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# Effect of Pilates exercise on balance and spinal curvature in subjects with upper cross syndrome: a randomized controlled clinical trial

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**Introduction:** To investigate the outcomes of Pilates exercise compared to traditional treatment for management of the upper cross syndrome (UCS).
**Methods:** Forty participants (females) with UCS were randomly divided into two equal groups: group A (control group) and group B (experimental group). Both groups received two sessions per week for four consecutive weeks. Group A received traditional physical therapy program in form of stretching, strengthening and postural correction exercises while Group B received Pilates exercise program. Primary outcome measures were balance, spinal curvature, Craniovertebral angle (CV), and rounded shoulders while the Neck Disability Index and Visual Analogue Scale served as secondary outcome measures. Measurements were recorded before and after treatment.
**Results:** Comparison between pre-and post-treatment test results showed that all dependent variables significantly improved for both groups ($p$ > 0.001). However, Pilates exercise resulted in greater improvement in terms of balance, spinal curvature, CVA, and pain ($p$ > 0.001).
**Conclusions:** Pilates exercise program proved better than traditional physical therapy program in improving spinal curvature, balance, and function and reducing pain in UCS.
**Key words:** balance, Pilates exercise, upper cross syndrome, spinal curvature

## Introduction

The most prevalent postural issue that results in joint dysfunction of the shoulder girdle and cerviothoracic region, especially at the atlantooccipital and the glenohumeral joint, is known as upper cross syndrome (UCS) [1]. Nasser et al. 2021 estimated that the prevalence of UCS was 32.43% among office employees, 24.32% among drivers, 27.03% among housewives, 16.22% among teachers, and 37.1% among medical students [2]. Furthermore, Mubashir [3] noted 11%–60% incidence of UCS across a range of societies and age groups.

Upper cross syndrome is a widespread problem in workplaces that occasionally prevents workers from showing up for their scheduled shifts. In many countries, according to, Ostergren et al. 2005, work-related musculoskeletal injuries and complaints place a major strain on one's health because they frequently result in lost workdays and high workers compensation and disability costs [4]. Nowadays, bad habits brought about by technology such as overuse of mobile phones, televisions, computers, and tablets, resulted in negative impacts on health. Bending in abnormal positions while using these devices causes various mechanical loads on the neck and upper back area, rounded shoulders from increased thoracic kyphosis etc., and this leads to poor posture that can cause UCS [5].

Most jobs require prolonged use of forward arm in dominant flexor synergy, such as physical therapist and computer operators [6]. The development of this postural syndrome has been linked to several variables, including work habits, proprioceptive inputs, and even psychogenic problems like low self-esteem or despair [7]. Increased forward head angle and hyperextension of the upper part of the cervical spine, which are frequently linked to forward head, rounded shoulder, protracted scapulae, and thoracic kyphosis, are the two factors that induce UCS [8]. It appears with over-facilitation, tightness, or over-excitation of the pectoralis major and minor, subclavius, upper fibers of trapezius, levator scapulae, sternocleidomastoid and sub occipital muscles and weakness or inhibition of the middle and lower fibers of the trapezius rhomboids, serratus anterior, longuscolli and capitis, infraspinatus, teres minor and thoracic paraspinal muscles [9]. The joint surfaces may be directly impacted by these muscle imbalances and movement disorders, potentially resulting in joint deterioration [10].

Breathing issues can occasionally occur in UCS. This is caused by the rib cage not being able to fully expand for lung inflation. The main muscles involved in breathing include the diaphragm, intercostals, scaleni, transverse abdominis (TrA), pelvic floor muscles, and deep intrinsic spinal muscles. Each of these muscles aids in stabilizing the spine and breathing. Therefore, decreased thoracic spine mobility and involvement of the auxiliary respiratory muscle are the causes of respiratory dysfunctions in UCS [11]. As part of physical therapy for UCS, the tight muscles are primarily stretched, the weak and elongated muscles are strengthened, the posture is adjusted, and manual therapy such as joint mobilization or myofascial release is used [12].To our knowledge, five studies reported the role of physical therapy in UCS. Thacker et al. [13] used a variety of exercises and active release technique to treat UCS while Ali et al. [14] used stretching exercises versus muscle energy techniques for managing UCS. On the other hand, Rostamizalani et al. [15] examined the impact of three corrective exercise techniques on the forward head and quality of life in males with UCS, and Arif et al. [16] employed traditional physical therapy to treat UCS, both with and without muscle energy approaches. Finally, to treat cervical dysfunction in UCS [16], Gillani et al. [17] used eccentric muscular energy approach versus static stretching activities. No studies reported using Pilates exercise program in managing UCS, yet there was one study that investigated the effect of Pilates on chronic nonspecific low back pain (LBP) by Da Luz et al. [18], and on scoliosis by Kim et al. [19] and found great effects of Pilates on both LBP and scoliosis.

Pilates exercise is a method that uses movements to stretch and strengthen certain muscles to condition the body and enhance posture, muscle tone, alignment, and flexibility [20, 21]. Pilates is intended to strengthen, rebalance, and realign the body in conjunction with other workout regimens. Focus is also placed on improving individual body awareness which further decreases the risks of strain or injury that can occur with imbalances. Pilates teaches individuals to identify their own musculoskeletal strengths and weaknesses and equips them with the knowledge to correct and rebalance their entire body mechanics [21]. The objective of this study was to investigate the outcomes of Pilates exercise compared to traditional treatment for management of UCS. Authors hope that the current clinical trial will represent an addition to the treatment of UCS

## Subject and methods

### Design

This is a double-blind randomized controlled clinical experiment (assessment and patients), which investigated the effects of Pilates exercise compared to traditional physical therapy program on UCS. In two different instances, data were collected both before and after the treatment. The study was carried out between October 2022 and January 2023 and was conducted in the out-patient clinic – College of Physical Therapy. Both the physical therapists evaluating patients pre- and post- treatment remained blinded to patients' allocation for the duration of the research. Additionally, by designating the groups with numbers, the statistician who carried out the outcome analysis was rendered blind to the group allocation.

Participants

The College of Physical Therapy outpatient clinic at Deraya University, recruited 70 female patients with UCS. Following a confirmed clinical medical diagnosis of UCS, their orthopaedic doctor recommended they begin physical therapy. After physical therapy screening, 40 participants met the inclusion criteria which was as follows: age 17 to 22 years, gender females, body mass index between 20–25 kg/$m^2$ [22]. presence of excessive antero-posterior curvature of the thoracic/dorsal spine (Cobb angle for kyphosis) greater than 41° [23] using the spinal mouse device [24], CV angle of less than 50° [25], presence of normal cognitive function and willing to participate in the study [12].

Sample size calculation was done using balance index, as reported from pilot study , with 80% power at $\alpha$ = 0.05 level, number of measurements 2, for 2 groups and effect size = 0.47 using F-test repeated measure MANOVA within and between interaction. The minimum proper sample size is 38 subjects, adding 4 (10%) subjects as drop out, so total sample size is 42 subjects 21 in each group. The sample size was calculated using the G*Power software (version 3.0.10),

Participants were excluded if they experienced any recent trauma (within three months of the initial consultation) [22], chief complaint of headaches or facial pain [26], presence of contra-indications to Pilates exercises such as pregnancy, hypertension, osteoporosis, and spinal tumors [22], presence of any structural abnormality in the upper and middle back (e.g., scoliosis or presence of positive Adam's test) [27]. Participants on anti-inflammatory or muscle relaxant medications were given a three-day period "wash out" before participating in the study [26].

Following the signature of a consent form, demographic information was gathered, and 40 participants (females) were then randomized to two equal groups: control group (group A) and experimental group (group B). Randomization was done by assigning an identification number to each participant by an independent researcher. Group A (*n* = 20) received standard physical therapy program including strengthening, stretching and postural correction exercises while Group B (*n* = 20) received Pilates exercise (Figure 1). There were no dropouts of the study, all participants were able to finish the treatment program.

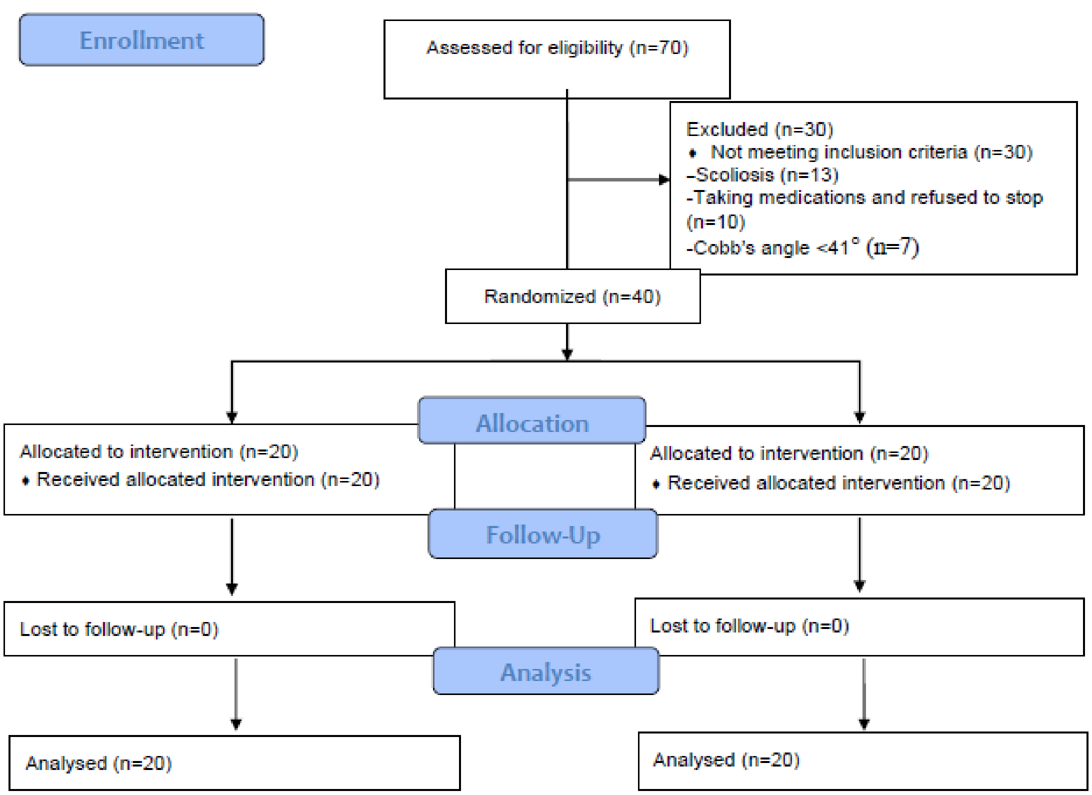


Figure 1. Flowchart for the study's screening procedure

The pre and post treatment scores of outcome measures were examined by the same independent, experienced physical therapist not included in the clinical trial. Both groups received two sessions per week for four consecutive weeks by another well trained physical therapist. Session duration for both groups ranged from 55 minutes to 1 hour.

Treatment

Group A received stretching, strengthening and postural correction exercises as follows [13]:

– Exercises for postural correction, stretches, and strengthening for the pectoralis major, elevator scapulae, upper trapezius, serratus anterior, rhomboids, and deep neck flexors muscles.

– The stretches included Brugger's, wall angels, sitting chair stretches, doorway stretches. Every stretch was performed 30 seconds on and 30 seconds off, 3 times per day,

– Push-ups and head-neck retraction were also included, total time about 60 minutes.

Group B received Pilates exercises. Session duration was 60 minutes, 10 to 12 exercises in form of 10 steps were carried out per session, with no more than three repetitions of each exercise, as appropriate to each participant's ability. The exercises were performed by each participant independently. The following is a detailed description of each exercise utilized in both treatments, along with its starting and ending positions, number of repetitions, and picture [28]:

1. Corrected neck alignment while lying on the back on a mat (use pillows if needed): Press the base of the cranium, triceps, back, and shoulder blades against the mat, then breath while maintaining muscle contraction as shown in Figure 2.

2. Arm circles (both directions) on the mat, then use strong ribcage breathing to connect into scapula as shown in Figure 2.

3. Diamond press: lie prone on a mat, using the lower part of the trapezius and serratus anterior muscles to slide shoulder blades out and down. Move into slight back extension maintaining this position as shown in Figure 2.

4. Diamond press: repeat above but add lateral arm movement to back extension as shown in Figure 3.

5. Arm slides 90°: lies supine on mat with arms bent at 90° and thumbs on floor. Slide elbows on floor toward waistline while contracting serratus anterior muscle. Repeat on the floor with other fingers. Always maintain proper neck alignment as shown in Figure 3.

6. Arm circles on a tiny barrel while lying on back with the head and neck supported by the barrel. Opened chest, then link the scapula to the barrel. Hold this position while performing arm circles as shown in Figure 3.

7. Chair expansion: seated on mat with back to chair, expand chest, stabilize scapula, hands-on stepper, raise and lower arms.

8. Lying prone, stabilize the scapula and pump arms up and down with lower back support as shown in Figure 4.

9. Straps for chest expansion: kneel on a mat facing a wall, chest open, upper back muscles engaged, maintain alignment, and then released. Rotating the head 90° to the right and left repeatedly as shown in Figure 4.

10. Kneel plank on a Swiss ball: kneel on the mat and place the barrels on the ball in front of you. Position is adjusted to meet plumb line requirements. Keep alignment while allowing the ball to move forward and fall diagonally. Shoulder stabilizers are used to move back with perfect alignment as shown in Figure 4.

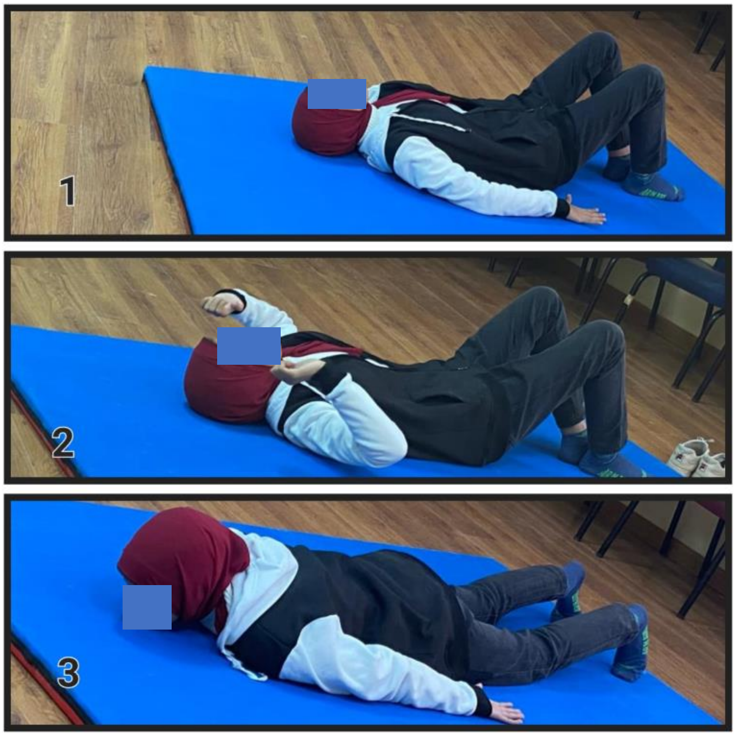

Figure 2. Steps (1, 2, 3) of Pilates exercise

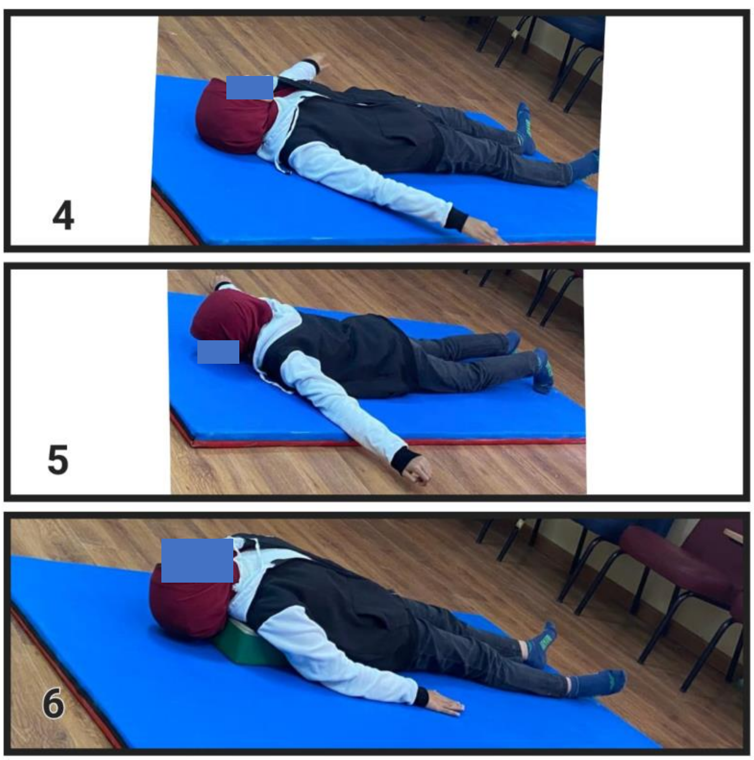

Figure 3. Steps (4, 5, 6) of Pilates exercise

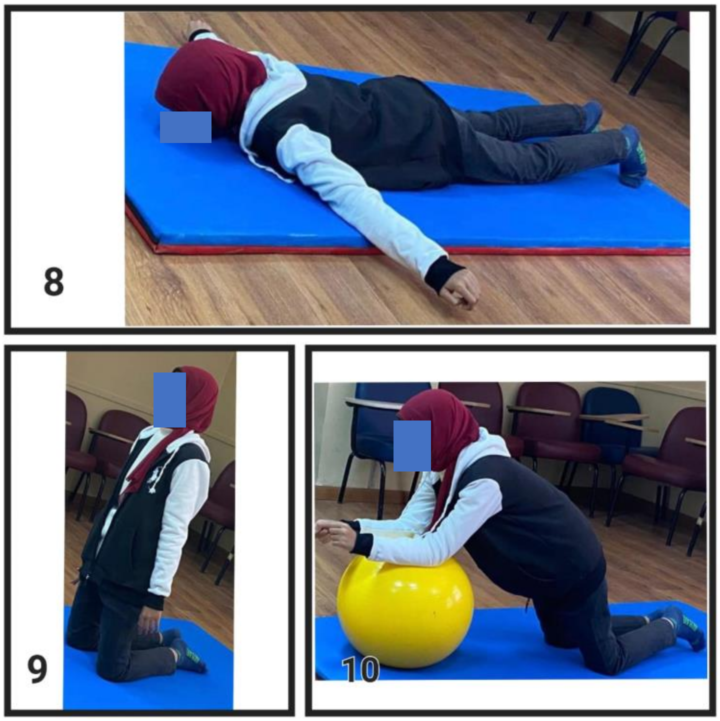

Figure 4. Steps (8, 9, 10) of Pilates exercise

Outcomes measures

Primary outcome measures were spinal curvature, CV angle, rounded shoulder and balance while pain and functional impairment were the secondary outcomes measures.

Primary outcome measures

*Spinal curvature using spinal mouse device*

The spinal mouse device (Idiag AG, Fehraltorf, Switzerland) is a tool that is physically guided along the skin of the spine and reconstructs the spine in the sagittal and frontal planes in neutral and extreme positions. Real measurements taken from subjects are used to create the photos. In the sagittal plane, measurement positions are (a) Standing straight; (b) full flexion; and (c) full extension. For research and patient monitoring in the clinic, spinal mouse is a rapid, easy, trustworthy, and risk-free technique [29].

In the current study, the spinal mouse was used to measure spinal curvature. Prior to each use, a baseline calibration was done, and each participant's personal information was reported. The angle of the thoracic kyphosis in the thoracic spine, from standing position with the spine in erect, extension, and flexion positions ranged from 41°–44° [24]. The computer printed and recorded the test's results. The average error of the three trials as well as the value of each trial's mistake were included [30].

*Craniovertebral angle*

The seventh cervical (C7) vertebra's spinous process and a second line connecting the spinous process of the C7 vertebra and the tragus of the ear together constitute the CV angle, which is one of the most objective ways to measure head posture [31]. The smartphone app forward head posture can measure the craniovertebral angle in a standing position with validity and reliability, making it potentially helpful as an assessment tool [32]. In the current study, CV angle was measured as follows: from a person's side, an imaginary horizontal line was marked at C7 spinous process (e.g., located at the back of the vertebra at the base of each participant's neck). The CV is formed by the junction of a second line drawn from the C7 spinous process up to the tragus, which is the pointed region in front of the earhole. A forward head position is commonly defined as having CV angle while standing less than 50°. An image snapped from the side was used to calculate this angle [33].

*The rounded shoulder or sagittal shoulder posture*

The rounded shoulder posture is measured by the angle created when a horizontal line through C7 crosses a line that runs between the posterior portion of the acromion and the midpoint of the larger tuberosity of the humerus. This angle serves as a reference for the forward position of the shoulder joint. There is a clinical reliability and validity for this technique; a lower angle suggests that the shoulder is more forward in comparison to C7, or a more rounded shoulder [34]. The rounded shoulder test was developed to measure rounded shoulder posture. In supine lying position, the therapist measured the distance from the shoulder joint to plinth using a tape measurement, with more than six cm indicating presence of rounded shoulder posture [35].

*Balance evaluation using Biodex Balance System*

The Biodex Balance System (Biodex Medical Systems Inc., Shirley, NY, USA) is an advanced measuring and training tool for static and dynamic balance. It is considered reliable and efficient tool. In the current study, the Biodex balance system was used to measure the equilibrium (static and dynamic balance). Prior to each use, the device was calibrated, and each participant's personal information was recorded. The ability of participants to maintain the center of balance was highlighted by the Postural Stability Test. The Patient's score on this test examined deviations from centre, so a lower score is preferable to a higher score. Each participant was standing on the plate form with both lower extremities. There was a 20 second test period, using level of stability: 8 and position: Two Legs. The equipment recorded and printed the test's results. It contained the average error of the three trials as well as the value of each trial's error [30].

Secondary outcome measures

*Visual Analogue Scale (VAS) to measure pain intensity*

The VAS is a non-numerical pain scale, which consists of a 100 mmhorizontal line with 0 at the left side of the line indicating no pain, and 10 on the right side of the line indicating the most intense pain that could be felt. In the study, each participant was told to mark along the horizontal VAS line to indicate how much pain they were experiencing right then. Using a ruler, the distance in mm from the lower limit was calculated [36].

*The Arabic Neck Disability Index (ANDI)*

The ANDI is a ten-item questionnaire used to evaluate neck pain-related impairment. Six elements relate to activities of daily living, whereas four deal to subjective symptomatology (pain intensity, headache, concentration, and sleeping) (lifting, work, driving, recreation, personal care, reading) [37]. Each item's score ranges from 0 (no pain and no functional limitation) to 5 (worst pain and maximum limitation), for a total score that ranges from 0 (no disability) to 50 (totally disabled). A score of less than 4 indicates no disability, 5–14 mild disability, 15–24 moderate disability, 25–34 severe disability, and scores greater than 35 complete disability. It takes about 5–10 minutes to complete and grade the questionnaire then convert the scoring to precent, and there is no specific training needed to deliver it [38]. Each participant answered 10 questions on the questionnaire, with 6 options for each topic. Participants were told to select just one response that best reflected their current situation [39].

Data analysis and statistical design

All data were examined for the existence of extreme scores, homogeneity of variance, and the normality assumption. The normality tests Shapiro–Wilk and Kolmogorov–Smirnov test revealed that all variables were measured had a normal distribution. In the current study, data was presented as mean and SD. To compare demographic information between participants in both groups, unpaired t-test was utilised. Using multivariate analysis of variance, all measured variables were compared between and within groups. The statistics package for social sciences computer programme was used for data analysis (version 20 for Windows; SPSS Inc., Chicago, Illinois, USA) P equal to or less than 0.05 was regarded as significant.

## 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 ethical committee of the College of Physical Therapy, Cairo University (approval No.: P.T.REC/012/003992). Clinical Trials registration number: NCT05591729.

## Results

Demographic data of patients

A total of 40 participants joined this study and were assigned to two equal groups at random (Table 1). The mean age of groups A and B were (19.2 ± 1.4) and (19.3 ± 1.5) years, height (159.5 ± 5.7) and (160.3 ± 6.4) cm. and weight (66.5 ± 6.3) and (67.4 ± 5.6) kg respectively. The mean age, height, and weight of the two groups did not significantly differ from one another ($p > 0.05$).

Table 1. Subjects' characteristics of both groups

| Variables | Group A (mean ± *SD*) | Group B (mean ± *SD*) | *t*-value | *p*-value |
|---|---|---|---|---|
| Age (years) | 19.2 ± 1.4 | 19.3 ± 1.5 | –0.054 | 0.957 |
| Height (cm) | 159.5 ± 5.7 | 160.3 ± 6.4 | –0.415 | 0.681 |
| Weight (kg) | 66.5 ± 6.3 | 67.4 ± 5.6 | –0.422 | 0.675 |

## Effect of Pilates exercise on spinal curvature

The mean ± *SD* of spinal curvature for participants in groups A and B pre-treatment were 45.9 ± 2.6 and 45.2 ± 2.2 degrees respectively, while post-treatment were 42.1 ± 2.7 and 35.1 ± 2.4 degrees respectively. Between the two groups, there was no statistically significant difference in the pre-treatment mean values of spinal curvature ($p = 0.369$). On the other hand, group B benefited post-treatment ($p = 0.001$). Within both groups, there was a statistically significant difference between the pre- and post-treatment means of spinal curvature ($p = 0.001$). Groups A and B experienced percentage changes in pre- and post-treatment mean values of 8.3 and 22.3%, respectively as shown in Table 2.

Table 2. Comparison between pre- and post-treatment mean values of measured variables between and within groups

| Variables | Group A | Group B | MD (95% CI) | *p*-value | $\eta p^2$ |
|---|---|---|---|---|---|
| Spinal curvature (degree) | | | | | |
| Pre-treatment | 45.9 ± 2.6 | 45.2 ± 2.2 | 0.7 (0.858–2.25) | 0.369 | 0.021 |
| Post-treatment | 42.1 ± 2.7 | 35.1 ± 2.4 | 7 (8.62–5.3) | 0.001* | 0.666 |
| *p*-value | 0.001* | 0.001* | | | |
| Percentage of change | 8.3% | 22.3% | | | |
| Craniovertebral angle (degree) | | | | | |
| Pre-treatment | 42.5 ± 3.4 | 43.2 ± 3.7 | 0.75 (0.3–1.5) | 0.509 | 0.012 |
| Post-treatment | 38.4 ± 3.6 | 34.2 ± 3.3 | 4.15 (1.9–6.3) | 0.001* | 0.274 |
| *p*-value | 0.001* | 0.001* | | | |
| Percentage of change | 9.6% | 21% | | | |
| Rounded shoulder (cm) | | | | | |
| Pre-treatment | 5.1 ± 0.5 | 5.2 ± 0.39 | 0.115 (0.414–0.18) | 0.440 | 0.016 |
| Post-treatment | 3.9 ± 0.55 | 4.1 ± 0.38 | 0.12 (0.423–0.183) | 0.428 | 0.017 |
| *p*-value | 0.001* | 0.001* | | | |
| Percentage of change | 23.5% | 21% | | | |
| Overall stability index | | | | | |
| Pre-treatment | 1.1 ± 0.2 | 1.07 ± 0.2 | 0.015 (0.119–0.149) | 0.822 | 0.001 |
| Post-treatment | 1.4 ± 0.25 | 1.7 ± 0.2 | 0.340 (0.847–0.193) | 0.001* | 0.356 |
| *p*-value | 0.001* | 0.001* | | | |
| Percentage of change | 27% | 59% | | | |
| Visual Analogue Scale (mm) | | | | | |
| Pre-treatment | 7.4 ± 1 | 8 ± 1.1 | 0.55 (1.26–0.162) | 0.126 | 0.061 |
| Post-treatment | 4 ± 0.8 | 2.5 ± 1.2 | 1.4 (0.802–2.098) | 0.001* | 0.351 |
| *p*-value | 0.001* | 0.001* | | | |
| Percentage of change | 46% | 68.7% | | | |
| Neck Disability Index | | | | | |
| Pre-treatment | 46.8 ± 7.7 | 51.3 ± 6.8 | 4.5 (9.1–0.146) | 0.057 | 0.092 |
| Post-treatment | 16.8 ± 3.6 | 15.2 ± 4.6 | 1.65 (1.013–4.3) | 0.217 | 0.040 |
| *p*-value | 0.001* | 0.001* | | | |
| Percentage of change | 64.1% | 70.4% | | | |

± *SD*, $\eta p^2$ – partial eta square, MD – mean difference, CI – confidence interval, * significant

Effect of Pilates exercise on CV angle

The mean ± *SD* of CV angle for participants in groups A and B pre-treatment were 42.5 ± 3.4 and 43.2 ± 3.7 degrees respectively, while post-treatment were 38.4 ± 3.6 and 34.2 ± 3.3 degrees respectively. There was no statistically significant difference in pre-treatment mean values of CV angle between both groups ($p = 0.509$). While there was significant difference post treatment ($p = 0.001$) in favour of group B. Between the pre- and post-treatment mean values of the CV angle within both groups, there was a statistically significant difference ($p = 0.001$). In groups A and B, the percentage of change between pre- and post-treatment mean values was 9.6% and 21%, respectively (Table 2).

Effect of Pilates exercise on rounded shoulders

The mean ± *SD* of rounded shoulder for participants in groups A and B pre-treatment were 5.1 ± 0.5 and 5.2 ± 0.39 cm respectively, while post-treatment were 3.9 ± 0.55 and 4.1 ± 0.38 cm respectively.

Pre-treatment and post-treatment mean values of rounded shoulder did not differ statistically significantly between the two groups ($p$ = 0.440 and $p$ = 0.428 respectively). However, there was statistical significant difference between pre and post treatment in group A and group B ($p$ = 0.001) with percentage changes of 23.5% and 21%, respectively (Table 2).

Effect of Pilates exercise on balance

The mean ± *SD* of overall stability index for participants in groups A and B pre-treatment were 1.1 ± 0.2 and 1.07 ± 0.2 respectively, while post-treatment were 1.4 ± 0.25 and 1.7 ± 0.2 respectively. Pre-treatment mean values did not differ statistically between the two groups ($p$ = 0.822). On the other hand, group B benefited post-treatment due to a substantial difference ($p$ = 0.001). Within both groups, there was a statistically significant difference between the pre- and post-treatment mean values ($p$ = 0.001). Groups A and B experienced percentage changes in pre- and post-treatment mean values of 27% and 59%, respectively (Table 2).

Effect of Pilates exercise on pain

The mean ± *SD* of pain for participants in groups A and B pre-treatment were 7.4 ± 1 and 8 ± 1.1 mm respectively, while post-treatment was 4 ± 0.8 and 2.5 ± 1.2 mm respectively. Pre-treatment mean values did not differ statistically between the two groups ($p$ = 0.126). On the other hand, group B benefited post-treatment due to a substantial difference ($p$ = 0.001). Within both groups, there was a statistically significant difference between the pre- and post-treatment mean pain levels ($p$ = 0.001). Between pre- and post-treatment mean values, group A and group B experienced percentage changes of 46% and 68.7%, respectively (Table 2).

Effect of Pilates exercise on Neck Disability Index

The mean ± *SD* of NDI for participants in groups A and B pre-treatment were 46.8 ± 7.7 and 51.3 ± 6.8 respectively, while post-treatment were 16.8 ± 3.6 and 15.2 ± 4.6 respectively. Pre- and post-treatment mean values for both groups did not differ statistically ($p$ = 0.057 and $p$ = 0.217 respectively). Within both groups, the mean NDI values before and after therapy differed statistically ($p$ = 0.001). Groups A and B experienced percentage changes of 64.1% and 70.4% between pre- and post-treatment mean values, respectively (Table 2).

## Discussion

The effects of a Pilates exercise program on spine curvature, rounded shoulders, balance, pain, and neck-specific impairment in patients with UCS are the subject of current study, which to authors knowledge is the first study evaluating the effects Pilates on UCS. The present study's findings point to improvements in both the control and Pilates groups in all measured parameters; however, the Pilates group showed a bigger improvement. These preliminary findings suggest that the use of Pilates exercise in the management of UCS may contribute to more positive outcomes in terms of spine curvature, balance, pain relief, and functional impairment.

Using the traditional treatment program consisting of postural correction, stretching and strengthening exercises was effective in improving function of muscles of shoulders, chest, and upper back and had an impact on spinal alignment in UCS. When muscles are tight, it can lead to joint dysfunction, spinal malalignment, and pain. Additionally, muscles tightness usually occurs in an asymmetrical way, so stretching can help prevent this problem to promote good spinal health and improve and maintain flexibility, which then minimizes the occurrence of any injury [13]. These findings are in line with those of Bayattork et al. [40] who suggested assessing the efficiency of a thorough corrective exercise program on the alignment, particular muscle activations, and pertinent movement patterns in men with UCS. The results of their study provided fresh understandings into how exercise affects alignment as well as vital outcomes like muscle activation and movement patterns. Also, Thacker et al. [13] studied the effects of alternative techniques (active release techniques and exercises) on UCS, which proved effected but to accurately compare it with results of the current study can be inaccurate since treatment modalities are different.

Pilates method is one of the current approaches used to promote muscle recovery as it works the body by using gravity and springs to increase resistance and help with the execution of each movement, thus it may be more effective in the treatment of UCS [41]. This technique, which was established by Joseph Pilates, uses exercises to promote body-mind harmony based on several principles, including centering, control, precision, fluidity of movements, concentration, and breathing [42].

The current study's findings are consistent with prior Pilates research, such as the one by Da Luz et al. [18], who found that, after six weeks of follow-up, a Pilates exercise program was superior to alternative therapies in the treatment of chronic low back pain.

In individuals with idiopathic scoliosis, Kim et al. [19] examined the effects of Schroth and Pilates workouts on the Cobb angle (magnify the scoliosis deformity) and body weight distribution. For 12 weeks, one group did Schroth exercises three times a week while the other did Pilates exercises. The Cobb angle and weight distribution in patients might be changed by Schroth and Pilates exercises, according to the results; nevertheless, an intergroup comparison revealed that Schroth exercise was superior to Pilates exercise [19].

The effectiveness of the Pilates technique as a therapeutic modality was established by De Araujo et al. [43] who evaluated the effects of Pilates exercise on chronic mechanical neck pain. There were improvements in pain, function, quality of life, and a decrease in the usage of analgesics. For 12 weeks straight, patients in the Pilates group participated in two sessions a week of Pilates.

## Limitations

The results of this study were constrained by its preliminary nature and the small number of participants. The demographic representation in each group did not necessarily correspond to that of the general population (e.g., sex, age). Additionally, the current study recruited only females and there was no follow up. Therefore, results of this study cannot be generalized to all population, yet it presents a start. To verify and assess our findings, larger and more extensive research is required.

## Conclusions

This study provides preliminary evidence that traditional treatment program consisting of stretching exercises, strengthening and postural correction was effective in UCS but Pilates exercise program proved more effective in terms of spinal curvature, craniovertebral angle, rounded shoulder, balance, pain, and neck specific disability level.

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## Disclosure statement
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## Conflict of interest
The authors declare no conflict of interest.

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