European Journal of Physical and Rehabilitation Medicine 2022 October;58(5):757-66
DOI: 10.23736/S1973-9087.22.07361-0

ORIGINAL ARTICLE

Impact of adding scapular stabilization to postural correctional exercises on symptomatic forward head posture: a randomized controlled trial

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ABSTRACT

BACKGROUND: One of the most overspread postural abnormalities is forward head posture (FHP) and it is described as head projection anteriorly in relation to the trunk which appears mainly in sagittal plane. Scapular stabilization exercise (SSE) is capable of restoring each of thoracic cage and head neutral optimum position by neck and shoulder muscles interactions and through controlling scapular position and movement
AIM: This study was conducted to investigate the impact of adding scapular stabilization (SSE) to postural correctional exercises (PCE) on symptomatic FHP.
DESIGN: The pre-post single-masking (assessor) randomized experimental trial.
SETTING: Participants with postural dysfunction in form of FHP admitted to outer clinic of the Faculty of Physical Therapy.
POPULATION: Sixty participants (20 to 35 years) with symptomatic FHP and recruited from outer clinic at faculty of physical therapy.
METHODS: Participants were allocated randomly by opaque sealed envelope to two groups who are referred from an orthopedist: Group “A” received SSE and postural correction exercises, whereas Group “B” received only postural correctional exercises; treatments were performed three times/week for 10 weeks. The craniovertebral angle, pressure pain threshold, cervical flexor and extensor muscles endurance, Arabic neck disability index, upper trapezius and sternocleidomastoid muscle root mean square during rest and activity were used to evaluate the patients’ pretreatment and post-treatment.
RESULTS: within group analysis for sixty participants reported statistical significant difference between baseline and post-treatment as P value <0.05 with more refinement in stabilization exercise group.
CONCLUSIONS: Adding SSEs to PCEs is more effective method than PCEs seldom for the management of FHP patients.
CLINICAL REHABILITATION IMPACT: Both scapular stabilization and postural correction exercise increase craniovertebral angle and pressure pain threshold (PPT) and decrease muscle activity and disability. Scapular stabilization alone increase craniovertebral angle and PPT and decrease muscle activity and disability more than postural correction exercise. In addition of statistical significant difference in all variables but there were clinical change in disability only.

(*Cite this article as:* Abd El-Azeim AS, Mahmoud AG, Mohamed MT, El-Khateeb YS. Impact of adding scapular stabilization to postural correctional exercises on symptomatic forward head posture: a randomized controlled trial. Eur J Phys Rehabil Med 2022;58:757-66. DOI: 10.23736/S1973-9087.22.07361-0)

KEY WORDS: Exercises; Electromyography; Posture.

It was reported in the latest surveys that about 75% of the whole world population takes up most of their time on high technology devices such as smartphones, iPads, laptops, electronic readers, and video-game devices.[1] Prolonged inherence of static position due to overuse of such devices, ultimately lead to spasm of neck muscles and assumption of awkward postures[2]. Prolonged sitting in specific static posture is the main cause of postural abnormalities such as forward head posture (FHP), which is identified by head anteriorly displaced in regard to the line of gravity.[3] FHP causes exaggerated extension at the upper cervical spine (C1-C3) and flexion at the lower cervical spine (C4-C7) which is a consequence of changing head position in relation to the line of gravity.[4, 5]

FHP has been found to be a possible hazard element for shoulder aches,[6] abnormal scapular kinematics,[7] myofascial pain syndrome[7] and apparently producing imbalance of several neck muscles, as the upper cervical spine flexors, scapular retractor muscles, suboccipitals, scalenus anterior, upper trapezius and sternocleidomastoid, levator scapulae, and semispinalis capitis post major[8] Besides, assuming such posture results in over activation of the neck extensor and the upper and lower trapezius muscles even during rest[9]. Similarly, the load on posterior structures of cervical spine as ligaments, joints, and muscles is magnified in response of prolonged forward posture of the head and lead to change of both scapular position and kinematics.[10]

Furthermore, it was reported that FHP lead to spasm and shortening of cervical extensor muscles, inhibition of cervical flexor muscles, in addition awkward scapular position and movement[11]. Also, inhibition of mid scapular retractor (*i.e.*, Rhomboids, Middle and Lower fibers of trapezius) and spasm of Pectoralis muscles is reported.[3] Some compensatory actions occur in FHP, the upper trapezius muscle over activated to overcome weakened cervical extensor muscles in order to carry the weight of the head,[12] and the sternocleidomastoid to overcome inhibited cervical flexors.[13] Both of these muscles have shown increment of the electromyographic activity.[12]

These compensatory actions from UT and SCM muscles executed to prevent damage to the body and decrease pain[14] but this action in the same time lead to malalignment in the neck, posture tilting, and muscle imbalance.[15] For resolving this difficult; patients with FHP should restore the normal body alignment. This involves strengthening the weak muscles (deep cervical flexor muscles) and lengthening of the shorted muscles (cervical extensor).[16] Patients with FHP not only have problems around the neck but also around the neck-shoulder muscles, in addition abnormal postures such as rounded shoulders.[17] In order to correct head and neck posture, it is important to improve the thoracic spine.[18] Therefore, scapular stabilization exercise (SSE) is used as an effective way to recover the imbalance in posture and muscles[19]

SSE is effective in the early rehabilitation and the balance of both sides of the trapezius with the movement and couple motion of the scapula[20] and also for placing cage of the thorax at the normal central position, restore normal alignment of the neck and correct its awkward posture through correcting position and restoring kinematics of the scapula.[21] However, there is lack of randomized studies investigating the influence of adding SSEs to postural correctional (PCE) on correcting FHP in symptomatic patients. Therefore, the aim of our study was to investigate, through a randomized study, the impact of scapula stabilizing exercises on PCE on correcting FHP in symptomatic patients" and answer the following question; was there a difference between scapular stabilization in addition to PCE and PCE alone on craniovetebral angle (CVA), pressure pain threshold (PPT), endurance of flexor and extensor muscles, SCM and UT muscles activity and disability in patients with FHP?

Materials and methods

Study design

This pre-post single-masking (assessor) parallel randomized experimental trial was conducted in acquiescence with the 1964 Helsinki Declaration and its subsequent modifications and the guidelines of Consolidated Standards of Reporting Trials. This trial conducted from July 2021 to the end of September 2021 at out-patient clinic at Faculty of Physical Therapy, Cairo University. The ethical unique number for this trial was P. T. REC/012/0023244 and the date was 15/6/2021 from Research Ethics Committee at Faculty of Physical therapy, Cairo University. Prof/Dr: Amira El Tohamy was the chairperson of research ethics committee. The other unique number from Clinical Trials Registry (Registry ID: NCT 04959942). Before participating in study, the participants signed a written consent form and were given details about the study.

Sample size

The sample-size calculated based on *t*-test, power 80%, type I error 5% two sided. The effect size (0.82) calculated on the primary outcome (CVA) from pilot study on 10 subjects. The minimum sample size =50 and to account for drop out, the number increased by 10%. The appropriate sample was 60 subjects. G* Power version 3.1.9.2 (Franz Faul, Uni Kiel, Germany) was used for calculation.

Participants and randomization

A computer-generated block randomization was used to sort the subjects randomly into two groups. The size of the block was four to avoid bias and assures balance between groups. To ensure the concealment of the allocation, randomization codes were placed in sealed envelopes with sequential numbers. The first author, who was not involved in data collection, applied randomization, the second author opened the opaque sealed envelope and applied the treatment, the fourth author gathered the data and was blinded to the allocation stage, and the third author analyzed and interpret the data.

The patients included in this study if they have CVA equal or less than 50, and had cervical pain for more than 6 weeks and had visited an orthopedist clinic.[22] Patients were excluded, if they had clinical conditions other than MNP, like 1) cervical spine spondylosis; 2) fractures or cervical spinal surgery; 3) Cervical or shoulder neurological movement disorder; 4) temporo-mandibular surgery; 5) pathologic trauma. Eight patients were excluded because they did not meet the inclusion criteria[23] (Figure 1, 2**)**.

Outcome measures

The outcomes of the study were measured before beginning the treatment program and after 10 weeks of study. Outcome measures were neck alignment assessed by calculating CVA by photographing (Canon power shot A490, 3.3 optical zoom, 10 mega pixels, China), PPT measured by the Commander Algometry (JTECH medical, Midvale, UT, USA), endurance of cervical flexor and extensor muscles assessed by using Stop watch. The Arabic Neck Disability Index (ANDI) was used to measure neck function, ultimately, muscle activity in the form of root mean square (RMS) at rest and activity via EMG.

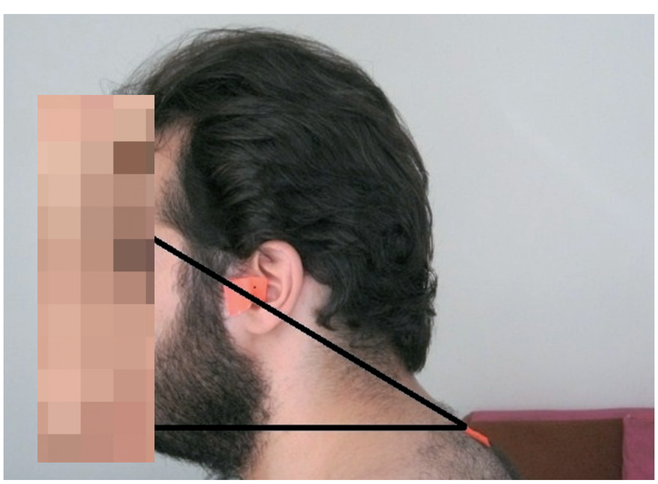

Figure 1.—CVA measurement.

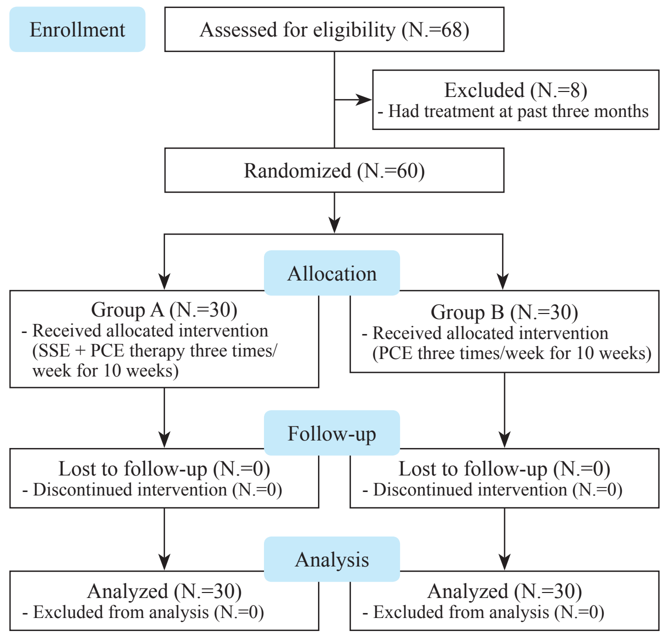

Figure 2.—CONSORT flow chart.

CVA

Lateral photographing is a valid and reliable instrument to objectively measure FHP.[24] CVA is the angle between a horizontal line passing across C7 and a line passing over C7 to the tragus of the ear.[25] Adhesive markers were fixed on the tragus of the ear and the spinous process of the C7 vertebra (Figure 1).

PPT

The Commander Algometry (JTECH medical, Midvale, UT, USA) is a valid tool and commonly used for the assessment of the PPT.[26] It is a handheld device that applies manual pressure to assess pain sensitivity of deeper structures. Its tip was positioned on the trigger area on UT and pressure was slowly increased by 1 kg/s. When the patients sensed discomfort and verified it verbally, the value of pressure was recorded in kilograms per square centimeters. The process was repeated three times with 60 s intervals in between.[27]

Endurance of cervical muscles

Neck flexion endurance

NFET is considered a suitable and reliable technique for non-instrumented evaluation of endurance of DNF muscle. It is considered to have good to excellent intra-rater reliability.[28] The test was done while the patient was lying in the supine and crook positions with maintaining the chin tucked to the maximum and isometrically maintained, the patient was asked to lift the head and neck till the head was around 2.5 cm off the plinth with keeping the chin tucked to the chest. If the patient lost the retraction of the chin, a verbal command was given such as " keep your chin in."[28] Normal Value: 34 sec.[29]

Neck extension endurance

NEET is maybe the most common one, as it is a simple test using by the clinicians without any complex tools. The patients was instructed to lie in a prone position with her head out of the plinth and held on a stool, her arms were at side and a physiotherapy belt was tightened and secured across the level of T6 to support the upper thoracic spine. A perpendicular line was secured beneath the Velcro strap attached around her head, which hung to just short of the floor. Then she was asked to tuck the chin in and hold the head stable in a straight position while the stool was removing. At this moment, the stopwatch was started to record the endurance time in seconds.[30] Sixty seconds are the target time for the test, but if any subject could able to hold for longer, they are encouraged to do so, and this was recorded as their holding time.[30]

Neck function

The neck function was assessed by the ANDI tool which has a moderate value of reliability and validity.[31] It includes 10 sets, each including six choices (0-5). Scores of 0-4 indicate no disability; 5-15, mild disability; 5-14, moderate disability; 25-34, severe disability; and >34, complete disability.[32] Patients were asked to pick the choice that described their function.

Electro myographic activity of UT and SCM Muscles

First skin of the subject prepared in a standard way before application of electrode to minimalize electrical impedance. After cleaning and abrading the skin, bipolar surface electrodes (Ag/AgCl) were positioned over the UT and SCM muscles consistent with established Surface Electromyography for the Non-Invasive Assessment of Muscles guidelines.[33] Placement of electrodes for the UT, 1 electrode was located 2 cm lateral from the midpoint of a line connecting spinous process of C7 and the acromion. A second electrode was located 1 cm laterally on the same line, and the reference electrode was located on the C7 spinous process. For the SCM, electrodes were positioned at the lower third of the line joining the mastoid process and the sternal notch. The reference electrode was positioned over the acromion process.[34]

For maximum voluntary isometric contraction (MVIC) of the UT, the patient was instructed to do a shoulder shrug against resistance given by the physiotherapist. For MVIC of the SCM, the patient was asked to lie in a supine position and asked to flex the neck against resistance given by the examiner on the forehead.[35] These MVIC tests were repeated 3 times for each muscle, and the mean of the 3 tests was recorded for further assessments. After each MVIC effort, a 30 seconds rest period was given.

Electromyographic signals were measured and analyzed by an analog-to-digital convertor (the MyoSystem 1400A Noraxon, Scottsdale, AZ, USA). Data collected at a sampling rate of 1000 Hz were measured with a combined preamplifier gain of 100<&thins P>000 to 10,000 and a bandwidth of 20 to 450 Hz[36]. The EMG activity of both UT and SCM muscles was measured at rest for 10 seconds when the patient was in a relaxed sitting position. In addition to resting EMG activity, these muscles were assessed during activity, specifically 120° of shoulder abduction for the UT in a standing position and neck flexion in a supine position for the SCM. The mean root-mean-square of 3 contractions was taken for evaluation.[37] The root-mean-square of EMG signals was recorded during rest and activity for both muscles were obtained and normalized by their respective MVICs to obtain muscle activity at rest and during activity in terms of %MVIC.

Interventions

Group (A) received SSE and PCE three times a week for 10 weeks, whereas Group (B) received PCE only three times a week for 10 weeks.

SSEs

Consisted of five phases. In supine lying position, the patient was instructed to take a deep breath in order to relax her body. In crook-lying position, she raised her dominant arm to 90° shoulder flexion with full extension of elbow and scapular protraction.[35] In quadruped position, she lifted up her arms alternatively with shoulder abduction and 120 ° flexion. In sitting position, with 90° knee flexion on a stool or bed without backrest, she held a pair of dumbbells (2 kg) in each hand and lifted them up laterally while maintaining scapulae's height below 80°. The patient was instructed to hold each stage for 10 seconds and then return to the starting position and three sets of 10 repetitions with 30-second pause in between were completed. In sitting position, the patient was sitting in front of a mirror.

Then, she was asked to check and correct her posture by herself.[38]

As for the progression of SSE, T to Y the patient was instructed to lie in prone lying position on Swiss ball with arms abducted to 90° (the letter T); then she asked to flex her elbows to 90°, retract her scapulae and externally rotate her arms while keeping her arm in 90° abductions. While maintaining the retraction of scapula, she asked to raise her arms above head and extend the elbow while her arm flexed and abducted to 120° (the letter Y).

As for T to Y to W the patient was instructed to lie in prone lying position on Swiss ball and formed the letter T (as described before) then she changed her position to letter Y with her thumbs up. She depressed and retracted scapulae while raising her arm 10 -15 cm. While maintaining the retraction of scapula; she flexed her elbows and extended her shoulders to form the letter W.

As for scapular protraction, the patient was instructed to lie in prone lying position, with her toes and forearms held the body, and then she pushed up 1-2 cm and protracted her scapulae.

Scapular-clock exercise was the second exercise we used to ease the motions of the scapulae (elevation, depression, protraction, and retraction) in addition to joint kinesthesia (to develop proprioceptive consciousness of positioning, posture and safe movement) and range of motion. The patient was asked to stand beside a wall and put her hand on a ball and press it while moving it to show 3, 6, 9 or 12 o'clock based on an imaginary clock she had on her mind.[39]

PCEs

The program consisted of four exercises; two of them strengthening (deep cervical flexors and scapular retractors) and the other two stretching: cervical extensors (suboccipital muscles and pectoral muscles). The program was based on a program by Harman.[3]

As for strengthening of deep cervical flexor muscles, each patient was instructed to sit with her arms relaxed by her side. The therapist lightly touched the area under the nose and above the lip then, asked the patient to tuck her head in and down.

As for strengthening of the scapular retractor muscles, the patient started this exercise with sitting on a chair without backrest. The patient was asked to squeeze the inferior angle of the scapula together; to retract them; while the therapist resisted this motion gently. The patient was asked to imagine grasping a quarter between the shoulder blades. Then, the patient was asked to stand with her hands holding together across the lower back; to adduct the scapulae.

These exercises were applied for three sets with 12 repetitions per set, with 6 seconds hold.

Stretching exercises

In stretching of sub-occipital muscles, the patient assumed sitting position. Then, after identification the spinous process of the 2nd cervical vertebra, it was stabilized by the therapist's thumb. After that, the patient was asked to slowly nod, doing just a tipping motion of the head on the upper spine.

In stretching of the pectoralis major muscle, the patient assumed sitting position with her hands behind the head, in order to stretch sternal head, shoulders should be abducted and externally rotated 90° and in order to stretch the costal division, arm should be raised to approximately 135 degrees. Then, the therapist applied passive stretch at the end of range of motion.

The exercise was performed three times with 30 seconds hold in between.

Statistical analysis

The data analysis was carried out by using SPSS software version 23.0 (Armonk, NY, USA). Descriptive statistics were calculated before the beginning of treatment and after ten weeks of intervention. For checking the normality of data, Shapiro-Wilk's test was used. According to the results of normality distribution, mixed-design multivariate analyses of variance (MANOVA) was used to identify any change between both groups on the combined mean change scores of CVA, PPT, ANDI and RMS. Wilks' lambda was used to detect the F value. When there is significant difference between both groups multiple pairwise comparisons by Bonferroni were applied. Un-paired *t*-test was used to identify between groups changes in physical characteristics of subjects. Chi-square (χ^2) test was used to clarify the difference between groups at sex and the affected side.

Results

Figure 2 illustrates the flow chart of the study, which demonstrated that sixty eight subjects with symptomatic FHP were recruited from the outpatient clinic at the faculty of physical therapy in Giza governorate. Eight subjects were excluded because they had received treatment within the previous three months. So, sixty people were eligible to participate in the study and were randomly assigned to ei-

Table I.—*Demographic data of experimental and control groups.*

	Mean±SD		P value
	Experimental group	Control group	
Age (years)	24.32±1.25	25.47±3.56	0.61 [b]
Weight (kg)	66.8±8.71	69.65±9.21	0.32 [b]
Height (cm)	167.8±11.79	172.85±8.89	0.13 [b]
BMI (kg/m^2)	23.6±0.89	23.89±0.23	0.48 [b]
Sex			χ^2=1.1 0.29 [b]
Males	14 (47%)	10 (33%)	
Females	16 (53%)	20 (67%)	
Affected side			χ^2=0.57 0.44 [b]
Right	25 (83%)	27 (90%)	
Left	5 (17%)	3 (10%)	

[b]no significance difference; x-par: mean; SD: standard deviation; P value: significance level; BMI: Body Mass Index; χ^2: chi square test.

ther the experimental or control groups. For physical characteristics analysis between groups; Un-paired *t*-test was used and informed no statistical significance difference with regard to age, weight, height, BMI, six and affected side distribution between both groups as P>0.05 (Table I).

Results of outcome measures; CVA, PPT, CROM, NFE, NEE, ANDI, and RMS:

Generally, MANOVA reported statistically significant difference between both groups as Wilks' Lambda (ʎ) value=0.16, f=13.59 and P=0.001. Also, there were statistical significant effect at times as ʎ=0.005, f=333.74 and P=0.0001. Finally, there were significant interaction between groups and time as ʎ=0.09, f=16.82 and P=0.0001.

Univariate test revealed statistically significant effect at time (pre and post-treatment) in CVA as f=192.1 and P=0.0001, in PPT at right and left side the f-value= 35.9 and 89.53 respectively and P=0.0001 at both sides.in flexion and extension endurance test the f-value=366.1 and 241.1 respectively and P=0.0001 at both tests. At UT right and left side in resting position; the f=101.17 and 117.41 respectively and P=0.0001 at both sides. During activity the f-value=258.16 and 191.3 respectively and P=0.0001 at both sides. At resting position of SCM at right and left side the f-value=275.2 and 235.25 respectively and in activity f=285.3 and 289 respectively and P=0.0001. Finally, f=293.3 and P=0.001 in ANDI.

In the same line Univariate Test revealed statistical significant effect at treatment in CVA as f=20.41 and P=0.001, in PPT at right and left side the f-value= 16.18 and 5.38 respectively and P=0.0001 at right and 0.02 at left side. In flexion and extension endurance test the f-value=10.2 and 20.8 respectively and P=0.01 at flexion and 0.0001 at extension endurance. At UT right and left side in resting position; the f=5.41 and 11.13 respectively and P=0.02 and 0.002 respectively. During activity the f-value=23.1 and 38.01 respectively and P=0.0001 at both sides. At resting position of SCM at right and left side the f-value=2.36 and 0.64 and P= 0.01 and 0.12 respectively and in activity f=11.73 and 19.47 respectively and P=0.001 and 0.0001 respectively. Finally, f=31.8 and P=0.0001 in ANDI.

Within and between group analysis:

In CVA and PPT at both sides there were statistically significant increase in both groups as P<0.05 with more favor to experimental group. Between groups analysis at post-treatment there were statistically significant difference as P<0.05. Also, there was statistical significant increase in flexion and extension endurance test in both groups with more favor to experimental group. Between groups analysis at post-treatment there were statistical significant difference as P<0.05.

In UT muscle the RMS value during rest and activity decreased significantly as both groups as P<0.05 with more favor to experimental group and also there were statistical significant difference at post-treatment between both groups. In RMS of SCM at rest and activity there were significant decreases at both groups with more favor to experimental groups and also there were statistical significant difference between both groups at post-treatment except for left SCM at resting position. Finally the disability decreased in both groups with more favor to experimental group (Table II).

Discussion

This study investigated the effect of SSE on CVA, PPT, NFE, NEE, neck function, and muscle activity of both upper trapezius and sternocleidomastoid (muscle amplitude (RMS) at rest and activity) in patients with FHP. As stated by our statistical analysis and findings, the results showed significant improvement in both groups with more supremacy to experimental group (SSEs).

In order to clarify the role of SSE and PCE on FHP, we have to shed a light on the results of FHP on cervical spine alignment and scapula. FHP aggravates spasm in muscles that interfere and inhibit scapular upward rotation. Consequently, there is an evident increase in UT muscle activity in such cases[40] even during rest. Besides, we hypothesized that prolonged FHP induced clear cervical length-tension relationship transformation, that result in increased need of cervical neck muscles stabilization; at the time they are

Table II.—*Between and within group analysis of CVA, PPT, NFE, NEE, ANDI, and RMS during rest and activity.*

Outcome measures	Mean±SD		P value between	F value between
	Experimental group	Control group		
CVA				
Baseline	39.58±3.97	39.02±2.86	0.62	0.25
Post-treatment	52.89±4.18	45.66±2.97	0.0001 [a]	39.6
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	-13.31	-6.64		
95% (CI)	-15.3 to-11.2	-8.7 to-4.58		
PPT right				
Baseline	1.62±0.22	1.55±0.38	0.45 [b]	0.57
Post-treatment	2.41±0.41	1.83±0.45	0.0001 [a]	16.99
P value (within)	0.0001 [a]	0.03 [a]		
Mean difference	-0.79	-0.28		
95% (CI)	-1.05 to -0.53	-0.54 to -0.03		
PPT left				
Baseline	1.15±0.35	1.24±0.31	0.4 [b]	0.71
Post-treatment	2.21±0.42	1.71±0.39	0.001 [a]	14.18
P value (within)	0.0001 [a]	0.0001 [a]		
Mean difference	-1.04	-0.47		
95% (CI)	-1.27 to -0.81	-0.7 to -0.24		
ANDI				
Baseline	27.6±2.32	28.4±2.64	0.31 [b]	1.03
Post-treatment	12.2±2.44	17.1±1.33	0.0001 [a]	62.06
P value (within)	0.0001 [a]	0.0001 [a]		
Mean difference	15.40	11.30		
95% (CI)	13.97 to 16.82	9.87 to 12.72		
Flexion endurance				
Baseline	21.8±3.99	23.1±2.61	0.23 [b]	1.48
Post-treatment	37.5±3.03	33.65±3.2	0.0001 [a]	14.99
P value (within)	0.0001 [a]	0.0001 [a]		
Mean difference	-15.7	-10.55		
95% (CI)	-17.6 to -13.7	-12.5 to -8.58		
Extension endurance				
Baseline	36.25±3.56	37.45±4.36	0.6 [b]	0.28
Post-treatment	63.9±5.7	48.55±4.7	0.0001 [a]	84.72
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	-27.65	-11.10		
95% (CI)	-31.22 to -24	-14.67 to -7.52		
Right UT (rest)				
Baseline	2.15±0.49	2.28±0.39	0.37 [b]	0.88
Post-treatment	1.20±0.37	1.59	0.006 [a]	8.49
P value (within)	0.0001 [a]	0.0001 [a]		
Mean difference	0.94	0.68		
95% (CI)	0.71 to 1.18	0.44 to 0.91		
Left UT (rest)				
Baseline	2.31±0.41	2.48±0.51	0.24 [b]	1.38
Post-treatment	1.02±0.32	1.58±0.21	0.001 [a]	14.15
P value (within)	0.0001 [a]	0.0001 [a]		
Mean difference	1.28	0.89		
95% (CI)	0.99 to 1.57	0.6 to 1.18		
Right UT (activity)				
Baseline	70.05±3.04	69.98±4.02	0.95 [b]	0.004
Post-treatment	49.95±2.74	60.75±5.93	0.0001 [a]	54.48
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	20.09	9.23		
95% (CI)	18.14 to 22	7.28 to 11.17		

(To be continued)

Table II.—*Between and within group analysis of CVA, PPT, NFE, NEE, ANDI, and RMS during rest and activity (continues).*

Outcome measures	Mean±SD		P value between	F value between
	Experimental group	Control group		
Left UT (activity)				
Baseline	71.07±3.64	72.11±4.19	0.41 [b]	0.71
Post-treatment	51.55±5.79	61.11±3.71	0.0001 [a]	38.47
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	19.52	11.01		
95% (CI)	16.36 to 22.6	7.85 to 14.17		
Right SCM (rest)				
Baseline	3.2±0.45	3.07±0.61	0.42 [b]	0.67
Post-treatment	1.75±0.24	2.09±0.43	0.004 [a]	9.50
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	1.46	0.97		
95% (CI)	1.25 to 1.67	0.76 to 1.18		
Left SCM (rest)				
Baseline	3.38±0.51	3.42±0.47	0.82 [b]	0.05
Post-treatment	1.98±0.37	2.16±0.35	0.27 [b]	1.23
P value (within)	0.0001 [a]	0.0001 [a]		
Mean difference	1.40	1.25		
95% (CI)	1.15 to 1.64	1 to 1.5		
Right SCM (activity)				
Baseline	79.18±3.76	76.6±4.92	0.07 [b]	3.47
Post-treatment	54.06±3.5	64.2±4.88	0.0001 [a]	56.93
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	25.12	12.40		
95% (CI)	22.81 to 27.4	10.09 to 14.71		
Left SCM (activity)				
Baseline	80.21±3.41	80.5±3.63	0.79 [b]	0.06
Post-treatment	57.65±3.75	64.1±3.09	0.0001 [a]	34.79
P value (within)	0.0001 [a]	0.001 [a]		
Mean difference	22.56	16.4		
95% (CI)	20.27 to 24.8	14.1 to 18.68		

[a]Significant difference; [b]no significance difference; x-par: mean; SD: standard deviation; P value: significance level; PPT: pressure pain threshold; ANDI: Arabic Neck Disability Index; CVA: cranio vertebral angle; CI: confidence interval.

not capable of meeting such need, so they are counter balanced by UT and SCM hyperactivity. Further, Weon *et al.* assured that when the head is in a neutral position induced reduction in the activity of both upper and lower trapezius muscles. For that reason, it could be presumed that excessive activity of the superficial muscles of cervical spine can be prevented by enhancing alignment of head posture.[7]

Effects of SSEs

SSE is accounted as effective strategies that enhance and improve abnormal FHP.[41] As stated by the results, there was significant increase in CVA which proofs an improvement in FHP. A preceding study showed the influence of applying stretching and muscle strengthening exercise programs on refining and improving FHP through CVA increment.[42] Besides, Shiravi *et al.* declared that cervical muscle strength and function is improved through inhibiting upper trapezius muscle activity in FHP subjects using SSE.[43] Kang *et al.* emphasized the influence of SSE in facilitating cervical muscles, dampening the trapezius and serratus anterior muscles, and correction of FHP, which empowers the results of this study.[44]

When this awkward FHP is corrected, this result in proper alignment of the cervical spinal, inhibiting the superficial muscles spasm and fatigue such as the upper trapezius and sternocleidomastoid, therefore muscle imbalance is alleviated. So, there is a positive influence of pain reduction on PPT and NDI. McDonnel *et al.* assumed that there is a significant reduction of NDI after the intervention programs being implemented, involving scapular exercise for three months, in order to relocate the abnormally aligned scapula, which is compatible with the study results.[45]

Our study supposed that there is a significant decrease in the sternocleidomastoid, upper trapezius muscle activity following the intervention. Kang *et al.* assured on the enhancement of the activities of the lower trapezius, serratus anterior muscles and the role of scapular stabilization on inducing massive improvement of the neck muscles activity.[41] Moreover, increasing of scapular tilt and reduction in the upper rotation angle through scapular alignment as a consequence of lower trapezius muscle activation[2] In addition, increasing serratus anterior muscle activity result in inhibition of upper trapezius hyperactivity which has a viable role on raising of the scapula and stretching of the neck.

Accordingly, an opposite rotating movement is supposed to occur as a sign of improvement of such abnormal postures.[44] Thus, SSEs can be regarded as a method of producing structural changes of the neck and muscles compensation to produce a massive improvement in subjects suffering FHP while solving neck, back and scapular problems.[41]

Effects of PCEs

The two primary advantages resulting from performing PCEs on regular basis are; firstly, they have a great effect on reducing adverse mechanical loads caused by cervical and scapular awkward kinetics and position. Secondly, they improve deep spinal postural stabilizing muscles strength. Moreover, performing such exercises on regular basis may produce postural habits changes.[46] We postulated that assuming proper posture and increasing awareness of its importance play a viable role in alleviating pain and discomfort. Our findings come in agreement those of Mclean, who assured the impact and effectiveness of PCEs on cervical muscles.[47] Abd El-wahab and Sabbahi discovered changes in the amplitude of the H-reflex in response to PCEs and as a result it was proposed for cases suffering of cervical radiculopathy (C7).[48]

The control group improvement may be correlated to PCEs, instructions on daily activities performance within limit of pain, and keeping away from muscle excess load. Factors as task acquaintance or improved postural awareness could be the main cause of their improvement,[24] or caused by the deep cervical flexor muscles direct activation[49] which have a fairly high density of muscle spindles[50] that improve cervical kinesthetic senses.[51]

Limitations of the study

Despite potential strengths, the present study shows certain limitations. First, young individuals with FHP were recruited, which limits the generalizability of the results to the same population. Second, CVA was measured by taking digital pictures rather than more robust cephalometric radiographic analysis. And third, we haven't measured the EMG activity of both lower trapezius and serratus anterior muscle despite it has an integral role in scapular kinetic and kinematics.

Conclusions

Adding SSEs would seem to be more effective in improving the craniovertebral angle, pressure pain threshold, muscle activity and disability than postural correction exercises alone. Further studies are needed with large sample and different age groups such as adolescent, young adult and old to increase the generalizability of trial, in addition using objective methods for assessment to increase strength of trial and also assess serratus anterior and lower trapezius due to its integral role in scapular kinetics and kinematics.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions.—Alshaymaa S. Abd el Azeimformulated the idea and the study design. Alshaymaa S. Abd el Azeim, Marwa T. Mohamed, Amira G. Mahmoud and Yasmin S. Elkhateeb conducted research, provided research materials, was responsible for the clinical evaluation of the participants, and organized data; YE were involved in writing the manuscript; AA carried out the data analysis and interpretation; Amira G. Mahmoud, and Marwa T. Mohamed revised the final draft; all authors confirmed the final manuscript and were responsible for the content of the manuscript. All authors read and approved the final version of the manuscript.

History.—Article first published online: June 8, 2022. - Manuscript accepted: June 6, 2022. - Manuscript revised: February 18, 2022. - Manuscript received: November 13, 2021.