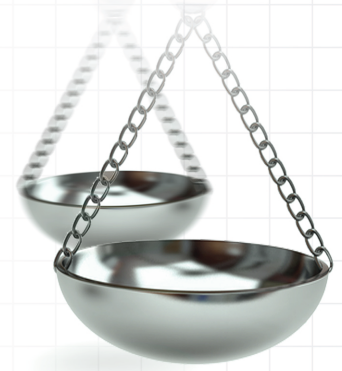




Effectiveness of clinical Pilates and home exercises in sagittal cervical disorientation: randomized controlled study

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Aim: To compare effects of clinical Pilates and home exercises on postural disorders, strength and endurance of deep cervical flexors (DCF), cervical range of motion (CROM), pain intensity and functional disability in sagittal cervical disorientation. **Patients & methods:** Forty six patients were included and divided into two groups. Clinical Pilates group performed stabilization based exercise and home exercise group performed conventional exercises. **Results:** Craniovertebral, head tilt, cervicothoracic angles and strength and endurance of DCF muscles had improvement in favor of clinical Pilates group ($p < 0.05$). There was no difference between groups in terms of right-left acromial distance, pain intensity, functional disability and CROM parameters ($p > 0.05$). **Conclusion:** Clinical Pilates exercises have been found to provide clinically significant improvements in craniovertebral, head tilt, cervicothoracic angles and strength and endurance of DCF muscles. However, in the increase of CROM, decreasing pain severity and functional impairment parameters there was no superiority of both exercise training.

Clinical trial registration number: NCT03352921 (Clinicaltrials.gov).

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Keywords: cervical disorientation • clinical Pilates • exercise • forward head posture • home exercise program • posture

Posture is defined as the alignment or orientation of body segments while maintaining an upright position [1]. The American Academy of Orthopedic Surgeons defines poor posture as a faulty relationship of the different body parts. These disorders can produce problems in different components of the musculoskeletal system, including joints, ligaments, muscles, nerves, tendons, and may result in permanent pain or functional impairment. In some occupational groups, various postural disorders and musculoskeletal problems may arise due to nonergonomic conditions [2]. The problems with the musculoskeletal system especially in desk-based workers are becoming a common health problem in many societies. Desk-based workers are under the influence of repetitive loads during the time they work at the desk unaware of the stress that affects their bodies. Therefore, serious musculoskeletal problems arise [3]. Cervical disorientation, which develops in desk-working individual, is closely related to the occupation, working environment and psychosocial factors of participants. This leads to dysfunction of the cervical region, decreased work performance of the individual, negative socioeconomic factors and decreased quality of life [4,5]. Due to the interdependence of muscle chains in the spinal region, postural disorders in the craniocervical region cause postural compensations in other segments of the spinal region. Related to biomechanical disorders, local symptoms such as decreasing cervical joint movements, muscle strength imbalance, fatigue, shortening of muscles, pain and degenerative changes in joints occur [6]. The normal postural alignment of the cervical region in the sagittal plane is defined as the acromioclavicular joint and the meatus acusticus externus on the same vertical line [6–8]. Cervical alignment disorders can be seen in sagittal and frontal planes. The forward head posture (FHP) is the most common postural disorder which is a combination of lower cervical flexion and upper cervical hyperextension [9–11]. FHP weakens the deep cervical flexor (DCF) muscles, scapular retractor muscles (Rhomboides Major-Minor

muscle, and the mid and lower trapezius muscle). FHP also shortens the pectoralis major-minor, suboccipital muscles, scalen muscle group and levator scapula muscle [6,12]. Clinical Pilates exercises (CPE), which include basic principles such as respiration, focusing in the center, concentration, control, stability, continuity of movement and isolation are methods commonly used in the positioning of spinal segments and increasing postural awareness. It is a combination of mind-body exercises that provide respiratory control with spinal stability, contribute to increased kinesthetic awareness, muscular strength, flexibility and coordination. When the literature is examined, many studies have been done in order to evaluate postural problems occurring in many different occupational groups, to prevent early period and to reduce permanent deformities which may occur in long term [13–16]. According to the best of our knowledge, there is not any compared study to home exercise program (HEP) which is constituted by the traditional exercise programs and that analyzes the effects of CPE according to the main principles and key elements of Joseph Pilates in terms of cervical postural disorders. This study was performed to compare the effects of CPE and HEP on postural disorders, strength and endurance of DCF muscles, cervical joint range of motion, pain intensity and functional disability in the desk-based workers with sagittal cervical disorientation.

Design

Trial design

This is a randomized comparative experimental study. The study was approved by the Eastern Mediterranean University Scientific Research and Health Ethics Committee (6 November 2017, 2017/50-37). Individuals were asked to sign informed consent form for participation to the study. The study was conducted in the Neuromuscular Education Laboratory of the Physiotherapy and Rehabilitation department of the Faculty of Health Sciences of the Eastern Mediterranean University. The study started on 1 December 2017 and completed on 1 June 2018. This study was recorded in clinicaltrial.gov. (Clinical number: NCT03352921). The study was applied by the principles of the Declaration of Helsinki.

Participants

Participants were randomly divided into two groups as CPE group (n = 23) and HEP group (n = 23) in a single-block pattern using randomized allocation software program version 1.0.0. The flow diagram of the study is shown in Figure 1. The study included 46 participants aged between 30 and 60 who were working at a desk-based with sagittal cervical disorientation. Four people from the CPE group, four people from the HEP group left study for some reasons. The study was completed with 38 people.

Inclusion criteria

- Neck pain at least for 3 months
- Anterior head tilt of sagittal segmental alignment disorders
- Craniovertebral angle (CVA) as <50 degree
- Desk work minimum for 3 years
- Working with the computer daily at least for 5 h
- Less severe physical activity level according to the International Physical Activity Questionnaire

Exclusion criteria

- Taken any physiotherapy program for the last 6 months due to neck or back pain complain
- Pain intensity ≤ 3 cm according to the visual analog scale
- Structural scoliosis
- Broken neck history
- Scapular dyskinesis
- Rheumatic disorder that affects the neck
- Acute torticollis
- Vertebral column surgical history
- Spinal cord compression due to tumor or other reasons
- Neurological deficit (abnormal reflexes, decreased sensation, and weakness of arms and legs)
- Temporomandibular joint problem
- Taking any kind of pain killers except for basic analgesics

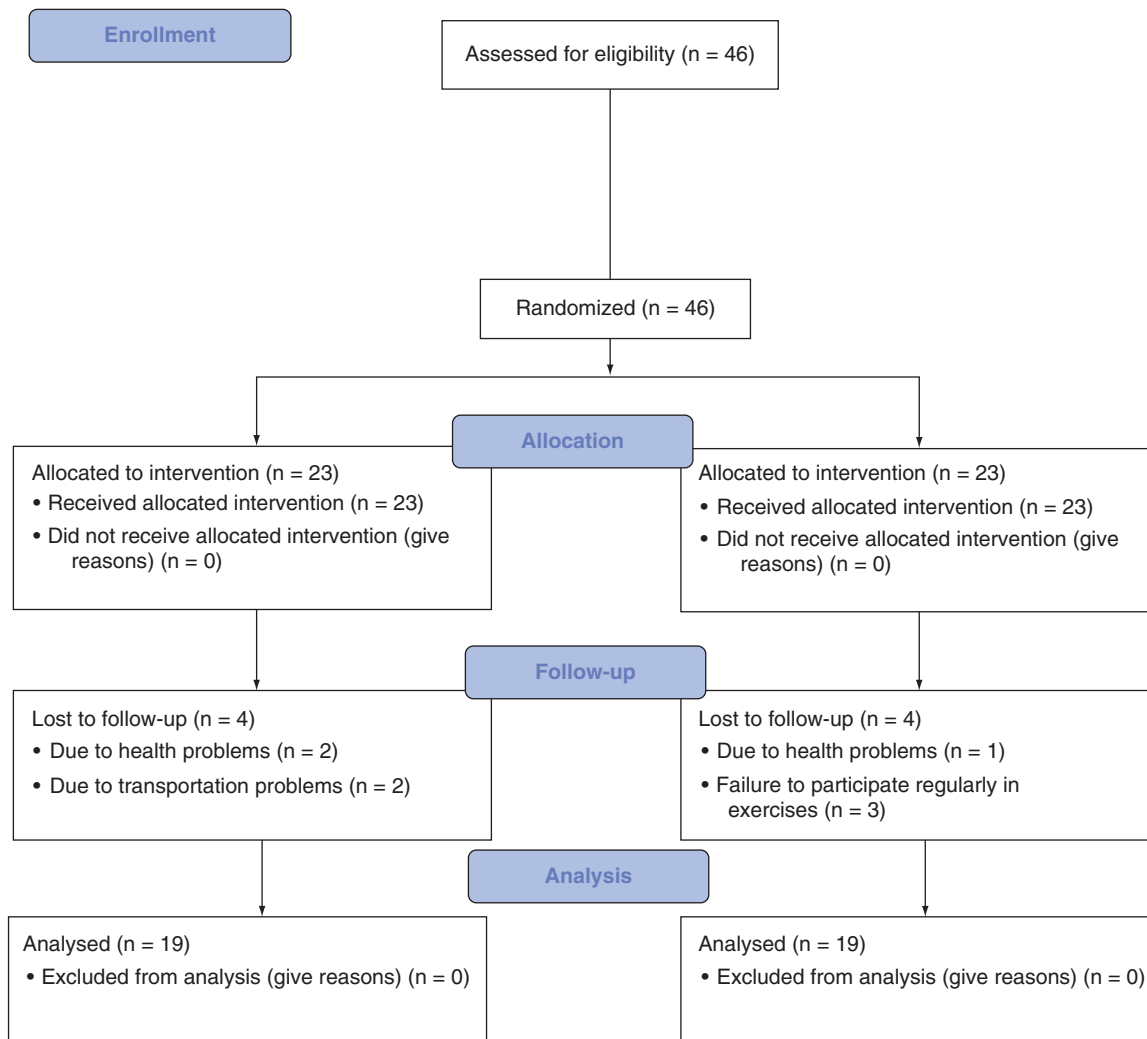


Figure 1. Flow diagram of the progress through each stage of the study.

Outcomes

The participants were informed about the assessments to be made and the equipment to be used during the tests. All evaluations were performed by the same physiotherapist. Evaluations were performed at the beginning of the study and 8 weeks later. The primary outcome measure of the study was postural disorders. The secondary outcome measures of the study were strength and endurance of DCF muscles, pain intensity, functional disability and cervical ROM.

Sociodemographic & clinical features

The sociodemographic characteristics of the subjects such as age, gender, height, bodyweight, BMI, occupation and duration of computer use in a day were recorded.

Postural disorders

The evaluation of cervical and upper thoracic posture was done through the lateral photography [17–19]. Four markers were placed on specific anatomic points (eye canthus, ear tragus, spinous process of 7th cervical spine and spinous process of 4th thoracic spine) and the lateral projections of those points have been used in order to have angular calculations [8]. The participants were asked to move their heads to the front and back three-times leaving their both arms released near the body within the neutral position on standing [7,20]. Until the result obtaining of the test, they were asked to look forward. While the participants were standing on this position, their photos were taken via

a digital camera (Nikon D90 brand) which was placed on a tripod that was 1.5 m far and was placed on their rights within 90 degrees right angle. The height of the camera and the lens was set to be next to the acromion [21,22]. The images were transferred to the computer and opened in paint program to draw their straight lines that intersects the determiners. CVA, head tilt angle (HTA) and cervicothoracic angle (CTA) measurement was calculated by using computer programs (MB-Ruler – triangular screen ruler; Markus Bader-MB Softwaresolutions). The CVA is the angle between the horizontal line from C7 and the line joining C7 – tragus. It provides information about neck angle and the position of head toward [18,19,22]. HTA was used to evaluate the tilt of the head in the sagittal plane. This angle is between the vertical line aligned to ear tragus and the line that joins the eye canthus and tragus [8,17,23]. CTA is the angle between tragus-C7 process line and C7-T4 spinous process line [8,23]. In order to evaluate the scapular protraction, the participants were asked to lay in supine position with hands on abdomen and the knees and the elbows in flexion position. Before the evaluation, the posterior of the acromion was palpated and marked with a pen while participants were lying in the supine position. And then, the distance of posterior acromion to the bed was measured by the ruler. The distance was recorded in centimeters unit [24].

Strength & endurance of DCF muscles

The muscle activation and static endurance of the deep flexor muscles (M. Rectus Capitis Anterior, M. Rectus Capitis Lateralis, M. Longus Capitis and M. Longus Kolli) were evaluated by craniocervical flexion test [25]. The test was performed with the biofeedback pressure unit (Stabilizer Pressure Biofeedback-ChattanoogaRR Stabilizer). In order to evaluate the force of DCF, the participants were asked to lay back as the head on neutral position as well as knees on flexion. The upper part of the cell was placed without swelling just below the occipital bone and care was taken not to slide into the subcervical region. The pressure cell was inflated to 20 mmHg to support cervical lordosis. The participants were asked to place their tongues to the soft palate, tight lipped but leaving the teeth a little separate. They were asked to press their chins toward their necks without lifting head up, as if saying ‘yes’ (posterior cervical tilt). In order to follow the pressure change on manometer, the test was held through showing the manometer to the participant. Test was applied as providing ten contractions for 10-s duration on each level on five different pressure levels (22, 24, 26, 28 and 30 mmHg). The first step of the test was swelling the cell until 20 mmHg and asking the participant to have 10-s contraction in order to increase the pressure into 2 mmHg. The contractions were repeated ten-times. If an participant was able to continue ten contractions during 10-s, the test was continued. However, if she/he was not able to do so, the test was ended. A total of 10-s resting time was provided between the repetitions. At the end of the test, activation score (AS) and performance index (PI) results were obtained. The maximum pressure that was repeated ten-times and held stable for 10-s is defined as AS point. During the calculation of PI, the pressure level was aimed at which the participant was not able to continue the ten contractions for 10-s. PI was calculated according to multiplying pressure level by the repetition number that the participant made for 10-s contractions [26,27].

Pain intensity

Visual analog scale was used to determine the intensity of neck pain during rest and activity. Individuals were asked to specify the point representing the intensity of neck pain by putting the ‘X’ mark on the scale. The distance between the point marked by the participant and the point of zero was measured with the ruler and the value was recorded in centimeters unit as the pain intensity of the participant [28,29].

Functional disability

Neck disability index (NDI) was used to evaluate the functional disability of the neck. The NDI evaluates the disability occurred in daily life as a result of neck pain [30]. The validity and reliability study of the Turkish version of the questionnaire has been done by Aslan *et al.* [31].

Cervical range of motion

In order to evaluate the CROM, inclinometer (Baseline Bubble Inclinometer) was used. The cervical flexion, extension and right–left lateral flexion measurements were done on sitting position and the right and left rotation measurements were done in supine position. Two inclinometers were used at the same time during all the measurements except for cervical rotation in order to eliminate the movement of thoracic part and also to determine only the range of cervical movements. For the evaluation of cervical flexion, one of the inclinometers was placed on participants head and the other one placed to spinous process of T1 vertebra. Both inclinometers were set to

zero point. And then, the participants were asked to bend their heads to the front. At the end of the movement, the cervical flexion degree was recorded by subtracting the inclinometer value of T1 spinous process from the inclinometer value placed on the head. For the evaluation of cervical extension, one of the inclinometers was placed on participants head and the other one placed on spine scapula. Both inclinometers were set to zero point. And then, the participants were asked to bend their heads behind. At the end of the movement, the cervical extension degree was recorded by subtracting the inclinometer value of spine scapula from the inclinometer value placed on the head. During the cervical flexion and extension measurements, both inclinometers were stabilized as to be parallel to the sagittal plane. For the evaluation of cervical lateral flexion, one of the inclinometers was placed on participants head and the other one placed to T1 vertebra spinous process. Both inclinometers were set to become parallel to the frontal plane and to become on zero point. The participants were asked to make their ears closer to their shoulders without turning their heads. At the end of the movement, the lateral flexion degree was recorded by subtracting the inclinometer value of T1 spinous process from the inclinometer value placed on the head. The tests were done bilaterally. During cervical rotation measurement, only one inclinometer was used as the body stability was done by the bed. The inclinometer was placed on the forehead while the participants are on the supine position. It was stabilized to be parallel to the frontal plane and set to the zero point. The participant was asked to do left and right as much as she/he could. Each measurement was repeated three-times and the best value was recorded [32].

Interventions

Twenty three participants were included to the CPE group at the beginning of the study and four of them left then. The group training continued with 19 people. The CPE training was given to the participants in the group by a physiotherapist as daily 1-h three-times a week for 8 weeks. The CPE training was done with three separate group ($n = 8$, $n = 6$ and $n = 5$). Twenty three participants were included to the HEP group at the beginning of the study and four of them left then. The participants included in this group were asked to do the HEP taught to them in their houses as three-times a week for 8 weeks.

'Neck health' seminar was given to both of the groups on different days at the beginning of the study.

CPE program

The five key elements (neck, shoulder, rib cage, lumbopelvic part and breathing) were taught to the participants in CPE group after the explanation of main principles of CPE in the first session (concentration, breathing, focus on the center, control, decisiveness, flow in motion and isolation provision). The exercise program started with a 10-min warm-up program. It was continued with the main exercises that provided 40-min core stabilization, including trunk, upper and lower extremity movements, and the training was ended with 10-min cooling exercises. The exercises were performed in different positions (prone, laying aside, prone, sitting and standing). The exercises were advanced with an interval of 3 weeks. Only elastic resistant band (green and blue colored theraband) was used as an equipment of the program. All the exercises were done as ten-times for 8 weeks. Trial protocol is given in Table 1.

Home exercise program

For the participants in HEP group, stretching exercises for pectoral muscle groups, levator scapula, upper trapez, lateral flexor, extensor, cervical flexors and scalene muscle groups were done. Also, posture exercises, strengthening training to the back extensors and scapular adductor muscles and active cervical joint motions to every direction were given. As well as craniocervical flexion exercises in supine and standing positions were given. The exercises were proceeded within 3-week breaks. All exercises were taught to the patients by the physiotherapist at the beginning of the study. A direction was given to the participants in terms of the photos of exercises, how to do them and how to proceed them. An exercise follow-up time table was given for providing the regular participation to the exercises at the same time. Every fortnight, their participation was controlled via calling them on the phone or communicating them through a common network. Exercise program is given in Table 2.

Sample size calculation

Before the study, G*Power 3.1.9.2 package program was used in order to determine the sample size and statistical strength analysis. The CVA value was taken as the basis for calculating the sample size. A study by Lee *et al.* [33] about the evaluation of CPE's effectiveness on people who had FHP was taken as base and its affect size for clinical

Table 1. Clinical Pilates Exercise Program

Warming phase	Upper extremity proprioceptive neuromuscular facilitation exercises Cork screw Toy soldier Kleopatra The saw		
Exercise phase	First 3 week (1–3 week)	Second 3 week (4–6 week)	Last 2 week (7–8 week)
	Double leg stretch (one) Shoulder bridge (one) Arm openings (one) Arm openings (two) Swan dive (one) Swimming (one) Swimming (two) Diamond press (Green theraband) Scapula isolations (Green theraband) Open book (Green theraband) Roll up (Green theraband) Triceps pull (Green theraband)	Double leg stretch (two) Shoulder bridge (two) Arm openings (one) (Green theraband) Arm openings (two) Swan dive (two) Breast stroke preparations Swimming Diamond press with arm openings (Green theraband) Scapula isolations (blue theraband) Open book (blue theraband) Roll up (blue theraband) Roll up with rowing (Green theraband) Triceps pull (blue theraband)	Double leg stretch (three) Shoulder bridge (four) Arm openings (one) (blue theraband) Arm openings (two) Swan dive (green theraband) Cobra Breast stroke Swimming in kneeling (green theraband) Diamond press with arm openings (blue theraband) Roll up with rowing (blue theraband) Roll up with obliques (green theraband) Triceps pull (blue theraband)
Cooling phase	Mermaid Chest stretch Roll down Spine stretch Swinging		

Table 2. Home Exercise Program

Exercises	First 3 week (1–3 week)	Second 3 week (4–6 week)	Last 2 week (7–8 week)
Stretching exercises for: – Scalen muscle group – Cervical flexors, extensors, lateral flexors and pectoral muscle group – Upper trapezius	10-s hold × nine repeat	15-s hold × 16 repeat	30-s hold × three repeat
– Postural exercises – Chin-tuck exercises (standing and supine position) – Active cervical joint movements in all directions	Ten repeat	15 repeat	20 repeat
Strengthening exercises for: – Back extensors – Scapular adductor muscles	3-s hold × ten repeat	5-s hold × 15 repeat	5-s hold × 20 repeat

Pilates was calculated as 0.98. The two-tailed Mann–Whitney U-test as used for the comparison of two groups of the study and the first sample size in each group was calculated as under the assumptions of $\alpha = 0.05$, $\beta = 0.20$ (19 for each group, total 38 participants). By considering the 20% loss during the study, 46 participants were decided to be included in the study.

Statistical methods

The discrete and continuous variables of the study were determined as average $\pm$ standard deviation ($\bar{x} \pm SD$), percentage and number. Statistical significance value has been accepted as $p < 0.05$. Statistical Package For Social Sciences (SPSS) 18.0 data analysis program was used in the data analysis.

The suitability of dataset to the normal distribution was determined by Shapiro–Wilk test. The significance of the difference between two averages obtained before and after the treatment among the group was tested by using Wilcoxon test. Mann–Whitney U-test used in comparisons among groups and for categorical variables Fisher's exact test was used.

Table 3. The sociodemographic and clinical characteristics of participants participating in the study, 95% CI, n = 38.

Variables	Clinical Pilates group (n = 19)	Home exercise group (n = 19)	p-value
Age, year, $\bar{x} \pm \text{SD}$	41.1 $\pm$ 8.6 (36.9–45.2)	39.2 $\pm$ 8.0 (35.3–43.1)	0.62 [†]
Gender, n (%)			1 [‡]
– Females	18 (94.7) (75.4–99.1)	17 (89.5) (68.6–97.1)	
– Males	1 (5.3) (0.9–24.6)	2 (10.5) (2.9–31.4)	
BMI, kg/m ² , $\bar{x} \pm \text{SD}$	24.6 $\pm$ 4.4 (22.5–26.7)	27.7 $\pm$ 6.2 (24.7–30.7)	0.19 [†]
Occupation, n (%)			1 [‡]
– Bank worker	6 (31.6) (15.4–54.0)	6 (31.6) (15.4–54.0)	
– Government official	7 (36.8) (19.2–59.0)	8 (42.1) (23.1–63.7)	
– Other	3 (15.6) (3.1–38.4)	5 (26.3) (11.8–48.8)	
Working period, year, $\bar{x} \pm \text{SD}$	15.1 $\pm$ 10.4 (10.1–20.1)	13.2 $\pm$ 7.6 (9.5–16.9)	0.65 [†]
Computer use period, h/day, $\bar{x} \pm \text{SD}$	7.3 $\pm$ 2.0 (6.3–8.3)	7.2 $\pm$ 1.1 (6.7–7.7)	0.74 [†]
Duration of neck pain, month, $\bar{x} \pm \text{SD}$	32.6 $\pm$ 31.2 (17.6–47.6)	39.3 $\pm$ 23.1 (28.2–50.4)	0.18 [†]

[†]Mann–Whitney U-test.

[‡]Fisher exact chi-square test.

$\bar{x} \pm \text{SD}$: Average $\pm$ standard deviation.

The arithmetic averages were illustrated with 95% CI. In order to determine whether the data of groups were different, both p-values and 95% CI values were considered.

- If $p < 0.05$ and there is no overlap between 95% CI lower and upper limits, the averages of the measurements are different from each other.
- If the difference between the averages of two measurements does not contain the 95% CI lower and upper limits '0', then the averages of two measurements are different [34].

In order to determine the effectiveness of the treatment, the formula of $r = z/\sqrt{(n \times 2)}$ was used; during the effect size calculation, clinical effect size ($r \leq 0.1$) was interpreted as small effect, $r = 0.3$ as medium effect and $r \geq 0.5$ as large effect [35].

Data analysis

Sociodemographic & clinical characteristics

The sociodemographic and clinical characteristics of participants in CPE and HEP groups are similar (all $p > 0.05$; Table 3).

Postural disorders

Before the 8-week exercise training, there was not any difference found between the right and left acromial distance, CVA, HTA, and CTA of the participants in both group (all $p > 0.05$). By the end of the study, there was a significant difference statistically between the CVA (95% CI: 159.6–166.0, $p = 0.019$), HTA (95% CI: 45.6–50.0; $p = 0.021$) and CTA (95% CI: 65.6–71.0; $p = 0.030$) values between the two groups for the favor of CPE group. After the treatment, there was not a difference found between the right and left acromial distance (all $p > 0.05$; Table 4). When the left and right acromial distance, CVA, HTA, and CTA parameters of CPE group before and after the treatment are compared, there has been a significant statistical difference. On the other hand, there has been a significant difference in the values of left acromial distance and CVA in HEP group (all $p < 0.05$; Table 4). The r was respectively, 0.6, 0.2, 0.5, 0.6 and 0.6 in terms of left and right acromial distance, CVA, HTA, and CTA parameters in CPE group. However, these r values in HEP group have been found as 0.6, 0.3, 0.2, 0.6 and 0.5, respectively (Table 4).

Table 4. The comparison of intragroup and intergroup postural disorders.

Variable	Group	Intergroup comparison before treatment (x ± SD) (95% CI)	Intragroup comparison before the treatment (p-value) [†]	Intergroup comparison after the treatment (x ± SD) (95% CI)	Intragroup comparison after the treatment (p-value) [†]	Intragroup comparison before and after the treatment (p-value) [‡]	r
CVA	CPE	41.5 ± 4.8 (39.2–43.8)	0.693	47.8 ± 4.6 (45.6–50.0)	0.021	0.001	0.6
	HEP	41.2 ± 3.6 (39.5–42.9)		44.6 ± 3.8 (42.8–46.4)			
HTA	CPE	65.3 ± 8.1 (61.4–69.2)	0.589	68.3 ± 5.6 (65.6–71.0)	0.030	0.159	0.2
	HEP	66.8 ± 6.3 (63.8–69.8)		64.4 ± 3.9 (62.5–66.3)			
CTA	CPE	158.0 ± 5.7 (155.3–160.7)	0.737	162.8 ± 6.6 (159.6–166.0)	0.019	0.004	0.5
	HEP	157.1 ± 7.0 (153.7–160.5)		158.1 ± 5.3 (155.5–160.7)			
Right AD	CPE	9.4 ± 1.9 (8.5–10.3)	0.693	7.8 ± 1.7 (7.0–8.6)	0.712	0.001	0.6
	HEP	9.3 ± 2.1 (8.3–10.3)		7.7 ± 2.3 (6.6–8.8)			
Left AD	CPE	9.1 ± 2.0 (8.1–10.1)	0.597	7.7 ± 1.9 (6.8–8.6)	0.575	0.001	0.6
	HEP	8.8 ± 2.1 (7.8–9.8)		7.3 ± 2.5 (6.1–8.5)			

[†] Mann–Whitney U-test.

[‡] Wilcoxon sign test.

The bold font highlights the important r values showing clinical effectiveness.

AD: Acromial distance; CPE: Clinical Pilates exercise; CTA: Cervicothoracic angle; CVA: Craniovertebral angle; HEP: Home exercise program; HTA: Head tilt angle; r: Clinical effect size; x ± SD: Average ± standard deviation.

The PI & AS of DCFs, pain intensity & functional disability

The AS and PI values of DCF muscles, the neck pain intensity during rest or activities and also NDI scores of both group members before the treatment, have been found as similar (all $p > 0.05$). After the treatment, when the AS (95% CI: 8.6–10.0; $p = 0.001$) and PI (95% CI: 76.4–98.6; $p = 0.001$) values of DCF of participants were compared, the statistical significant difference was for the favor of CPE group. After the treatment when the pain intensity and NDI scores of the groups were compared there has not been a difference (all $p > 0.05$; Table 5). When the AS and PI values of DCF before and after the treatment of the CPE group were compared with the AS values of the participants in HEP group, significant differences have been found out statistically (all $p < 0.05$). There was a statistically significant difference (all $p = 0.001$) between the intensity of neck pain at rest and during the activity and NDI score in both CPE group and HEP group (Table 5). CPE was found to have a large clinical effect calculated for AS and PI of DCF (all $r \geq 0.5$) However, the r value for AS of HEP has been found as medium ($r = 0.3$) and for PI value it has been found low–medium ($r = 0.2$). When the effect size of neck pain intensity during the rest and activities of CPE and HEP group, the r value has been found large (all $r \geq 0.5$). The r value of NDI scores of participants in CPE and HEP group has been found as 0.6 (Table 5).

Cervical range of motion

When the groups were compared in terms of ROM before the treatment, there has been only a statistically significant difference in right lateral flexion ROM ($p = 0.017$). When CROM values of groups after the treatment were compared, there has not been any statistically difference in all directions (all $p > 0.05$; Table 6). When the CROM values of CPE group before and after treatment were compared, there were statistically significant differences in left lateral flexion and right and left rotation ($p = 0.001$). When CROM values of HEP group were compared before and after treatment, there was a statistically significant difference in extension, right lateral flexion and right and left rotation ROM parameters (all $p < 0.05$; Table 6). The r values of CROM of CPE group participants have been small ($r = 0.1$) for flexion, extension and right lateral flexion. For left lateral flexion it has been found medium ($r = 0.3$) and for right and left rotation large effect was found ($r = 0.6$). However, the r values in HEP group have been found as 0.2, 0.5, 0.5, 0.3, 0.6 and 0.5, respectively (Table 6).

Table 5. The comparison of intragroup and intergroup of activation score and performance index of deep cervical flexors, pain intensity during rest and activity and functional disability levels.

Variable	Group	Intergroup comparison before treatment (x ± SD) (95% CI)	Intragroup comparison before the treatment (p-value) [†]	Intergroup comparison after the treatment (x ± SD) (95% CI)	Intragroup comparison after the treatment (p-value) [†]	Intragroup comparison before and after the treatment (p-value) [‡]	r
AS	CPE	5.2 ± 3.9 (3.3–7.1)	0.057	9.3 ± 1.4 (8.6–10.0)	0.001	0.001	0.5
	HEP	3.4 ± 2.9 (2.0–4.8)		4.0 ± 2.8 (2.7–5.3)		0.038	0.3
PI	CPE	51.1 ± 36.2 (33.7–68.5)	0.089	87.5 ± 23.1 (76.4–98.6)	0.001	0.002	0.5
	HEP	29.5 ± 28.6 (15.7–43.3)		37.1 ± 24.7 (25.2–49.0)		0.204	0.2
PIR	CPE	4.1 ± 0.8 (3.7–4.5)	0.482	1.2 ± 1.4 (0.5–1.9)	0.486	0.001	0.6
	HEP	4.5 ± 1.3 (3.9–5.1)		1.5 ± 1.5 (0.8–2.2)		0.001	0.6
PIA	CPE	6.5 ± 2.1 (5.5–7.5)	0.770	2.6 ± 2.0 (1.6–3.6)	0.328	0.001	0.6
	HEP	6.7 ± 2.1 (5.7–7.7)		3.4 ± 2.4 (2.2–4.6)		0.001	0.6
NDI	CPE	13.9 ± 6.0 (11.0–16.8)	0.334	4.3 ± 3.5 (2.6–6.0)	0.445	0.001	0.6
	HEP	15.1 ± 5.9 (12.3–17.9)		5.3 ± 4.0 (3.4–7.2)		0.001	0.6

[†] Mann–Whitney U-test.[‡] Wilcoxon sign test.

AS: Activation score; CPE: Clinical Pilates exercise; HEP: Home exercise program; NDI: Neck disability index; PI: Performance index; PIA: Pain intensity in activity; PIR: Pain intensity during rest; r: Clinical effect size; x ± SD: Average ± standard deviation.

Discussion

In this study, the effects of CPE and HEP on postural disorders, DCF muscles' strength and endurance, pain intensity, functional disability and CROM in participants working on desk with sagittal cervical disorientation, have been analyzed comparatively. Clinically the CPE has been found as more effectively on CVA, HTA and CTA values. On the other hand, both exercise trainings do not surpass each other in increasing CROM and decreasing the pain intensity and functional disability. Nevertheless, CPE is more effective in increasing the endurance and strength of DCF whereas HEP has been found to be more effective clinically in increasing CROM. CVA, is one of the methods which is used for evaluation of the head posture in lateral posture analysis. Postural compensations occur in the other parts of the spinal region with low CVA values in participants with head anterior tilt [7,36–38]. In our study, despite the increase in the CVA values in both groups after treatment, an improvement was obtained in favor of the CPE group.

Postural disorders

In literature, many different exercise methods have been reported as contributing to CVA [39–42]. In particular, the role of CPE in the activation of deep muscles may have been effective in correcting the head posture by improving postural awareness and proper posture control. In addition, planning of home exercises consisting of combined exercises, performing craniocervical flexion exercises in sitting and supine positions, and following up fortnightly the groups by telephone or common network may have contributed to the great clinical effect. Especially increasing the strength of the deep flexor muscles, which have meaningful postural function especially in both groups, is important in increasing this angle. In a study conducted in order to examine the effects of stretching and strengthening exercise program for 8 weeks in elite swimmers, the participants were divided into two groups as exercise and control group. In exercise group, stretching exercises were given to cervical extensor and pectoral muscles and strengthening exercises were given to medium-lower trapezius, serratus anterior and DCF muscles. However, there was no intervention done to the control group. According to the findings, the exercises have been found to be corrective effect on head anterior tilt [39]. Lee *et al.* analyzed the stretching exercises, McKenzie and Kendall exercises on postural problems in participants with rounded shoulder and head anterior tilt. In the

Table 6. The comparison of intragroup and intergroup of cervical joint movement range values.

Variable	Group	Intergroup comparison before treatment (x ± SD) (95% CI)	Intragroup comparison before the treatment (p-value) [†]	Intergroup comparison after the treatment (x ± SD) (95% CI)	Intragroup comparison after the treatment (p-value) [†]	Intragroup comparison before and after the treatment (p-value) [‡]	r
Cervical flexion ROM	CPE	48.2 ± 10.0 (43.4–53.0)	0.649	50.6 ± 9.4 (46.1–55.1)	0.848	0.527	0.1
	HEP	46.7 ± 11.0 (41.4–52.0)		50.3 ± 7.9 (46.5–54.1)		0.135	0.2
Cervical extension ROM	CPE	67.0 ± 11.2 (61.6–72.4)	0.132	69.1 ± 11.0 (63.8–74.4)	0.953	0.437	0.1
	HEP	62.5 ± 9.2 (58.1–66.9)		69.3 ± 9.1 (64.9–73.7)		0.003	0.5
Cervical right lateral flexion ROM	CPE	45.4 ± 9.3 (40.9–49.9)	0.017	47.5 ± 9.2 (43.1–51.9)	0.574	0.420	0.1
	HEP	38.7 ± 8.1 (34.8–42.6)		45.6 ± 5.9 (42.8–48.4)		0.002	0.5
Cervical left lateral flexion ROM	CPE	45.7 ± 8.2 (41.7–49.7)	0.370	49.8 ± 5.8 (47.0–52.6)	0.079	0.043	0.3
	HEP	43.0 ± 7.6 (39.3–46.7)		46.4 ± 6.4 (43.3–49.5)		0.032	0.3
Cervical right rotation ROM	CPE	70.0 ± 10.0 (65.2–74.8)	0.592	83.7 ± 5.5 (81.0–86.3)	0.321	0.001	0.6
	HEP	72.4 ± 7.2 (68.9–75.9)		81.7 ± 6.6 (78.5–84.9)		0.001	0.6
Cervical left rotation ROM	CPE	75.5 ± 9.5 (70.9–80.1)	0.073	85.2 ± 5.3 (82.6–87.8)	0.087	0.001	0.6
	HEP	72.6 ± 8.9 (68.3–76.9)		81.1 ± 7.8 (77.3–84.9)		0.002	0.5

[†] Mann–Whitney U-test.[‡] Wilcoxon sign test.

CPE: Clinical Pilates exercise; HEP: Home exercise program; r: Clinical effect size; ROM: Range of motion; x ± SD: Average ± standard deviation.

evaluation after eight weeks, those exercises had positive effects on head anterior tilt and rounded shoulder as well as they had not surpassed to each other [43]. In a double-blind randomized study, the combined and Pilates exercises have been compared in the participants with head anterior tilt. For CPE group, stabilization training program was given with local exercises such as DCF and scapular retractor strengthening exercises, also stretching exercises for neck extensor muscles and pectoral muscles. For the participants in combined exercise group, strengthening exercises for back muscles, scapular retractor, pectoral stretching and craniocervical flexion exercises were given. In the end of the study, CVA values of the Pilates group showed a significant increase compared with the combined exercise group [33]. In our study, we focused on local and global stability with CPE, which was planned according to the main principles and five key elements that Joseph Pilates had determined. In this respect, our study is the first study to demonstrate the effectiveness of CPE in participants with sagittal cervical dysfunction. In a study comparing the effects of deep neck flexor muscle training on cervical postural control in the rehabilitation program of chronic neck pain patients, it was shown that deep neck flexor muscle training resulted in an important increase in CVA after 6 weeks of training [44]. HTA gives information about the upper thoracic posture whereas the HTA gives information about the tilt of head on sagittal plane [23]. In our study, postural smoothness was obtained in the upper thoracic region and HTA was close to neutral in CPE group. There was no difference in both HTA and CTA values after treatment in the HEP group. HTA and CTA measurements were not assessed after exercise

approaches and no cut-off values for these angular parameters were determined. Therefore it is impossible to certainly state the effects of CPE on those parameters. In our study, it was found that bilateral scapular protraction was corrected after treatment in both groups. The clinical effects of both exercise types were large in reducing the round shoulder. Within this regard, for reducing the acromial distance, the scapular stabilization gained from the visual symbolization and also the strengthening exercises given to back extensors and scapular retractor and pectoral muscle stretching provide similar effects. In other words, in participants with scapular protraction, CPE or HEP consisting of stretching and strengthening exercises can be used interchangeably. It is obvious that the exercises done at home would be cheaper although a financial analysis has not been done.

DCFs' strength & endurance

DCF has an important postural function in supporting, controlling and stabilizing cervical lordosis [42]. Frequently, FHP is developed in participants with neck pain and there is a decrease in strength and endurance of DCF muscles [40,45]. In the electromyography (EMG) study to evaluate the DCF strength, the EMG activity of DCF in people with chronic neck pain is lower than the people who do not have, whereas this activation increased in superficial muscles [46]. Therefore, the strengthening of DCF and increase of its endurance is clinically suggested for the neck pain management [42]. In our study, the AS and PI values of DCF showed significant improvement at the end of the 8-week training in the CPE group. In the HEP group, only the change in AS was significant. In the comparison between groups, the difference in the AS and PI values of the DCF was found to be in favor of the CPE group. In order to stabilize the cervical region, it is important to maintain upper cervical retraction during all exercises. Because in FHP alignment, the center of gravity of the head is in front of the vertical axis, thus increasing the load on the posterior neck muscles. This biomechanical strain reduced the strength of the core stabilizer neck muscles as DCF. FHP was associated with poor strength of the upper cervical flexors. Upper cervical retraction exercises play an important role for activation of deep neck muscles. This situation explains the increase of AS of the DCF in CPE group. These exercises require patients to control neutral spinal alignment with deep flexor muscles. Craniocervical flexion exercises were given to the participants in HEP group both in laying down and standing position. This situation explains the increase of AS of the DCF in HEP group. PI defines the static endurance of DCF. In order to maintain proper posture during CPE, the contraction of deep muscles is necessary during the whole session. Prolonged stabilization may result in increased endurance of DCF muscles. As a result, we think that maintaining its activity throughout all exercises may have contributed to the increase in endurance. There is no increase in the endurance value in this muscle group in HEP group because the given craniocervical flexion exercise is a strengthening exercise and also it is not done for increasing the endurance. Both, the craniocervical flexion training with pressured biofeedback device and the craniocervical training against the gravity on laying down position, cause an increase in DCF performance and both exercises are emphasized to the preference for increasing the endurance in clinic [47]. In one study, the participants taking craniocervical flexion exercise have increased their DCF activation whereas a reduction in superficial neck flexor muscles activation. On the other hand, the participants with strengthening of neck flexors do not have an increase in DCF activation according to the EMG analysis [48]. Many symptoms occur as a result of anterior head tilt in participants working on desk and remaining on static posture for a long period of time. The most important of these symptoms is neck pain. Head anterior tilt may cause myofascial pain by increasing both loading and abnormal stress in both noncontractile structures and posterior cervical muscles [49].

Pain intensity

The exercise is the most frequently used method for increasing the physical functions and for increasing the participation to functional activities as well as the reduction of problems possible to occur in musculoskeletal structures including sagittal cervical disorientation [50]. The effects of stabilization-based Pilates exercise program and combined exercise program including stretching and strengthening have been compared in a study for 10 weeks and at the end they showed that, both exercise methods were effective in reducing the pain but this effect did not make a difference between the two groups [33]. The effect on pain intensity of that study is showing similarity with the findings of our study. The different exercise methods used for reducing the pain intensity have been not superior to each other. The study by Borisut *et al.* compared the muscular activities and pain intensity of female participants with chronic neck pain in different exercise programs and they divided them into four groups. The strength-endurance exercises for superficial neck flexor and extensor muscles were given to the first group, the craniocervical flexion exercises with pressured biofeedback device were given to the second group, the strength-

endurance exercises and craniocervical flexion exercises together were given to the third group and at last for the fourth group no exercise training was given. As a result, using together the strength-endurance and craniocervical flexion exercises have been effective for cervical muscles as intervention for the treatment of patients with chronic neck pain [51]. As parallel to this study, the combined exercise use is to be an effective method in terms of reducing the pain intensity in participants with neck pain. By the end of our study, it was determined that pain intensity decreased in both groups and there was no difference between the groups. We are influenced by the fact that CPE is effective on DCF, improving postural control, reducing excessive stress and muscle spasm in superficial muscles, thereby helping to reduce muscular fatigue. Also, the HEP group strengthens the weak muscles by stretching the shortened muscles and reduces the imbalance between muscles. According to these results, the different exercise programs are thought to have positive effects on reducing the pain intensity in participants with head anterior tilt. In addition, our study showed that home program, which consists of stretching and strengthening in the table-top workers with sagittal cervical disorientation has an important role in reducing the pain. On the other hand, the fact that participants have taken their own responsibilities is quite valuable for overcoming this chronic problem. In our study it has been found that, there has been no difference between the two treatment methods to reduce the pain and furthermore they had similar clinical effect. For this reason, we think that HEP should be preferred by the physiotherapist according to planned and periodic intervals by taking the characteristics of cheap and easy to apply by the patient.

Functional disability

Chronic neck pain with widespread prevalence is the common cause of community functional impairment [52]. The studies in literature show that, many different treatment methods have been effective in reducing the functional disability which was improved related to the neck posture problems [48,53–56]. Exercise is the first choice for patients with neck pain in clinics to use these functional disabilities. A comparison of the effects of cervical stabilization exercises and the general exercises in participant with chronic neck pain on functional disability has been done by Griffiths *et al.* It has been reported that, there have been significant improvements in neck pain and disability index of both group; however, there has not been a difference between the groups [57]. The study held by Falla *et al.* shows that, the craniocervical flexion exercises and traditional neck flexor strength-endurance exercises in participants with chronic neck pain reduced the functional disability level when evaluated with NDI after 6-week period [44]. By the end of this study, there is significant difference in NDI of both groups whereas no difference in comparison among groups. This result is parallel to the results of Falla *et al.* If we assume as the symptoms and findings of participating participants reduce both of the exercise management in the same rate, then the reduction of functional disability is an expected result. That is why, CPE and well-planned HEP can be stated as reducing the functional disability of participants in the same rate and also improving the independency level during the daily life activities.

Cervical range of motion

When the ROM values of cervical region in patients and healthy participants were compared, it was shown that the movements of the cervical region in three planes (flexion, extension and lateral flexion and rotation) were more limited in patients with neck problems [54,58–60]. There are studies in the literature which show that the different exercise programs given to the people with neck pain have increased the CROM [61–63]. A study by Patel *et al.* compared the effects of McKenzie neck exercises and strengthening exercises to DCF to the participants who had head anterior tilt. At the end of the six-session training, the CROM values of both groups have increased in many ways and no difference has been found [64]. The study by Kong *et al.* evaluated whether the combined use of McKenzie and Kendall exercises improved the CROM of smart phone users who had anterior head tilt. According to the findings of the study, it was suggested that the combined use of McKenzie and Kendall exercises could reduce the symptoms that occur in participants with anterior head tilt [65]. In our study, CROM of participants was evaluated with Bubble inclinometer. Although there was no difference between the groups after the treatment, it was found that the HEP group improved the range of motion in more directions when the ROM results were examined. The reason for this was the effect of stretching exercises given to HEP group. Therefore, stretching exercises in the exercise program that will be given to the participants with head anterior tilt and limitation in cervical region movements have an effect of increasing ROM. Olson *et al.* has stated that the reduced cervical rotation movement range had caused functional disability in the participants in their daily activities who had had neck pain [66]. At the same time CPE, which has stabilization training and includes strengthening exercises, has

a clinically significant effect on cervical rotation range of motion is important in terms of functional status and should not be ignored.

Limitations of the study

Evaluations were made at different times of the day. No standardization was determined for the evaluation hour. We think that the fatigue caused by the work pace of the participants which evaluated in the evening hours may affect the test results negatively compared with the participants which evaluated in the morning hours.

Conclusion

CPE have been found to provide clinically significant improvements in CVA, HTA and CTA, and strength and endurance of DCF muscles. However, in the increase of CROM, decreasing pain severity and functional impairment parameters there was no superiority of both exercise training.

Summary points

- In rehabilitation programs of desk-based workers with sagittal cervical disorientation, ensuring the postural smoothness and planning of the working environment should be included in the short-term objectives.
- Clinical Pilates exercise, should be included in the treatment plan to correct cervical disorientation, increase the strength and endurance of the deep neck flexor muscles.
- In terms of increasing cervical range of motion, home exercise program is clinically effective.
- Both exercise programs can be effective in reducing neck pain and decreasing functional disability.

Author contributions

All authors contributed to literature review and topic identification, and participated in writing phase of the article. E Angin and EH Tuzun participated in the screening of people to be included in the research. C Hurer contributed to the application phase of the study.

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Ethical conduct of research

The study was approved by the Eastern Mediterranean University Scientific Research and Health Ethics Committee (6 November 2017, 2017/50-37) and was applied by the principles of the Declaration of Helsinki. In addition, for investigations involving patients, informed consent has been obtained from the participants involved.

Data sharing statement

The authors certify that this manuscript reports original clinical trial data. Deidentified, individual data that underlie the results reported in this article will be available from the authors on request. Clinical trial registration number: NCT03352921.

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