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Effect of core stabilization exercises on lumbar lordotic angle in patients with lumbar disc degeneration

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Abstract

Introduction. Although core stabilization exercises (CSEs) prove to be effective in patients with various musculoskeletal disorders, their impact in lumbar disc degeneration (LDD) has not been fully investigated. This study aimed to examine the effects of CSEs on lumbar lordotic angle (LLA), pain intensity, and functional disability in patients with LDD.
Methods. Overall, 97 adult patients of both genders with LDD were randomly assigned to the study or control group. The study group (n = 48) received CSEs in addition to traditional physical therapy; the control group (n = 49) received only traditional physical therapy, 3 sessions per week for 12 weeks. LLA, pain intensity, and functional disability were determined before and after the treatment program. LLA was measured with the Surgimap Spine software on marked lateral view X-ray films (OmniDiagnost Eleva); pain intensity was evaluated with visual analogue scale (VAS); functional disability was assessed with Oswestry Disability Index (ODI).
Results. There was no significant pre-treatment difference between the groups in LLA (p = 0.84), VAS (p = 0.49), or ODI (p = 0.12). Significant post-treatment differences were observed in both groups in all variables (p = 0.001). However, there was a significant decrease in the mean post-treatment values of all variables (p = 0.001) in the study group compared with the control group.
Conclusions. CSEs could provide an additional effect of improving LLA, pain intensity, and functional abilities in patients with LDD.
Key words: core stabilization exercises, low back pain, lumbar disc degeneration, lumbar lordotic angle

Introduction

Degenerative disc disease (DDD) is common and occurs in nearly 30% of individuals [1]. It can incredibly influence quality of life because it often causes gentle to serious pain around the involved disc, as well as neuropathic pain in the nearby spinal nerve root [2]. Pain is usually due to simple wear and tear process and may result from a twisting back injury [1, 2].

Lumbar intervertebral disc differs from any other musculoskeletal tissue as it experiences broad dangerous changes with age and degeneration [3], which is the most common cause of chronic low back pain (LBP) all over the world. It is thought that lumbar lordosis and changes in lumbosacral parameters are exceptionally imperative causes of discogenic pain [4]. Previous studies have shown that there were changes within the spinal-pelvic sagittal force lines in patients with spinal distortions and lumbar degenerative illnesses to varying degrees [5–7].

The most common reason for LBP is mechanical factors due to improper positioning and movement of the torso (dynamic and static); these lead to overuse of the spine structures, resulting in the overload syndrome, degenerative lesions, or even disability [8, 9]. Furthermore, it is obvious that with aging, the loss of trunk muscle balance, along with an increase in lumbar lordotic angle (LLA), would lead to an increase in intervertebral disc stresses. Consequently, any modification in LLA would induce a change in the level of lumbar disc degeneration (LDD) [10, 11].

Normal LLA may range from 31° to 50° as evaluated with Cobb's method [12]. An increase in LLA proportionally raises the shearing strain or stress in the anterior direction and shifts the centre of gravity anteriorly [13]. Expanded lordosis has been reported as the major cause of postural pain, radiculopathy, and facet pain; excessive lumbar lordosis leads to extended compression of the apophyseal joint and an increment in the front shear force at the lumbosacral intersection [14].

In recent years, electrotherapy, stretching, and strengthening exercises for abdominal and back muscles have been used in physiotherapy programs for chronic LBP and DDD [15]. Moreover, core stabilization exercises (CSEs) can provide benefits within the treatment of chronic LBP via alteration of vertebral portions and an increment in energetic steadiness and strength of lumbar muscles [16–18]. CSEs expanded patients' ability to resist higher loads within DDD [19, 20] and it has been reported that a posterior energetic stabilization program resulted in a critical alleviation of pain and disability [21, 22]. From our review of the literature and to the best of our knowledge, this is the first study to examine the effect of CSEs on LLA in patients with LDD, and we hypothesized that CSEs would significantly improve LLA, pain intensity, and functional abilities in this group.

Subjects and methods

Study design

This randomized experimental trial was conducted in the outpatient clinic of the Kasr Alainy Hospital of Cairo University, Egypt, from September 2019 to September 2020. The protocol of the study was explained in detail to each patient before treatment.

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Sample size determination

Sample size calculation was performed prior to the study and based on the results of a pilot study among 5 subjects in each group. The G*Power statistical software (version 3.1.9.2; Franz Faul, Universität Kiel, Germany) was used. The appropriate sample size for this study turned out to be 76 patients. To compensate for the expected dropouts before the study completion, we conducted the research in a total of 97 participants. The calculations assumed the values of $\alpha = 0.05$, $\beta = 0.2$, and the effect size of 0.62.

Subjects

A total of 97 patients of both sexes participated in this study; their age ranged from 30 to 50 years [3]. With a diagnosis of LDD, they were referred by an orthopaedist to physical therapy at the outpatient clinic at Kasr Alainy Hospital, Cairo University. They were subjected to a standardized physical examination and were screened for eligibility criteria by an assessor who was blinded to the patients' allocation. A flow chart of the individuals' recruitment and retention throughout the study is presented in Figure 1. The figure shows that 109 patients were initially screened and after that 97 subjects were competent to participate in the study. They were distributed randomly to the study group ($n = 48$) or the control group ($n = 49$) by a blinded independent research assistant who used random cards generated automatically by a computer.

The inclusion criteria were as follows: LDD [6] diagnosed by an orthopaedist and confirmed by lumbosacral X-ray, as well as mild to moderate disability according to the Oswestry Disability Index (ODI) (up to 40%) [23, 24]. The participants' body mass index (BMI) ranged from 25 to 29.9 kg/m^2 [4]. The exclusion criteria involved herniated lumbar disc or central canal stenosis, history of spinal surgery, and current medical treatment or physical therapy for chronic LBP.

Outcome measures

Assessments were carried out for all participants before and after 12 weeks of treatment by an outcome assessor who had 10-year experience. The primary outcome variable for this study was LLA, whereas the secondary outcome variables were pain intensity and functional disability.

LLA was determined with an OmniDiagnost Eleva device (Philips Medical Systems Nederland, Veenpluis 4–6, 5684 PC Best, The Netherlands, 2013) (Figure 2). We applied lateral view radiographs in a standard neutral standing position for the lumbosacral spine, which provided a vertical 30 × 90 cm film with a constant distance between the radiographic source and the subject. After that, on marked X-ray films, LLA was measured with the Surgimap Spine software (version 2017) (Figure 2). Its reliable and reproducible measurements, as well as accurate feedback are critical for clinical studies [25]. LLA was measured with Cobb's method [26], by drawing a line across the upper endplate of L1 (line 1) and a line across the lower endplate of L5 (line 2); line 3 was drawn perpendicularly to the first line, line 4 was drawn perpendicularly to the second line; the angle formed by the intersection of the 2 perpendicular lines (3, 4) is the Cobb's angle or LLA (Figure 3).

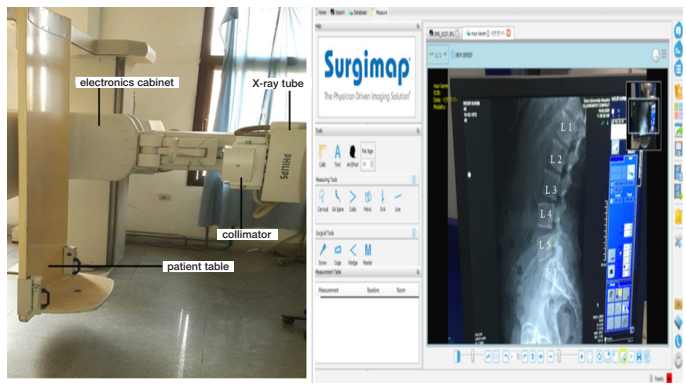
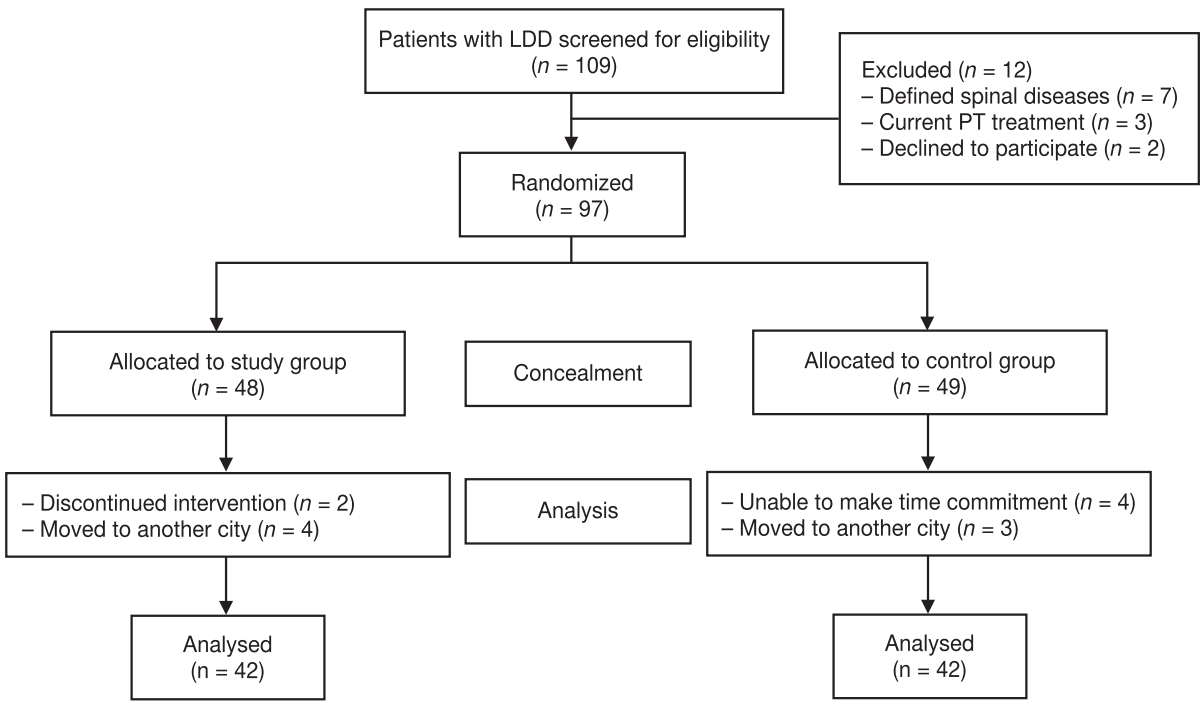


Figure 2. The OmniDiagnost Eleva device and Surgimap Spine software (version 2017)



LDD – lumbar disc degeneration, PT – physical therapy

Figure 1. A flow chart of patients' recruitment and retention throughout the study

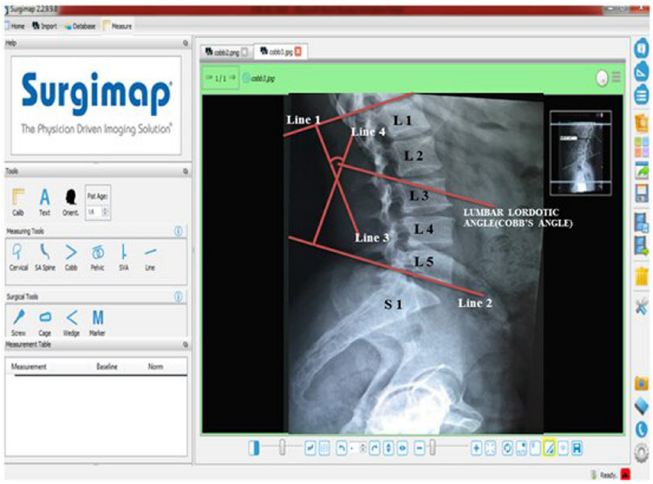


Figure 3. Using Surgimap Spine software (version 2017) to determine lumbar lordotic angle

This angle was chosen because it has excellent interrater and intrarater reliability (intraclass correlation coefficient [ICC] of 0.98 and 0.97) [26, 27].

For all study participants, pain intensity was assessed before and after treatment by using the visual analogue scale (VAS), which uses a line of 10 cm, where 0 refers to no pain and 10 indicates the worst pain. The patients were asked to mark the point reflecting their pain on the VAS line. Then, the score was determined by measuring the distance from the line left end to the point marked by the patient. VAS is a valid and reliable tool (ICC = 0.95) for pain assessment [28].

Functional disability was measured with ODI, which constitutes a reliable method (ICC = 0.91) [24]. ODI involves 10 items that evaluate pain and activities of daily living, including personal care, lifting, walking, sitting, standing, sleeping, sexual activity, social activity, and travelling. Each item is scored from 0 to 5, with 5 representing the most severe disability [23]. Thus, the total scoring of ODI ranges from 0 (no pain or disability) to 50 (severe pain and disability). The index is calculated by dividing the summed score by the total possible score; the outcome is then multiplied by 100 and expressed as a percentage [23].

Interventions

Patients in both groups received the same traditional physical therapy program. This included infrared irradiation, transcutaneous electrical nerve stimulation (TENS), and continuous ultrasound on the lumbosacral region, followed by traditional physical therapy exercises. The patient was positioned in prone lying and the lumbosacral region was uncovered. Infrared irradiation was administered on the lumbosacral region for 15 minutes at a 75–90 cm distance, with a Philips device (230–250 V, 250 W; China). Then, TENS was applied on the lumbosacral region paraspinally, with a frequency of 100–150 Hz, pulse width of 100–500 μs, intensity of 12–30 mA, and duration of treatment of 20 minutes, with a Phyaction 787 device (230 V, 300 mA, 50–60 Hz; Holland), followed by continuous ultrasound with 1.5 W/cm^2 intensity and a frequency of 1 MHz over the lumbosacral area, with a Phyaction U device (GymnaUniphy N.V., S.N 50297). The average local exposure time was planned to be 1 minute, and the effective radiating area of the transducer head was 5 cm^2.

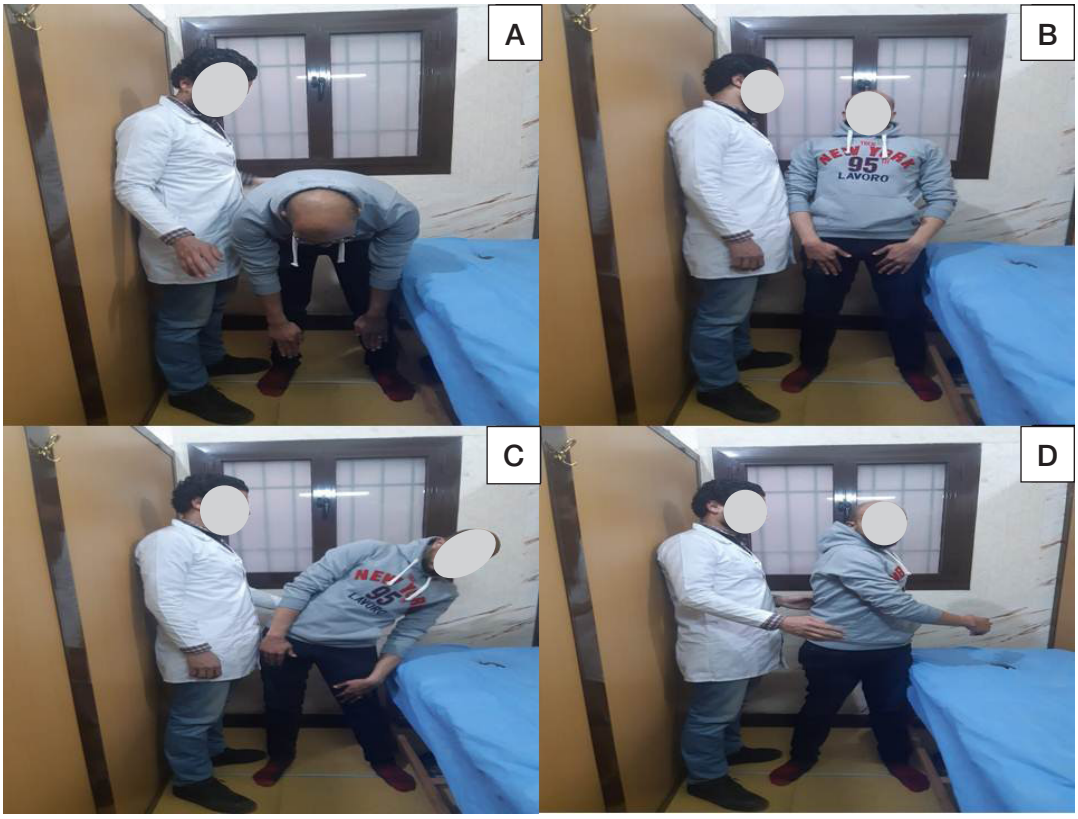
Traditional physical therapy exercises were divided into the following 5 types.

Active range of motion exercises

The patient was asked to move their back smoothly without resistance in flexion, extension, lateral flexion, and rotation to both directions, as shown in Figure 4.

Stretching exercises for lower back muscles

The patient was asked to passively move their knees to the chest to the end of the range, with gentle pressure for 30 seconds, then relax.



A – Flexion
B – Extension
C – Lateral flexion
D – Rotation

Figure 4. Active range of motion exercises

A – With straight arms
B – With both arms behind the head

Figure 5. Strengthening exercises for upper abdominal muscles

Strengthening exercises for upper abdominal muscles

These took the form of isotonic (concentric) contraction. The patient was asked to:

– Raise their head from the treatment bed with straight upper limbs, hold for 10 seconds, then relax (10 repetitions).

– Raise their head and shoulders with upper abdominal muscles, with both arms behind the head, hold for 10 seconds, then relax (10 repetitions), as shown in Figure 5.

Strengthening exercises for lower abdominal muscles

These took the form of isotonic (concentric) contraction. The patient was asked to:

– Drag their both lower limbs with knees to chest, hold for 10 seconds, then relax (10 repetitions).

– Alternatively, raise straight legs, hold for 10 seconds, then relax (10 repetitions).

– Perform cross leg raising exercises, hold for 10 seconds, then relax (10 repetitions).

Strengthening exercises for lower back muscles

These took the form of isotonic (concentric) contraction. The patient was asked to elevate their lower back and pelvis from the bed, hold for 10 seconds, then relax (10 repetitions) [29].

The control group received this conventional treatment only, while the study group additionally received CSEs 3 times per week for 12 weeks. For each exercise, we started with 5–10 repetitions, and then increased to 12–15, with 3-second rest periods between repetitions and 1-minute rest periods between exercises. Each repetition was held for no longer than 10 seconds [30, 31]. When performing the exercises, the patient was instructed to contract their abdominal muscles and keep this contraction, maintaining their normal breathing pattern.

Core stabilization exercises

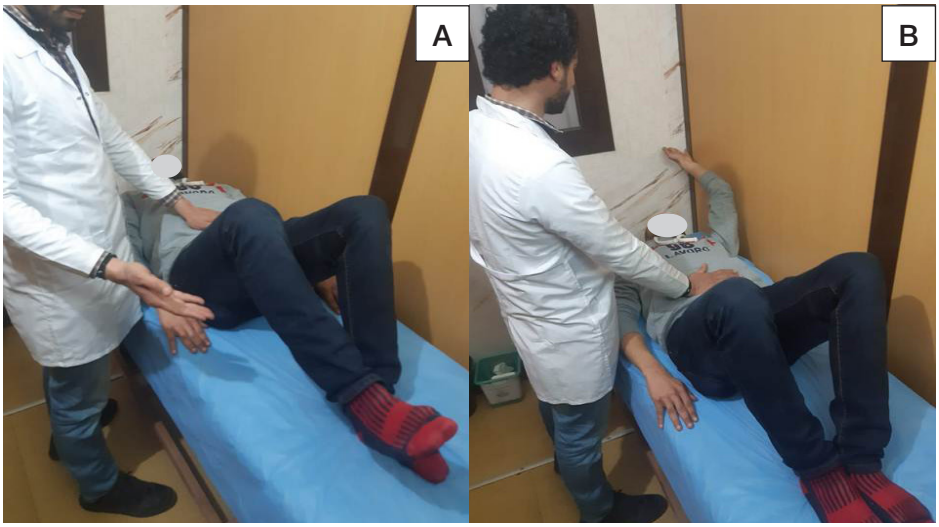
These were divided into 4 levels. Patients were instructed to take a relaxed breath in and out, hold the breath out, and maintain static abdominal contraction when performing the exercises. Each CSE level proceeded as described below.

Level 1: Hook-lying stabilization progression (weeks 1–3). While maintaining a hook-lying position, the patient was asked to lift one arm, both arms, perform heel slide, then lift, alternatively perform arm and leg lift, then curl up with hands to thighs and hands behind the head, as shown in Figure 6.

Level 2: Hands and knees stabilization progression (*weeks 4–6*). While maintaining a position of hands and knees stabilization, the patient was asked to rock forward, rock backward, and perform arm lift and leg lift progression, as shown in Figure 7.

Level 3: Bridging stabilization progression (*weeks 7–9*). While maintaining a position of bridging stabilization, the patient was asked to bridge with arm lift and bridge with leg lift, as shown in Figure 8.

Level 4: Plank exercises progression (*weeks 10–12*). While maintaining a position of plank stabilization, the patient was asked to do face-down plank progression and side plank progression, as shown in Figure 9.



A – With heel lift
B – With arm lift

Figure 6. Hook-lying

A – With arm lift
B – With leg lift

Figure 7. Hands and knees stabilization

A – With arm lift
B – With leg lift

Figure 8. Bridging stabilization

Figure 9
A – Face-down plank on feet
B – Side plank on feet

Statistical analysis

A *t*-test was conducted for comparison of subject characteristics between the groups. Chi-squared test served to compare sex distribution between the groups. The normality of data distribution was checked with the Shapiro-Wilk test. Levene's test was used to verify the homogeneity between the groups. Mixed MANOVA was performed for within- and between-group comparisons of effects on LLA, pain, and functional disability. Post-hoc tests with the Bonferroni correction were carried out for subsequent multiple comparison. The level of significance for all statistical tests was set at $p < 0.05$. The statistical analysis was conducted with the Statistical Package for the Social Sciences (SPSS), version 22 for Windows (IBM SPSS, Chicago, IL, USA).

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee of Human Scientific Research of the Faculty of Physical Therapy at Cairo University (approval No.: P.T.REC/012/002094) and registered at the Pan African Clinical Trials Registry (registry ID: PACTR201909860143787).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Subject characteristics

A total of 109 consecutive patients were screened for eligibility. Overall, 97 patients (mean ± *SD* age: 40.68 ± 4.75 years; mean ± *SD* weight: 76.39 ± 4.97 kg; mean ± *SD* height: 166.78 ± 4.1 cm; mean ± *SD* BMI: 27.44 ± 1.25 kg/m^2) satisfied the eligibility criteria, agreed to participate, and were randomized to the study group ($n = 48$) and the control group ($n = 49$). The reasons for ineligibility are presented in a flow diagram of the patients' recruitment and retention (Figure 1). There was no significant difference between the groups concerning the baseline demographic characteristics ($p > 0.05$) (Table 1).

Effect of treatment on LLA, VAS, and ODI

Study group

The mean ± *SD* pre-treatment LLA, VAS, and ODI values in the study group were 57.23 ± 5.53, 4.71 ± 1, and 35.64 ± 3.05%, respectively. The post-treatment values equalled 50.98 ± 5.38, 1.73 ± 0.44, and 18.57 ± 2.7%, respectively.

Table 1. Comparison of subject characteristics between the study and control groups

Characteristics	Study group (mean ± *SD*)	Control group (mean ± *SD*)	*MD*	*t*	*p*
Age (years)	40.52 ± 4.6	40.85 ± 4.9	–0.33	–0.32	0.74
Weight (kg)	77.07 ± 5	75.71 ± 4.95	1.36	1.24	0.21
Height (cm)	167.4 ± 4.03	166.16 ± 4.17	1.24	1.38	0.17
BMI (kg/m^2)	27.48 ± 1.2	27.41 ± 1.73	0.07	0.25	0.79
Females/males (*n*)	27/21	25/24		($\chi^2 = 1.19$)	0.27

MD – mean difference, BMI – body mass index

Table 2. Mean LLA, VAS, and ODI pre- and post-treatment values in the study and control groups

Parameters	Study group (mean ± *SD*)	Control group (mean ± *SD*)	*MD* (95% CI)	*p*
LLA (°)				
Pre-treatment	57.23 ± 5.53	57.43 ± 3.3	–0.2 (–2.17 to 1.78)	0.84
Post-treatment	50.98 ± 5.38	55.79 ± 3.81	–4.81 (–6.83 to –2.78)	0.001*
MD (95% CI)	6.25 (5.14–7.35)	1.64 (0.53–2.73)		
p	0.001*	0.004*		
VAS				
Pre-treatment	4.71 ± 1	4.85 ± 0.92	–0.14 (–0.56 to 0.27)	0.49
Post-treatment	1.73 ± 0.44	3.23 ± 0.48	–1.5 (–1.7 to –1.29)	0.001*
MD (95% CI)	2.98 (2.73–3.21)	1.62 (1.37–1.86)		
p	0.001*	0.001*		
ODI (%)				
Pre-treatment	35.64 ± 3.05	36.76 ± 3.44	–1.12 (–2.53 to 0.29)	0.12
Post-treatment	18.57 ± 2.7	27 ± 1.26	–8.43 (–9.34 to –7.51)	0.001*
MD (95% CI)	17.07 (16–18.13)	9.76 (8.69–10.82)		
p	0.001*	0.001*		

LLA – lumbar lordotic angle, VAS – visual analogue scale, ODI – Oswestry Disability Index, *MD* – mean difference
* Statistically significant values.

There was a significant decrease in all variables ($p = 0.001$) in the study group (Table 2).

Control group

The mean ± *SD* pre-treatment LLA, VAS, and ODI values in the control group were 57.43 ± 3.3, 4.85 ± 0.92, and 36.76 ± 3.44%, respectively. The post-treatment values equalled 55.79 ± 3.81, 3.23 ± 0.48, and 27 ± 1.26%, respectively. There was a significant decrease in LLA ($p = 0.004$), VAS ($p = 0.001$), and ODI ($p = 0.001$) in the control group (Table 2).

Comparison between groups

There was no significant difference in pre-treatment LLA ($p = 0.84$), VAS ($p = 0.49$), or ODI ($p = 0.12$) between the study and the control groups. However, the mean post-treatment values of all variables were significantly lower ($p = 0.001$) in the study group compared with the control group (Table 2).

Discussion

In spite of the growing knowledge and medical development pertaining to spinal disorders, DDD remains one of the most prevalent and costly health problems worldwide as it can cause mild to severe pain near the involved disc, as well as neuropathic pain resulting in chronic LBP [32]. The treatment of chronic LBP has proven very challenging owing to its negative impact on the socioeconomic status. Moreover, there is no certainty about the most proper approach for a specific patient [33].

We believe that the changes in disc morphology have an impact on numerous lumbosacropelvic angles and biomechanics of the spinal structure together; thus, changes within the lumbar curvature increase stress on the lumbar region, frequently inducing lumbar pain [34].

The purpose of this study was to examine the effect of CSEs in addition to traditional physical therapy compared with performing traditional physical therapy alone on LLA, pain intensity, and functional disability in patients with LDD.

Our results showed that LLA decreased with CSEs in LDD patients. In our study, there was a significant effect on LLA compared with pre-intervention measurements in both groups, with more significant improvement in the study group than in the control group.

The variation of lumbar lordosis is one of the common causes of chronic LBP because of abnormal posture and is a major contributor to the development of general chronic LBP; however, it can lead to excessive load being applied on vertebral joints and intervertebral discs, resulting in nerve root impingement and disc degeneration. Stress plays an important role in the degeneration of the lumbar disc. The more significant improvement in LLA in the study group than in the control group might be explained by the effect of CSEs on maintaining segmental stability, protecting the spine, and reducing stress that impacts on the lumbar vertebrae and intervertebral discs [12, 13].

The findings of the current study are in agreement with those of previous research conducted by Cho et al. [35], who reported that CSEs were more effective than conservative treatment for improving functional disability and LLA. Their results indicated that measuring LLA was helpful in diagnosing patients with LBP and assessing them after treatment. Furthermore, Hosseinifar et al. [36] showed that both CSEs and traditional physiotherapy resulted in decreasing pain intensity and disability, as well as improving LLA in patients with chronic LBP.

In contrast, there are studies that contradict the findings of the current study, such as that by Ko et al. [37], who concluded that CSEs did not affect LLA, although the exercises effectively improved strength and flexibility of the lumbar muscles and reduced pain intensity. This may be explained by the fact that lumbar lordosis is influenced by several factors, e.g. age, gender, and spinal disorders [38]. Similarly, Oh et al. [39] implied that CSEs did not significantly affect LLA in females in their 20–30s.

Physical and behavioural consequences of chronic LBP are interrelated, so behavioural changes are often accompanied by physical limitations in painful regions [40]. People with LBP experience discoordination in the function of different body parts as lumbar spine and hip joint [41]. Severe LBP can result in movement disability that ultimately may lead to avoiding daily activities or occupations in the short or long term [40, 41].

Exercises are among the main methods of treatment of chronic LBP. It has been shown that they reduce the duration and frequency of LBP [42, 43]. Specific exercises that activate abdominal and/or back extensor muscles are advocated to reduce pain and disability [44, 45]. This current study indicated significant alleviation in pain intensity and functional disability in both groups, with more significant improvement in the study group than in the control group. Therefore, it seems that CSEs decrease the stress on the spinal structure. As a result, it can be seen that lumbar stability, lumbar muscle strength, increased range of motion, and reduction of pain are effective in LBP patients [37, 38].

The findings of our study are in agreement with those obtained by Areeudomwong et al. [46], who measured the effect of 10-week CSEs on pain intensity, disability, and activation of trunk muscles in subjects with clinical instability of the lumbar spine and reported that CSEs enhanced the ability of the segmental muscles, which resulted in improved function and decreased pain in subjects with chronic LBP. CSEs may increase the activation of deep fibres and cross-sectional area of paravertebral muscles, facilitate the stability and coordination of lumbar spine, and subsequently lead to a better clinical outcome in the treatment of LBP [47].

Furthermore, Niemistö et al. [48] reported that functional disability was significantly lower in 204 patients who performed CSEs for 3–12 months than controls. In the same line, Hicks et al. [49] observed that functional disability decreased significantly after 8 weeks of CSEs. Similarly, in the present study, functional disability turned out significantly reduced after CSEs. This recovery of functionality is similar to that described by Sekendiz et al. [50], who noted that CSEs helped restore the function of the stabilizers contributing to the postural control of the trunk and deep abdominal muscles, and thus increased the range of joint motion.

In turn, the findings of the current study are in contrast with the research by Shamsi et al. [51] and Cairns et al. [52], who concluded that there was no extra benefit of adding CSEs to conventional physiotherapy in patients with recurrent LBP as CSEs were not more effective than conventional physiotherapy in reducing pain intensity among chronic non-specific LBP subjects. In the same line, May and Johnson [53] reported that there might be a role for CSEs in some patients with chronic LBP, but these were no more effective than other active interventions. This contradiction may be attributed to the differences in the conventional physiotherapy modalities in the control group between the above-mentioned studies and the current study.

Limitations

Our analysis has some potential limitations, which can serve as recommendations for future studies. The primary limitation was that no follow-up was performed to reveal the long-lasting effect and recurrence of the symptoms. Another major limitation was the invasive nature of the radiologic assessment. Additionally, we only focused on LLA to illustrate the effect of core stabilization in LDD. Therefore, the important parameters described in the global spinal balance, such as the degree of thoracic kyphosis, C7 sagittal plumb line, or sagittal vertical axis, may have been missed.

Conclusions

CSEs could provide an additional effect of improving LLA, pain intensity, and functional abilities in patients with LDD. So, they can be used with traditional physical therapy programs in the rehabilitation of patients with LDD and improve their quality of life.

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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