Non significant**

I-Comparison of lordotic angle between both groups:

The mean value ± SD of lordotic angle of the study group was 41.5 ± 12.15 degrees and that of the control group was 39.3 ± 10.36 degrees. The mean difference between groups was 2.2 degrees. There was no significant difference in lordotic angle between both groups (p = 0.42). **(Table 3)**.

Table (3) Mean values of lordotic angle of the study and the control groups.

	Study group	Control group	MD	t- value	p-value	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Lordotic angle (degrees)	41.5 ± 12.15	39.3 ± 10.36	2.2	0.79	0.42	**NS**

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference p value: Probability value NS: Non significant

II- Mean values of the sagittal imbalance between both groups:

The mean value ± SD of sagittal imbalance of the study group was 26.77 ± 14.18 mm and that of the control group was 14.5 ± 12.81 mm. The mean difference between groups was 12.27 mm. There was a significant increase in sagittal imbalance of study group in comparison to that of control group (p = 0.001). **(Table 4).**

Table (4): mean values of the sagittal imbalance between the study and the control groups.

	Study group	Control group	MD	t- value	p-value	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Sagittal imbalance (mm)	26.77 ± 14.18	14.5 ± 12.81	12.27	3.73	0.001	**S**

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference p value: Probability value S: Significant NS: Non significant

III- Mean values of the Coronal imbalance between both groups:

The mean value ± SD of coronal imbalance of the study group was 11.8 ± 4.43 mm and that of the control group was 10.63 ± 3.85 mm. The mean difference between groups was 1.17 mm. There was no significant difference in coronal imbalance between both groups (p = 0.25). **(Table 5)**.

Table (5): Mean value of the coronal imbalance between the study and the control groups.

	Study group	Control group	MD	t- value	p-value	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Coronal imbalance (mm)	11.8 ± 4.43	10.63 ± 3.85	1.17	1.15	0.25	**NS**

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference p value: Probability value S: Significant NS: Non significant

VI- Mean values of the pelvic obliquity both groups:

The mean value ± SD of pelvic obliquity of the study group was 5.57± 1.45 mm and of the control group was 1.03 ± 0.81 mm. The mean difference between groups was 4.54 degrees. There was a significant increase in pelvic obliquity of the study group in comparison to that of control group (p = 0.001). **(Table 6)**.

Table (6): mean values of the pelvic obliquity between the study and the control groups.

	Study group	Control group	MD	t- value	p-value	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Pelvic obliquity (mm)	5.57 ± 1.45	1.03 ±0.81	4.54	15.29	0.001	S

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference p value: Probability value S: Significant

V- Mean values of the pelvic torsion between both groups:

The mean value ± SD of pelvic torsion of the study group was 3.85 ± 0.92 degrees and that of the control group was 1.76 ± 0.67 degrees. The mean difference between groups was 2.09 degrees. There was a significant increase in pelvic torsion of the study group in comparison to that of the control group (p = 0.001). **(Table 7).**

Table (7): Comparison of pelvic torsion between the study and the control groups.

	Study group	Control group	MD	t- value	p-value	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Pelvic torsion (degrees)	3.85 ± 0.92	1.76 ± 0.67	2.09	10.43	0.001	S

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference p value: Probability value S: Significant

- The relationship between ODI and the spino-pelvic alignment in the study group:

The mean ± SD value of ODI of the study group was 28.77 ± 16.65% with maximum value of 70% and minimum value was 10%.

The correlation between ODI and lordotic angle was weak positive non significant correlation (r = 0.131, p = 0.420). **(Table 8, figure 2).**

The correlation between ODI and sagittal imbalance was weak positive non significant correlation (r = 0.027, p = 0.867). **(Table 8, figure3**).

The correlation between ODI and coronal imbalance was weak negative non significant correlation (r = -0.121, p = 0.455). **(Table 8, figure 4).**

The correlation between ODI and pelvic obliquity was weak positive non significant correlation (r = 0.286, p = 0.074). **(Table 8, figure 5).**

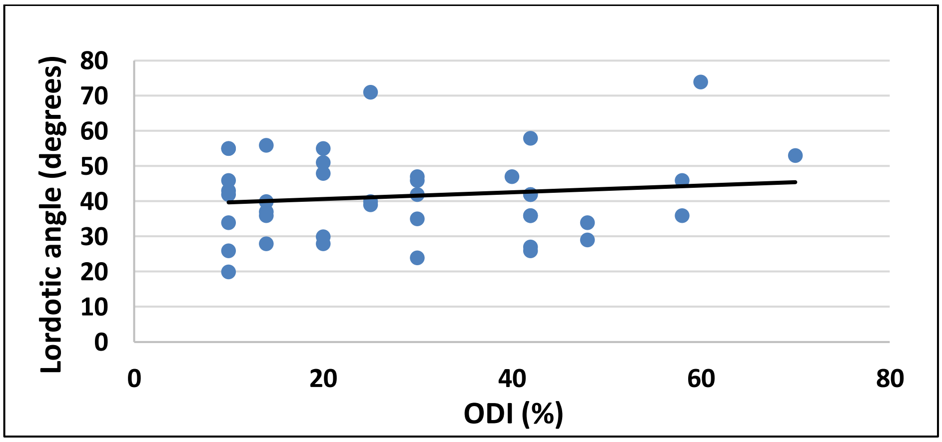
The correlation between ODI and pelvic torsion was weak negative non significant correlation (r = -0.357, p = 0.024). **(Table 8, figure 6).**

Table (8): Correlation between ODI and spino-pelvic alignment in study group:

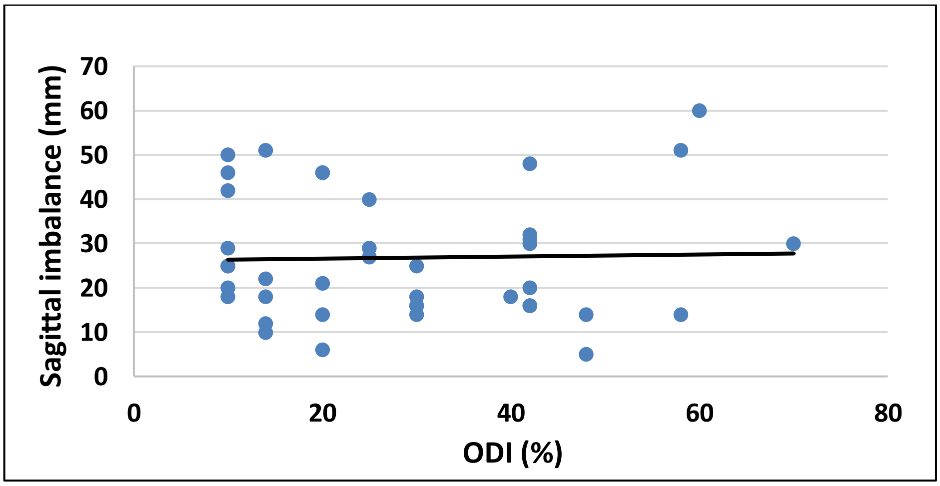
	Spino-pelvic alignment	**r value**	**p value**	**Sig**
(ODI)	**Lordotic angle (degrees)**	0.131	0.420	**NS**
	Sagittal imbalance (mm)	0.027	0.867	**NS**
	Coronal imbalance (mm)	-0.121	0.455	**NS**
	Pelvic torsion (degrees)	-0.124	0.445	**NS**
	Pelvic obliquity (mm)	0.286	0.074	**NS**

r value: Pearson correlation coefficient **p value: Probability value** **S: Significant** **NS: Non significant**

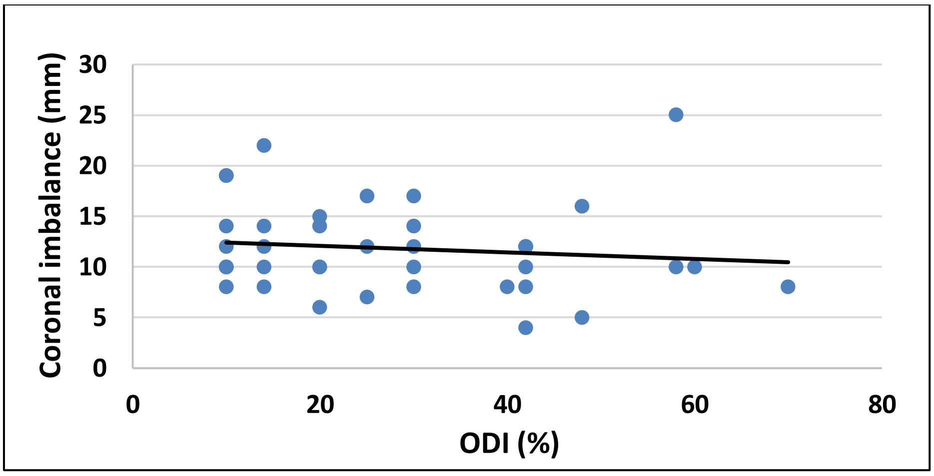
Fig(2) Correlation between ODI and lordotic angle.



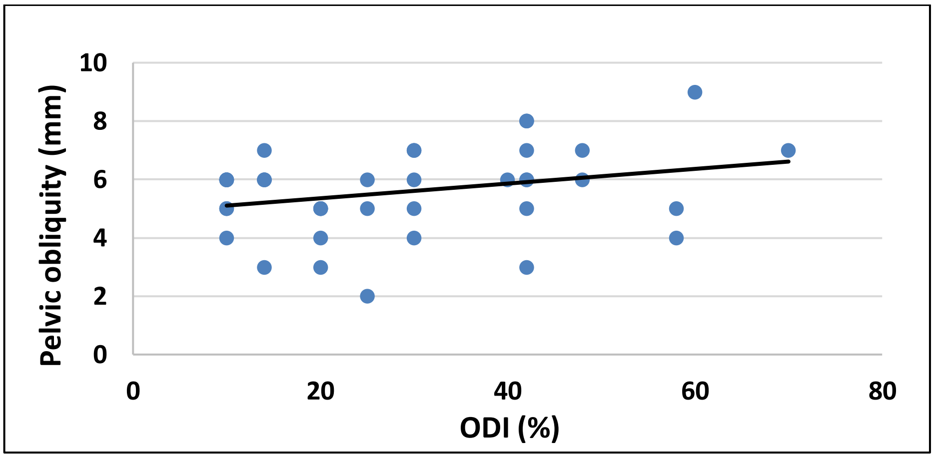
Fig(3)Correlation between ODI and sagittal imbalance.



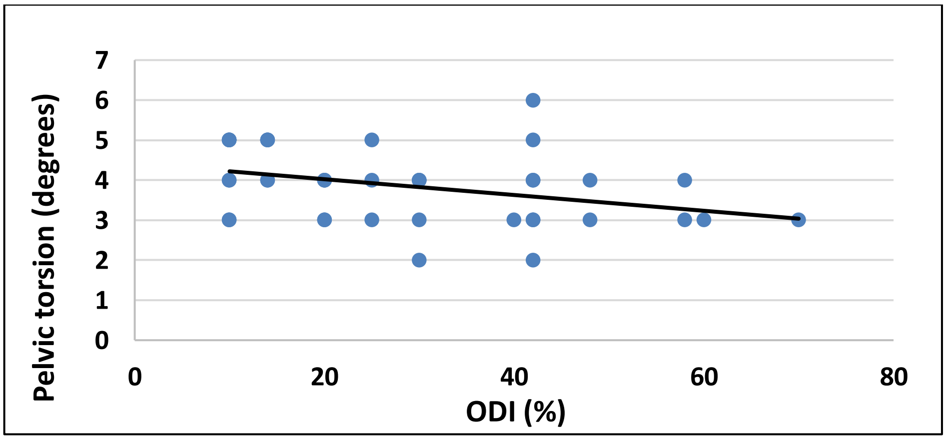
Fig(4)Correlation between ODI and coronal imbalance



Fig(5) Correlation between ODI and pelvic obliquity.



Fig(6) Correlation between ODI and pelvic torsion.



Discussion:

The present study was performed to examine the impact of chronic unilateral discogenic sciatica on the spino-pelvic alignment. The results of the current study reported that chronic sciatica has a significant effect on spino-pelvic alignment, as there was a significant increase in sagittal imbalance, pelvic obliquity and pelvic torsion and there was no significant difference between both groups concerning lordotic angle and coronal imbalance.

The current study showed that there is no significant difference about the lordotic angle between both groups although sagittal imbalance is accompanied by decreased lumbar lordotic angle. It is in accordance with the results of **Karademir et al., [15]** as lumbar lordosis was significantly reduced by multilevel disc herniation group as in comparison to bulging group and one level disc herniation group **[15].** It can be explained according to the spinal compensation mechanism that occurs when the paravertebral muscles are still functional, the not degenerated or little degenerated levels (above the pathologic segment) able to compensate by hyperextension to eliminate the global lordosis **[1].**

Barrey et al., [16] mentioned that loss of lordosis is not only structural, but it can be postural secondary to the analgesic posture of the patient to avoid posterior discal hyperpression. Also, it can be secondary to segmental discopathy and loss of disc height. It is difficult to distinguish between structural and postural lordosis loss. Also, **Dalichau et al., [17]** showed that low back pain is associated with loss of lumbar lordosis. Moreover, it was found to be inversely correlated with the severity of pain. Another supporting study by **Endo et al., [18]** demonstrated that Discectomy reduces lumbar lordosis and relieves pain in patients with LDH**.**

The results of the current study demonstrated that there was a significant difference between the mean values of the sagittal imbalance in the study compared to the control group. These results agreed with **Liang et al., [19]**. They reported that spinal sagittal imbalance resulting from LDH is a compensatory imbalance that occurs in the form of change in normal back curves as lumber flattening, pelvic tilt and dorsal kyphosis**.**

In the current study, coronal imbalance showed nonsignificant difference between both groups. It is in agreement with **Wang et al., [1]** as they reported that once nerve root decompression is achieved, the nonstructural and compensatory scoliosis posture and loss coronal balance is improved. Most patients (over 75%) regained spinal balance at once after surgery. At the six-month postoperative follow-up, all patients had recovered to normal coronal and sagittal balance. Another supporting study **Suk et al., [20]** reported that after surgical decompression, coronal imbalance improved immediately. Also, **Zhu et al., [21]** reported that discectomy improved coronal imbalance.

Another study by **Tahvildari et al., [22]** found that there wasn't apparent difference between patients underwent surgery and whose didn't undergo surgery after 2 to 5 years of their confirmed diagnosis with LDH. Conservative treatment of LDH may improve patient clinical symptoms within few weeks in most of patients**.**

Regarding the pelvic parameters, the current study showed a significant increase of the pelvic obliquity and pelvic torsion in the study group compared to the control group. This may be attributed to the weakness and the atrophy of the pelvic muscles and this can confirmed by the study of **Skorupska et al., [23]** which used the inter-rater reliability of the 3D manual method for segmenting and measuring the pelvic muscles volume of the gluteal and piriformis muscles in back pain a combined with leg pain. They found weakness of the mentioned muscles on the symptomatic side in subjects with sciatic or sciatic-like pain compared to unaffected side and healthy subjects.

Symptomatic pelvic muscle atrophy can be also due to nerve compression as a neurogenic type atrophy which induces metabolic changes in the sympathetic nervous system then metabolic activity of the musculoskeletal system then vasoconstriction and finally muscle atrophied in patients with subacute and chronic sciatica **[24].**

Regarding ODI, the current study showed non significant correlations between ODI and all measured variables in the study group. This is in accordance with **Baran and Karademir [15].** They reported that in functional disorders and pain is not related to the degree of the disease due to the subjective and complex structure of the pain**.**

The results of the present study were in agreement with **Khallaf [2]** who reported that there were no significant correlations between the postural changes and the functional limitations measured by the ODI as clinical symptoms are not always correlated with radiologic findings**.**

Conclusion:

Chronic sciatica has a significant effect on spino-pelvic alignment, as there was a significant increase in sagittal imbalance, pelvic obliquity and pelvic torsion. Also, there was no significant difference between both groups concerning lordotic angle and coronal imbalance.

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Conflict of interest

The authors declare that no conflict of interest

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