Journal of Associated Medical Sciences 2020; 53 (3): 62-71

JAMS
Journal of Associated Medical Sciences

Thai-Journal Citation Index Centre (TCI) & ASEAN Citation Index (ACI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index

Effects of an exercise program on cervical posture and sensorimotor function in persons with forward head posture

Nontacha Jantoon **Sureeporn Uthaikhup***

Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand

ARTICLE INFO

Article history:
Received 21 February 2020
Accepted as revised 26 August 2020
Available online 26 August 2020

Keywords:
CV angle, forward head posture, joint position sense, sensorimotor function, standing balance

ABSTRACT

Background: Forward head posture is associated with impaired musculoskeletal function and sensorimotor system. However, the effects of an exercise program as part of routine activities in persons with forward head posture remain unknown.

Objectives: To investigate the effects of an exercise program on cervical posture and sensorimotor function in persons with forward head posture.

Materials and methods: Sixty university students with forward head posture (aged between 19 and 24 years old) were recruited. Participants were allocated to either experimental or control group. The experimental group received a specific exercise program including postural correction, co-contraction of the cervical muscles and suboccipital muscle stretching, 7 days a week for 4 weeks. The control group continued with their normal daily routine. The outcome measures were the craniocervical (CV) angle, sagittal head tilt (SH) angle, cervical joint position error (JPE), and postural sway during narrow stance with eyes open and closed. The outcomes were measured at baseline and 4 weeks after intervention.

Results: The results showed that the CV angle and JPEs in rotation to the left and right sides were improved significantly in the experimental group compared to the control group after the exercise program ($p<0.05$). The CV angle, SH angle and JPEs before and after the exercise program were significantly found in the experimental group ($p<0.05$). There were no significant differences in the total sway area between groups and within group ($p>0.05$).

Conclusion: The results of this study suggested the 4-week exercise program (postural correction, co-contraction of the cervical muscles and suboccipital muscles stretching) was effective for improving the head and cervical posture and joint position sense.

Introduction

Forward head posture is one of the most common postural problems. It is often described when resting head posture held in front of the line of gravity with the eyes level or angled downwards in upright position.[1] The incidence of forward head posture varies from 66% to 85% of healthy populations.[2] Forward head posture is proposed as a risk factor of neck pain,[3, 4] although its relationship is still controversial,[5, 6] and is often caused by imbalance between the deep and superficial cervical muscles.[7] Deep cervical flexor muscles (i.e. longus colli and capitis muscles) providing dynamic cervical stability and support of cervical spine were demonstrated to be impaired[8, 9] while cervical extensor muscles, in particular suboccipital muscles were shortened.[2, 10, 11]

In addition to the musculoskeletal system, forward

* **Corresponding author.**
Author's Address: *Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand*
** **E-mail address:** : sureeporn.uthaikhup@cmu.ac.th
doi: 10.14456/jams.2020.18
E-ISSN: 2539-6056

head posture has also been proposed to be associated with the sensorimotor system.[12, 13] This may be explained by sensorimotor integration of the cervical proprioception and other sensory information from the visual, vestibular and somatosensory systems required for the postural control system.[14] Evidence suggests that the deep cervical muscles, in particular the longus coli and suboccipital muscles have high density of muscle spindles, which provide proprioceptive information for the sensorimotor system.[15, 16] Previous studies demonstrated that forward head posture and static neck flexion led to changes in the cervical proprioception [12, 13] and impaired postural control.[17] In contrast, a study reported that forward head posture did not affect postural control.[18] Although the association of forward head posture and the sensorimotor control is modest, its potential to impaired cervical proprioception contributing to postural control deficit is still promising.

A recent systematic review and meta-analysis study by Sheikhhoseini et al.[19] suggested that therapeutic exercises consisting of strengthening and stretching exercises for the cervical muscles might result in large changes in craniovertebral (CV) angle and moderate improvement in neck pain in participants with forward head posture. Exercise intervention involving craniocervical flexor muscles is mostly attributed to forward head posture. The head and cervical posture (CV and head tilt angles) was found to improve after craniocervical exercise program.[20-22] Whereas it is evident that exercise interventions can improve forward head posture, the exercise programs designed in most studies were conducted in non-functional position and a center-based program,[19, 20, 22-24] which pose limits to manage as part of activity in daily life. Given that the correct upright posture is necessary for forward head posture and the deep cervical flexor muscles play an important role for stabilizing and controlling the cervical spine, a specific exercise program involving the craniocervical exercise and posture correction should be encouraged as part of routine activities. This would partially help unload the cervical spine. Additionally, stretching exercise for shortened muscles, particularly the suboccipital muscles could be added as its impairment and effectiveness on forward head posture have also been revealed.[21] As yet there is no research addressing the effects of an exercise program as part of routine activities. Thus, the present study aimed to determine the effects of an exercise program on head and cervical posture as well as sensorimotor function (cervical proprioception and standing balance) in healthy persons with forward head posture. Knowledge gained would reinforce preventive and promotive programs in persons with forward head posture.

Materials and methods

Study design

This study was a randomized, controlled, assessor-blinded clinical trial (allocation ratio 1:1). Ethical approval was gained from the ethical review committee for research in humans, Faculty of Associated Medical Sciences, Chiang Mai University (AMSEC-61EX-085). The study was registered on the Thai Clinical Trials Registry (No: TCTR20190211005). All participants provided written informed consent before the commencement of the study.

Participants

Participants were volunteer university students, aged between 19 and 24 years old. University students were chosen as they were a relatively controlled setting and comparatively homogenous population. All participants were recruited through an advertisement on Facebook, and flyers on university campuses located in Chiang Mai. Inclusion criteria were no history of neck and shoulder pain for the past year, no any musculoskeletal problems/ conditions that could affect outcomes (e.g. torticollis, scoliosis, back pain, ankle pain, and myofascial pain) and non-athletes.

Participants were made an appointment with an independent assessor to receive initial physical assessment. All eligible participants must have forward head posture measured by the CV angle with a digital camera (Canon EOS 600D) in a natural sitting position.[25] Forward head posture was defined as the CV angle was lower than 50°.[26, 27] Manual examination was also performed on the cervical spine (C0-C7) to confirm no symptomatic cervical joint dysfunction.

Randomization and masking

Randomization was undertaken by an independent researcher who was not involved in the trial. Randomization was performed by computer-generated permuted blocks with a block size of four, stratified by gender and severity of forward head posture (<43.5° or ≥43.5°).[28] Allocation was concealed in sequentially numbered, sealed, opaque envelopes. The envelopes were opened by a researcher allocating participants to each group. The examiner was blinded to group allocation throughout the trial. The therapist was not blinded to treatment.

Interventions

Participants in the experimental group received the exercise program delivered by a physiotherapist with over 3 years of experience. The exercise program included postural correction, co-contraction of the cervical muscles, and suboccipital muscle stretching, according to the previous studies.[29-31] The postural correction consisted of gently rolling of pelvis forward to an upright neutral sitting position, followed by scapular correction and occipital lift. The participants were actively performed and maintained the position for 10 seconds with 5 repetitions, every hour at least 7 times throughout the day (Figure 1A). The co-contraction of the cervical muscles consisted of self-resistance isometric craniocervical flexion, and cervical rotation (right and left). For the isometric craniocervical flexion, the participants were asked to push the chin inferiorly against the fist of one hand while used the other hand wrapping around the front of the neck to monitor overuse of the sternocleidomastoid and scalene muscles. For the isometric cervical rotation, the participants performed with eye movement by pressing their palms against each side of their head and looking into the elbow (left or right) (Figure 1B).[30] Each isometric exercise was performed 10 repetitions with a 10-second hold a day. For the suboccipital muscles stretching, the participants sat upright, placed both hands under the back of the top portion of the head, and pushed the top of the head down with the chin tucked into the front of the neck (Figure 1C).[31] The participants were asked to hold the position for 10 seconds, with 5 repetitions a day. The exercise program was commenced the day after baseline assessment. The participants were asked to perform the exercise program daily for 4 weeks and complete an exercise diary to monitor compliance and record adverse events.

Figure 1. *Exercise program for experimental group. (A) postural correction, (B) co-contraction of the cervical muscles, (C) suboccipital muscle stretching.*

Participants in the control group were asked to carry on with their regular activities with no additional exercise and record if any particular discomfort or injury occurred during the study period.

Outcomes

Head and neck posture

The CV and sagittal head tilt (SH) angles were measured using a digital camera (Canon EOS 600D). The CV angle was defined as the intersection of a line drawn from the tragus of the ear to the C7 spinous process, and a horizontal line passing through the C7 spinous process[32, 33] (Figure 2). The SH angle was an angle between a line from the canthus of the eye to the tragus of the ear, and a horizontal line pass through the tragus of the ear. Three reflective adhesive markers were placed over anatomical landmarks (i.e. canthus of eye, tragus, and C7 spinous process). The participants were asked to assume their natural sitting position with barefoot. The camera was set at 80 centimeters away from the participants in sagittal standing posture and the camera lens was adjusted at the level of external auditory meatus by adjusting the height of the camera tripod.[6] The head and neck posture was taken two times in a lateral view with the right side of the participant photographed. The photographic data was exported into a computer and the CV and SH angles of each photograph were measured twice in degrees using Image J program.

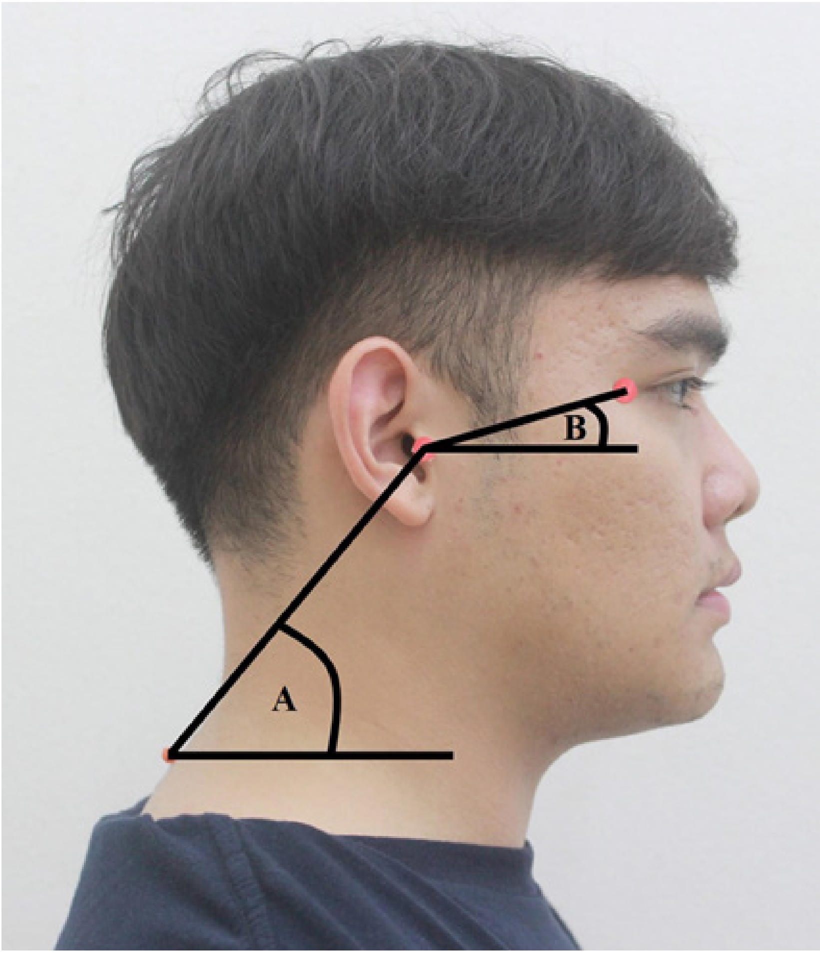

Figure 2*. (A) Craniovertebral angle, (B) sagittal head tilt.*

Intra-rater reliability was conducted in 15 university students, aged between 19 and 24 years old. The measurement of CV and SH angles were performed twice with an interval of 24-48 hours by a blinded examiner. The reliability results for both CV and SH angles were excellent ($ICC_{3,1}$ = 0.91 and 0.85, respectively).

Cervical proprioception

Cervical proprioception was measured by joint position sense (JPS) test using a laser pointer attached to the head as described by Revel et al.[34] The participants sat upright with the head in the neutral resting position, 90 centimeters away from the center of a target attached on a wall. They were asked to perform active cervical movements with eyes closed and then return to the starting position as accurately as possible. JPS was tested in cervical extension and rotation to the right and left directions in random order and each direction was measured three times. The participant's head was repositioned back to the starting position by the examiner before each trial. No verbal feedbacks were given during the measurement. An absolute joint position error (JPE) was calculated from the final laser position and the starting position for each trial in millimeters and then calculated to degrees using equation:

$$\text{Degree} = \tan^{-1}\left[\frac{error\ distance}{900(mm)}\right].$$

Degree of JPE of each movement was used for further analysis.

Static standing balance test

Sway meter was used to measure static standing balance.[35, 36] It comprised a 40-cm-long rod with a vertically mounted pen at its end attached to a belt. The sway meter was attached to the participants at their waist levels with rod extending posteriorly. Standing balance was tested under two different conditions: narrow stance (feet together) with eyes open and closed.[18] For each condition, the participants were instructed to stand as still as possible for 30 seconds. The pen was participant's postural sway on a millimeter graph paper fastened to the top of an adjustable-height table. The postural sway was calculated by displacements of center of pressure in the maximum anterior-posterior

(APmax) and medial-lateral (MLmax) directions and total sway area was summed by number of square millimeter squares (mm^2) traversed by the pen and then converted to square centimeter (cm^2).

Study procedure

All eligible participants completed a consent form and randomly assigned to either the experimental or control group. The outcome variables (CV angle, SH angle, JPEs, and postural sway) were measured at baseline and 4 weeks after intervention by a blinded examiner. The participants in the experimental group were trained to facilitate correct performance of each exercise program (postural correction, co-contraction of the cervical muscles and suboccipital muscle stretching). After the participants were able to do the exercise correctly and independently, they were asked to practice the exercise programs daily for 4 weeks. An appointment was made within the first week to ensure that the participants could perform the exercises correctly by themselves. A telephone reminder was scheduled to remind the participants to exercise every hour of the day. To increase compliance rate, the participants were also called by a researcher every week. The control group continued with their normal daily routine. The participants in both groups were asked not to change their normal daily routine with no additional exercise.

Sample size calculation

Sample size estimation was computed based on the CV angle data of a previous study by Gupta et al.,[23] using G*Power 3.1.9.2. The effect size for the difference between two independent means was 0.7. With a power of 0.8 and a significant level of 0.05, a total sample size of 52 participants was required for the study. To allow for a 15% dropout rate, 60 participants were recruited for the study.

Statistical analysis

To be included in the analysis, all participants had to complete at least 80% of the prescribed exercise program. A per-protocol analysis was used to determine the treatment effect. Descriptive statistic and independent t-test were used to determine demographic characteristics of the participants. Shapiro-Wilk test was used to analyze normality of the outcome variables. An analysis of covariance (ANCOVA) was used to examine differences in the outcomes between groups, using the baseline values as covariates. A mixed-model ANOVA was used to analyze differences in the outcomes between times for each group. All statistical analyses were performed using SPSS software. Level of significance was set at 0.05.

Results

Participants

The study commenced in February 2019 and was completed in July 2019. A flow diagram of participant recruitment and retention is presented in Figure 3. Sixty participants were enrolled into the study and none of those lost to follow-up. Seven participants in the experimental group (23.33%) did not achieve at least 80% of the exercise program and their data were excluded from the analysis. No additional exercise and no adverse effects were reported. Demographic characteristics for the participants are presented in Table 1. There were no between-group differences in the participant characteristics (p>0.05).

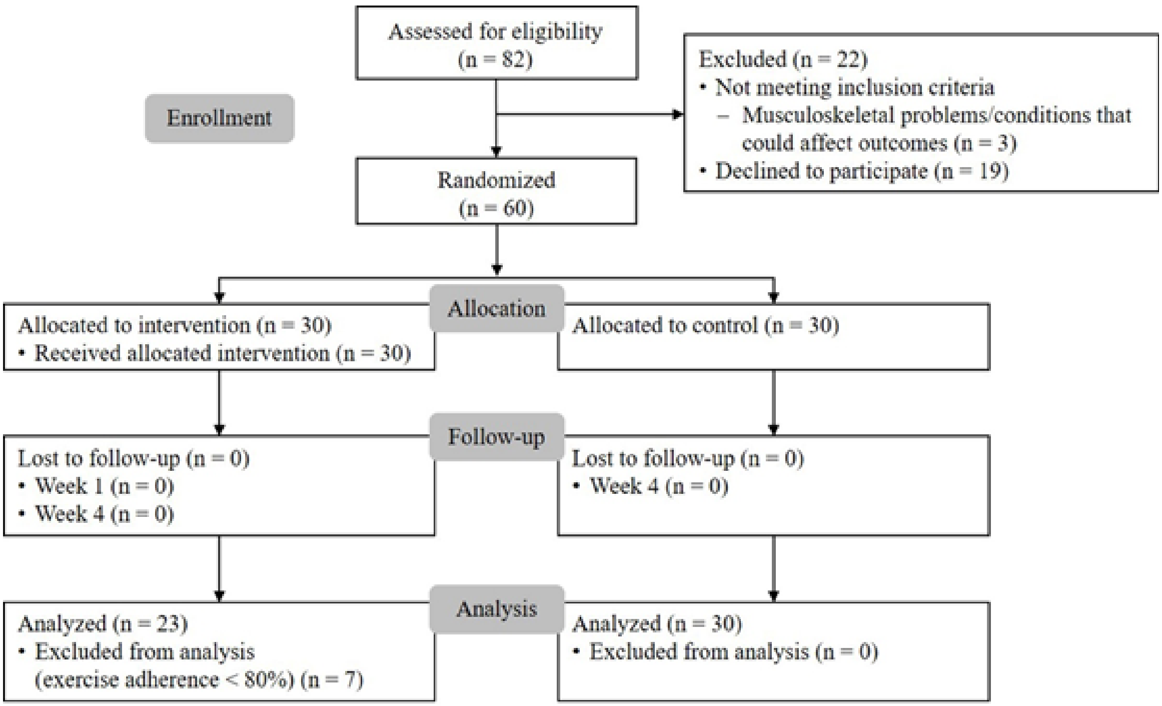

***Figure 3**. Flow diagram of the trial.*

Table 1 Demographic characteristics for the participants.

Variables	Experimental group (n=23)	Control group (n=30)	*p* value
Age (yrs)	22.00±1.28	21.67±1.54	0.41
Gender (% female)	65.22	66.67	0.91
Height (cm)	164.00±9.17	164.18±9.21	0.94
Weight (kg)	61.00±12.55	60.34±11.26	0.84
Duration of study in sitting position (hrs)	5.74±1.78	6.75±2.23	0.08
Duration of smartphone use (hrs)	7.63±3.41	8.07±3.92	0.97

Note*: Data are presented with mean±SD, otherwise as indicated. yrs: years, cm: centimeters, kg: kilograms, hrs: hours.*

Outcomes

Head and neck posture

The CV and SH angles for the experimental and control groups are provided in Table 2. The CV angle was significantly improved in the experimental group compared to the control group after the 4 weeks exercise program (p<0.05) (Table 2). There was no difference in the SH angle between groups (p>0.05). The CV and SH angles before and after the exercise program were significantly found in the experimental group (p<0.05), but not found in the control group (p>0.05) (Table 3).

Table 2 All outcome variables for baseline (pre-test) and after intervention (post-test) between the experimental and control groups**.**

Variables	Experimental group (n=23)		Control group (n=30)		Mean difference	*p* value	Effect size
	Pre-test	Post-test	Pre-test	Post-test	95% confidence interval		
Head and neck posture (degrees) - CV angle	46.23±2.74	49.27±2.99	45.07±3.13	45.93±3.47	-2.47 (-3.82 to -1.11)	0.01	0.21
- SH angle	20.53±4.82	18.03±5.63	18.57±4.33	17.76±5.49	0.67 (-2.31 to 3.64)	0.66	0.01
JPE (degrees)							
- extension	3.39±2.39	3.08±2.38	4.13±1.99	4.53±2.15	1.04 (-0.05 to 2.13)	0.06	0.07
- rotation to the left	3.83±1.34	2.94±1.47	5.16±2.78	5.04±3.13	1.20 (0.01 to 2.39)	0.05	0.08
- rotation to the right	3.58±1.32	2.49±1.19	4.06±2.48	4.83±2.65	1.41 (0.41 to 2.42)	0.01	0.24
Sway area (cm^2)							
- eyes open	0.83±0.39	0.74±0.34	0.77±0.38	0.78±0.36	0.06 (-0.11 to 0.24)	0.45	0.01
- eyes closed	0.96±0.49	0.83±0.38	0.85±0.39	0.90±0.52	0.13 (-0.11 to 0.37)	0.29	0.02

Note*: Data are presented with mean±SD, otherwise as indicated. yrs: years, cm: centimeters, kg: kilograms, hrs: hours.*

Cervical proprioception

The JPE values for the participants in both groups are provided in Table 2. The JPE values in rotation to the left and right sides were decreased in the experimental group compared with the control group after exercise (p<0.05) (Table 2). There was no significant difference between groups in the JPE value in extension (p>0.05). The JPE values in rotation to the right and left sides, but not in extension, before and after the exercise program were significantly found in the experimental group (p<0.05) (Table 3). The JPE values for all directions were not found before and after intervention in the control group (p>0.05).

Static standing balance

The total sway area during standing with eyes open and closed for both groups is provided in Table 2. There were no significant differences in the total sway area between groups and within group (p>0.05) (Table 2 and 3).

Table 3 Mean differences (95% confidence interval) within-group for all outcome variables.

Variables	Experimental group (n=23)		Effect size	Control group (n=30)		Effect size
	Mean difference (95% CI)	*p* value		Mean difference (95% CI)	*p* value	
Head and neck posture (degrees)						
- CV angle	3.04 (2.00 to 4.08)	0.01	0.41	0.85 (-0.06 to 1.76)	0.07	0.07
- SH angle	-2.50 (-4.91 to -0.89)	0.04	0.08	-0.81 (-2.87 to 1.25)	0.43	0.01
JPE (degrees)						
- extension	-0.31(-1.21 to 0.59)	0.49	0.01	0.39 (-0.39 to 1.18)	0.32	0.02
- rotation to the left	-0.89 (-1.80 to -0.01)	0.05	0.07	-0.13 (-0.92 to 0.67)	0.75	0.01
- rotation to the right	-1.09 (-1.99 to -0.19)	0.02	0.10	0.10 (-0.69 to 0.89)	0.06	0.07
Sway area (cm^2)						
- eyes open	-0.09 (-0.24 to 0.06)	0.25	0.03	0.01 (-0.13 to 0.14)	0.98	0.01
- eyes closed	-0.14 (-0.34 to 0.06)	0.17	0.04	0.05 (-0.13 to 0.22)	0.59	0.01

Note: *CV angle: craniovertebral angle, SH angle: sagittal head tilt angle, JPE: joint position error.*

Discussion

This study demonstrated that the CV angle and JPEs were significantly improved in the experiment group compared to the non-exercising control group. Additionally, the CV angle, SH angle and JPEs were significantly improved at 4 weeks of training in comparison with the baseline data. However, there was no change in standing balance after the exercise program. The results suggested that the 4-week exercise program consisting of postural correction, co-contraction of the cervical muscles, and suboccipital muscle stretching could improve forward head posture and joint position sense in healthy individuals.

The results of this study support a systematic review suggesting that therapeutic exercise might result in large changes in CV angle and moderate improvement in neck pain in participants with forward head posture.[19] Notably, the CV value in the experimental group was closed to normal value as suggested in previous studies.[26, 27] In addition, the results of this study are consistent with previous findings,[20-22] although the exercise program in this study was given as part of routine activities. Camitsis et al.[22] reported that the CV angle was greater in both standing (about 11%) and sitting (about 15%) after a home-based craniocervical exercise (10 times/set, 3 sets, 3-5 weeks) in asymptomatic subjects. Kim et al.[21] also demonstrated that the craniocervical exercise combined with suboccipital release could improve the CV angle in subjects with forward head posture. Similarly, Falla[20] found that the craniocervical flexor exercise improved the ability to maintain an upright cervical posture (CV angle) during the computer task in patients with neck pain.

Forward head posture is often associated with increased compressive loading of the cervical spine as well as a creep response in connective tissues.[3] There is also a contribution of prolonged static posture to risk for the development of symptoms in the neck and upper body.[37, 38] Evidence suggests that deep cervical flexor muscles play an important role for providing support and stability for the cervical spine and the weight of the head against gravity.[39] Particularly, a study found that logus colli counteracts the lordosis increment related to the weight of the head and to the contraction of the dorsal neck muscles.[8] This supports our results. Postural correction facilitates the activity of the deep neck flexor muscles, scapular muscles and lumbar multifidus, which are key postural muscles for improving the pattern of cervical, scapula-thoracic and lumbo-pelvic movement.[29] Co-contraction of the cervical muscles increases the activity of the deep neck flexors incorporated with superficial neck flexors, neck extensors and neck rotators.[40] Suboccipital muscle stretching decreases tightness of the suboccipital muscles, leading to reduced chin out posture. Nonetheless, the findings of this study found no significant difference in the SH angle between groups but between pre- and post-test in the experimental group. No differences (pre-post) in the SH angle were observed for the control group. One reason may be associated with the correctness of the exercise performance. Although all participants in the experimental group were properly trained by the physiotherapist, the head may not be well stretched into the stretch position when they performed independently at home. Thus the cervical extensors might be rather more stretched than the suboccipital muscles. Alternatively, no difference may be due to small sample size. The sample size in this study was calculated based on the CV angle. Also, the exercise duration may be not enough. This should be addressed in further research.

The results of this study revealed that JPEs in the left and right rotation were significantly decreased after exercise program 4 weeks, when compared with the control group. A trend was also observed in cervical extension for the experimental group, which no statistical significance may be due to a large variabilty in the experimental group. Additionally, there were significant differences between pre- and post-test for the JPEs in the left and right rotation in the experimental group, but not in the control group. Our results are supported by a previous study demonstrating that forward head posture was correlated with greater repositioning error than a more upright posture and could lead to disruption of afferent input from the muscle spindles.[41] The JPEs may also be related to alteration in cervical proprioception. Deep cervical and suboccipital muscles have the highest density of muscle spindles, which contain mechanoreceptors providing cervical proprioceptive information for the sensorimotor system.[15, 16] There is also evidence that high spindle density in the muscles is relevant to movement control of the cervical spine and kinesthetic information.[42] Thus, it is possible that the specific exercise intervention focusing the deep cervical muscles may rebuild cervical proprioception in persons with forward head posture.

Unexpectedly, there were no significant differences in the static standing balance after the exercise intervention. It is well-known that postural control requires sensory input from the visual, vestibular, somatosensory and cervical proprioception systems.[14, 43] One study found that forward head postures during computer-based work might contribute to some disturbance in the balance of healthy adults[17] whereas another study found that induced forward head posture did not affect postural control.[18] In this study, the change of postural sway in the experimental group seems to be greater than that in the control group, but the difference did not reach statistical significance. Knowingly, the deep cervical muscles providing proprioception which is important for the sensorimotor system.[15, 16] However, the sensorimotor system also comprises other sensory input from the visual, vestibular, and somatosensory subsystems for controlling postural stability. Thus although forward head posture can alter cervical proprioception and disturb balance,[17] it may be compromised by the other sensory systems. On the other hand, it is possible that the exercise may not be sufficient to improve standing balance. A specific balance training may be needed. Also, as we studied in young adults, their balance may be less impaired or affected by forward head posture. Yet, there is no normative data of postural sway using the sway meter for comparison with. Besides, the nonsignificant results may be due to small sample size. As this study is the first study investigating the effectiveness of a specific exercise on static standing balance, it can therefore be challenged to conclude whether static standing balance in those with forward head posture can be improved from the exercise intervention including postural correction, co-contraction of the cervical muscles, and suboccipital muscle stretching. Further research in this area is still required.

There are some limitations to this study. Participants recruited into the study were narrow age range (19-24 years) and university students. This potentially limits the generalizability of the study's results to other populations and in particular to older adults who are susceptible to age-related changes in musculoskeletal and sensorimotor systems. Additionally, the sample size in this study was calculated from one variable (CV angle). This may lead to non-significant results for the other outcomes. Additionally, it is difficult to control whether the participants in the experimental group could perform the exercise program correctly thoughout the study periods, in particular the suboccipital muscle stretching. Although the sway meter is reliable and valid to measure postural sway, forceplates or force platforms are ideal for measuring static standing balance. There was quite a number of the participants who did not complete the exercise program. This study is expected to support existing data and further emphasize the importance of good head and neck posture and a routine specific exercise during daily life activities. However, there remains a need for further research in order to reinforce the effects of a specific exercise intervention in persons with forward head posture. Further research is still requried to confirm the study findings in variety of ages (e.g. middle-aged and older adults) and populations (e.g. persons with neck pain and office workers). Additionally, further research should investigate whether the co-contraction of the cervical muscles can improve balance in those with forward head posture or a specific balance training is needed. The effects of the exercise program during performing functional or specific tasks such as computer typing should also be investigated in persons with forward head posture. Furthermore, sophisticated laboratory tests should be considered in further research to better understand the effects of exercise on balance in persons with forward head posture.

Conclusion

The results of this study suggested that an exercise program including postural correction, co-contraction of the cervical muscles, and suboccipital muscle stretching for 4 weeks was effective in improving the head and cervical posture (CV angle) and joint position sense (cervical rotation) in persons with forward head posture. Improvement in static standing balance was not found. The study emphasizes the importance of a routine specific exercise during daily life activities for university students with forward head posture.

Conflict of interest

No conflict of interest in this study

Acknowledgements

This study was granted by the Faculty of Associated Medical Science, Chiang Mai University. The authors would like to thank Mr. Patipan Saithichai and Miss Kawintra Sittikraipong for their assistance in data collection.

References

[1] Grimmer-Somers K, Milanese S, Louw Q. Measurement of cervical posture in the sagittal Plane. J Manipulative Physiol Ther. 2008; 31(7): 509-17.

[2] Griegel-Morris P, Larson K, Mueller-Klaus K, Oatis CA. Incidence of common postural abnormalities in the cervical, shoulder, and thoracic regions and their association with pain in two age groups of healthy subjects. Phys Ther. 1992; 72(6): 425-31.

[3] Singla D, Veqar Z. Association between forward head, rounded shoulders, and increased thoracic kyphosis: a review of the literature. J Chiropr Med. 2017; 16(3): 220-9.

[4] Wani SK, Subrat S, Ostwal P, Quazi R. Prevalence of anterior head translation in patients with neck pain. Int J Curr Microbiol Appl Sci. 2016; 9(2): 78-83.

[5] Nejati P, Lotfian S, Moezy A, Moezy A, Nejati M. The relationship of forward head posture and rounded shoulders with neck pain in Iranian office workers. Med J Islam Repub Iran. 2014; 28(1): 26-32.

[6] Nejati P, Lotfian S, Moezy A, Nejati M. The study of correlation between forward head posture and neck pain in Iranian office workers. Int J Occup Med Environ Health. 2015; 28(2): 295-303.

[7] Goh JYK, O'Leary S, Chow A, Russell T, McPhail S. The relationship between forward head posture and cervical muscle performance in healthy individuals. J Physiother. 2015. doi: 10.1016/j.physio.2015.03.3247

[8] Mayoux-Benhamou MA, Revel M, Vallee C, Roudier R, Barbet JP, Bargy F. Longus colli has a postural function on cervical curvature. Surg Radiol Anat. 1994; 16(4): 367-71.

[9] Gong W, Kim C, Lee Y. Correlations between cervical lordosis, forward head posture, cervical ROM and the strength and endurance of the deep neck flexor muscles in college students. J Phys Ther Sci. 2012; 24(3): 275-7.

[10] Kendall FP, Kendall ME, Provance PG. Muscles: Testing and Function, with posture and pain. 5th ed. Baltimore: Lippincott Williams and Wilkins; 2005.

[11] Burgess-Limerick R, Plooy A, Ankrum DR. The effect of imposed and self-selected computer monitor height on posture and gaze angle. Clin Biomech (Bristol, Avon). 1998; 13(8): 584-92.

[12] Mousavi-khatir R, Talebian S, Maroufi N, Olyaie G. Effect of static neck flexion in cervical flexion-relaxation phenomenon in healthy males and females. J Bodyw Mov Ther. 2015; 20(2): 235-42.

[13] Shimaa T. Abu El Kasem OMK, Neveen A. Abdel Raoof, Ibrahim M. Moustafa. Effect of forward head posture on sensorimotor integration. Int J Phys Ther. 2017; 4(2): 118-25.

[14] Riemann BL, Lephart SM. The sensorimotor system, part I: the physiologic basis of functional joint stability. J Athl Train. 2002; 37(1): 71-9.

[15] Boyd-Clark LC, Briggs CA, Galea MP. Muscle spindle distribution, morphology, and density in longus colli and multifidus muscles of the cervical spine. Spine J. 2002; 27(7): 694-701.

[16] Liu JX, Thornell LE, Pedrosa-Domellof F. Muscle spindles in the deep muscles of the human neck: a morphological and immunocytochemical study. J Histochem Cytochem. 2003; 51(2): 175-86.

[17] Kang JH, Park RY, Lee SJ, Kim JY, Yoon SR, Jung KI. The effect of the forward head posture on postural balance in long time computer based worker. Ann Rehabil Med. 2012; 36(1): 98-104.

[18] Silva AG, Johnson MI. Does forward head posture affect postural control in human healthy volunteers? Gait Posture. 2013; 38(2): 352-3.

[19] Sheikhhoseini R, Shahrbanian S, Sayyadi P, O'Sullivan K. Effectiveness of therapeutic exercise on forward head posture: a systematic review and meta-analysis. J Manipulative Physiol Ther. 2018; 41(6): 530-9.

[20] Falla D, Jull G, Russell T, Vicenzino B, Hodges P. Effect of neck exercise on sitting posture in patients with chronic neck pain. Phys Ther. 2007; 87(4): 408-17.

[21] Kim BB, Lee JH, Jeong HJ, Cynn HS. Effects of suboccipital release with craniocervical flexion exercise on craniocervical alignment and extrinsic cervical muscle activity in subjects with forward head posture. J Electromyogr Kinesiol. 2016; 30: 31-7.

[22] Camitsis A. The effect of craniocervical flexion exercise on cervical postureand cervical range of motion in asymptomatic participants. Durban: Durban University of Technology; 2015.

[23] Gupta BD, Aggarwal S, Gupta B, Gupta M, Gupta N. Effect of deep cervical flexor training vs. conventional isometric training on forward head posture, pain, neck disability index in dentists suffering from chronic neck pain. J Clin Diagn Res. 2013; 7(10): 2261-4.

[24] Ruivo RM, Pezarat-Correia P, Carita AI. Effects of a resistance and stretching training program on forward head and protracted shoulder posture in adolescents. J Manipulative Physiol Ther. 2017; 40(1): 1-10.

[25] Hickey ER, Rondeau MJ, Corrente JR, Abysalh J, Seymour CJ. Reliability of the cervical range of motion (CROM) device and plumb-line techniques in measuring resting head posture (RHP). J Man Manip Ther. 2000; 8(1): 10-7.

[26] Singla D, Veqar Z, Hussain ME. Photogrammetric assessment of upper body posture using postural angles: a literature review. J Chiropr Med. 2017; 16(2): 131-8.

[27] Van Niekerk S-M, Louw Q, Vaughan C, Grimmer-Somers K, Schreve K. Photographic measurement of upper-body sitting posture of high school students: A reliability and validity study. BMC Musculoskelet Disord. 2008. doi: 10.1186/1471-2474-9-113

[28] Jull G, Bogduk N, Marsland A. The accuracy of manual diagnosis for cervical zygapophysial joint pain syndromes. Med J Aust. 1988; 148(5): 233-6.

[29] Falla D, O'Leary S, Fagan A, Jull G. Recruitment of the deep cervical flexor muscles during a postural-correction exercise performed in sitting. Man Ther. 2007; 12(2): 139-43.

[30] Harman K, Hubley-Kozey CL, Butler H. Effectiveness of an exercise program to improve forward head posture in normal adults: a randomized, controlled 10-week trial. J Man Manip Ther. 2005; 13(3): 163-76.

[31] Lee DY, Nam CW, Sung YB, Kim K, Lee HY. Changes in rounded shoulder posture and forward head posture according to exercise methods. J Phys Ther Sci. 2017; 29(10): 1824-7.

[32] Hazar Z, Karabicak GO, Tiftikci U. Reliability of photographic posture analysis of adolescents. J Phys Ther Sci. 2015; 27(10): 3123-6.

[33] Lau HM, Chiu TT, Lam TH. Measurement of craniovertebral angle with Electronic Head Posture Instrument: Criterion validity. J Rehabil Res Dev. 2010; 47(9): 911-8.

[34] Revel M, Andre-Deshays C, Minguet M. Cervicocephalic kinesthetic sensibility in patients with cervical pain. Arch Phys Med Rehabil. 1991; 72(5): 288-91.

[35] Lord SR, Clark RD, Webster IW. Postural stability and associated physiological factors in a population of aged persons. J Gerontol. 1991; 46(3): 69-76.

[36] Sremakaew M, Jull G, Treleaven J, Barbero M, Falla D, Uthaikhup S. Effects of local treatment with and without sensorimotor and balance exercise in individuals with neck pain: protocol for a randomized controlled trial. BMC Musculoskelet Disord. 2018; 19(1): 48-59.

[37] Chiu TT, Ku WY, Lee MH, Sum WK, Wan MP, Wong CY, et al. A study on the prevalence of and risk factors for neck pain among university academic staff in Hong Kong. J Occup Rehabil. 2002; 12(2): 77-91.

[38] Yip CH, Chiu TT, Poon AT. The relationship between head posture and severity and disability of patients with neck pain. Man Ther. 2008; 13(2): 148-54.

[39] Petty NJ, Moore AP. Neuromusculoskeletal Examination and Assessment. 2nd Edition. New York: Chuchill Livingstone; 2001.

[40] Meadows J, Armijo-Olivo SL, Magee DJ. Chapter 3 - Cervical Spine. In: Magee DJ, Zachazewski JE, Quillen WS, Manske RC, editors. Pathology and Intervention in Musculoskeletal Rehabilitation 2th Edition. St. Louis: W.B. Saunders; 2016.

[41] Yong M-S, Lee H-Y, Lee M-Y. Correlation between head posture and proprioceptive function in the cervical region. J Phys Ther Sci. 2016; 28(3): 857-60.

[42] Kulkarni V, Chandy MJ, Babu KS. Quantitative study of muscle spindles in suboccipital muscles of human foetuses. Neurol India. 2001; 49(4): 355-9.

[43] Shumway-Cook A, Woollacott MH. Motor control : theory and practical applications. 2nd Edition. Philadelphia: Lippincott Williams & Wilkins; 2001.