The Effects of Modified Scapular Exercises in Participants with Neck, Scapular and Shoulder Pain: A randomized trial

ผลของการออกกำลังกายกล้ามเนื้อสะบักแบบประยุกต์ในผู้ที่มีอาการปวดคอ สะบัก และไหล่: การศึกษาแบบสุ่ม

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ABSTRACT

Background: Prolonged smartphone and computer use results in an imbalance of the neck, scapular, and shoulder muscles leading to pain and weakness. However, neck and shoulder exercises are varied and not specific to problems.

Objective: To evaluate the effects of modified scapular exercise in participants with neck, scapula and shoulder pain.

Methods: Forty-six participants were randomly allocated to the intervention group and the control group. The allocation sequence was concealed from the researcher enrolling and assessing participants. The intervention group received modified scapular exercise 3 times per week for 6 weeks, and the control group received stretching exercise, 2 times per day for 6 weeks. Neck disability index, pain scale, and muscle contraction force of the upper trapezius, rhomboid, and serratus anterior muscles were evaluated in both groups before and after the intervention.

Results: The results showed the statistical significance of the neck disability index (NDI) ($p<0.01$) and visual analog scale (VAS) ($p<0.001$) before and after the program but not a significant difference between the groups. As compared between groups, significant differences were found in muscle contraction force of right upper trapezius, rhomboid, and serratus anterior muscle ($p<0.05$).

Conclusion: The modified scapular exercise could decrease neck disability index score, pain and improve the strength of the neck, scapular, and shoulder muscles compared with those of stretching exercises.

Keywords: Neck and shoulder pain, Forward head posture, Modified scapular exercise, Smartphone use

บทคัดย่อ

ที่มาและความสำคัญ: การใช้สมาร์ทโฟนและคอมพิวเตอร์เป็นเวลานานส่งผลให้กล้ามเนื้อคอ สะบัก และไหล่ทำงานไม่สมดุล ก่อให้เกิดอาการปวดและนำไปสู่กล้ามเนื้ออ่อนแรง อย่างไรก็ตาม การออกกำลังกายคอและไหล่มีความหลากหลายและไม่เฉพาะเจาะจงกับปัญหา

วัตถุประสงค์: เพื่อประเมินประสิทธิภาพของการออกกำลังกายกล้ามเนื้อสะบักแบบประยุกต์ในผู้ที่มีอาการปวดคอ สะบัก และไหล่

วิธีการวิจัย: ผู้เข้าร่วมการศึกษาจำนวน 46 คน ถูกสุ่มเป็นกลุ่มทดลองและกลุ่มควบคุมโดยวิธีการแบ่งกลุ่มจะได้รับการปกปิดจากผู้วิจัยและผู้ประเมิน กลุ่มทดลองจะ

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ได้รับการออกกำลังกายกล้ามเนื้อสะบักแบบประยุกต์ 3 ครั้งต่อสัปดาห์ เป็นเวลา 6 สัปดาห์ และกลุ่มควบคุมได้รับการยืดเหยียดกล้ามเนื้อ 2 ครั้งต่อวัน เป็นเวลา 6 สัปดาห์ ทั้งสองกลุ่มจะได้รับการประเมินดัชนีความบกพร่องความสามารถของคอ ระดับอาการปวด และแรงหดตัวของกล้ามเนื้อ upper trapezius, rhomboid และ serratus anterior ก่อนและหลังเข้าร่วมการฝึก

ผลการวิจัย: ผลการศึกษาพบความแตกต่างอย่างมีนัยสำคัญทางสถิติของค่าดัชนีความบกพร่องของคอ ($p<0.01$) ระดับอาการปวด ($p<0.001$) ก่อนและหลังการฝึก แต่ไม่พบความแตกต่างระหว่างกลุ่มเมื่อเปรียบเทียบค่ากลางของแรงในการหดตัวของกล้ามเนื้อ upper trapezius, rhomboid และ serratus anterior ทางด้านขวา พบว่ามีความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างกลุ่ม ($p<0.05$)

สรุปผล: การออกกำลังกายกล้ามเนื้อสะบักแบบประยุกต์สามารถลดความบกพร่องของคอ อาการปวด และเพิ่มความแข็งแรงกล้ามเนื้อบริเวณคอสะบักและไหล่เมื่อเปรียบเทียบกับการยืดเหยียดกล้ามเนื้อ

คำสำคัญ: ปวดคอและไหล่ คอยื่น การออกกำลังกล้ามเนื้อสะบักแบบประยุกต์ การใช้มือถือ

Introduction

Neck/shoulder pain is a condition associated with the overuse of electronic devices, leading to repetitive injury at the neck, upper back, and shoulder regions.[1] It is commonly found in smartphone and computer users at a young age.[2–4] The posture when using these devices requires the users to look forward, downward position, hold their arms out in front resulting in fatigue, and injure the neck, upper back, and shoulder regions, respectively.[5–8] In addition, the musculoskeletal pain in users depends on the time-used, type, and size of the smartphone.[6,7,9] Previous studies found that using a smartphone device for 10-30 minutes leads to muscle fatigue, especially in the upper trapezius and cervical erector spinae muscles.[10,11] Daily uses of mobile handheld device longer than two hours was associated with pain in the left shoulder (OR 2.06, 95% CI 1.00-4.24(, the right shoulder (OR 2.55, 95% CI 1.25-5.21 (and the neck (OR 2.72, 95% CI 1.24-5.96(and the pain was associated with neck flexion posture.[5] Every 15 degrees of cervical flexion can increase pressure to the spine. Neck flexion of 15-60 degrees during smartphone use can produce a load of 5-27 kilograms on the cervical spine.[12] Moreover, forward head posture can affect the posterior and anterior neck, shoulder muscles, scapular position, and kinematics.[13] This data indicates that an increased range of cervical flexion and sustain in a period of time would increase the risk of the degenerative cervical spine. Furthermore, prolonged smartphone and computer use in this position results in abnormal muscle work. Using an electronic device with forwarding head posture causes greater pain in the upper trapezius muscle and induces increased upper extremity muscle activity.[14,15] Exercises program including stretching, strengthening, and endurance exercise is an effective treatment for individuals who have neck, scapular, and shoulder pain.[16–18] Strengthening and endurance exercises are effective in patients with chronic neck pain.[16] Dynamic exercise training can improve muscle strength and decrease pain compared with other types of exercise.[16,19] Scapular stabilization exercise is one of the exercise programs used in

the scapulothoracic joint problem. This exercise focuses on the trapezius, rhomboid, and posterior neck muscles. The exercise program included stretching and exercise using an elastic band composed of the overhead press, chest press, horizontal pull apart, retract scapula plus external rotation, and resisted shoulder extensions. After 4 weeks of exercise program, pain and muscle function decreased in all participants.[20] Resistive exercises using a dumbbell in supine, side-lying, and prone position for 10 weeks could improve muscle strength in the upper trapezius more than other parts of this muscle.[20] Consequently, it can improve muscle strength of trapezius and serratus anterior muscles and decrease pain in the neck and shoulder regions. Additionally, the appropriate alignment of the scapula could decrease movement disability of the scapulothoracic joint.[20,21] However, the exercise programs for neck and shoulder pain are varied and not specific to upper trapezius, rhomboid, and serratus anterior muscles in smartphone and computer users. Therefore, we are interested in the modified exercise program to solve this problem by a modified scapular exercise program using muscle function and mobility technique. This exercise affects more than one direction and facilitates multiple muscle works during exercise.[22] This study aimed to evaluate the effects of modified scapular exercise on neck disability index score, pain score, and contraction force of upper trapezius, rhomboid, and serratus anterior muscles. We hypothesized that the neck disability index (NDI) score, pain score, and muscle strength of upper trapezius, rhomboid, and serratus anterior were better in the intervention group.

Methods

Study design

A prospective, randomized controlled trial with concealed allocation was conducted in the Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University, Thailand. The present study was approved by the Prince of Songkla University Human Research Ethics Committee (REC 59-380-30-2) and was registered at the Thai Clinical Trials Registry (TCTR20170313001) at the beginning of the study. The sample size calculation compares the mean between two independent groups was calculated by n4Studies application.[23] The calculation using the NDI score that was reported from the previous study.[21] The total number of participants per group with estimating 20% dropout was 23 per group.

Participants

Participants were recruited by poster advertisement posted on the faculty board and internet advertisement on Facebook. The participants were the electronic device users with neck, upper back, and shoulder pain at least one month, and volunteers contacted the researcher team before enrolling in the study. The inclusion criteria were young adults aged between 18-32 years, daily smartphone and/or computer use of at least five hours per day, having experience with neck, upper back, and shoulder pain at least one month before enrolling in this study, having muscle tenderness and trigger point at least one

muscle of upper trapezius, rhomboid, and serratus anterior muscles. Participants were excluded from the study if they had any of the following conditions; any history of traumatic and neuromuscular disorder at the neck region received another treatment before the study. All participants who met the inclusion criteria were invited to participate in this study.

Procedures

After signing the written consent form of the study, the participant was asked to complete the questionnaire regarding the musculoskeletal symptom among the smartphone user. This questionnaire consisted of 3 sections: general characteristic data, smartphone/computer use data, and musculoskeletal pain data. A baseline measurement was performed before the training program. The participants were then randomly divided into two groups by the primary researcher using randomized block allocation to achieve an approximate balance of the intervention group sizes. The intervention group received modified scapular exercise by the second researcher, while the control group received stretching exercise alone. The outcome was measured before and after 6 weeks of the program.

Training program

The modified scapular exercise consisted of 9 exercises (Figure 1)developed from previous studies.[17,21,24,25] Each exercise was performed 3 sets of 10 repetitions 3 times per week for 6 weeks. The stretching exercise consisted of 10 repetitions of the wrist and hand, elbow extensor, pectoralis major, upper trapezius, rhomboid, anterior, posterior neck stretching and maintained each position for 10 seconds, 2 times per day for 6 weeks (Figure 2). All participants in both groups were given the opportunity to instruct self-care management and education regarding proper body posture. This study used the following outcome measures; pain intensity was measured by using a visual analog scale (VAS) with horizontal line 10 cm length, scales from 0-10, where a score of 0 indicated no pain and a score of 10 indicated worst pain. The participant marked on the line depending on pain and individual feeling. A neck disability was measured by using self-reported levels of neck pain and disability using a modified Thai version of neck disability index (NDI-TH), and the reliability of this test was high (Cronbach alpha = 0.85).[26] This questionnaire consisted of 10 sections designed to assess pain intensity, headache, concentration, sleeping, and activities of daily living including work, personal care, lifting, reading, driving and recreation. For each section, the score ranges from 0 representing the highest level of function to 5, the lowest level of function. The total score was the sum of the 10 individual section scores. Muscle contraction force was selected from 3 muscles; upper trapezius, rhomboid, and serratus anterior muscles measured by baseline digital gauge functions (Serial No.12-0387GAGE made in the USA) 3 times per muscle and recorded the best value for analysis. The outcomes were assessed before the training program and post 6 weeks of the program.

Figure 1 The modified scapular exercises

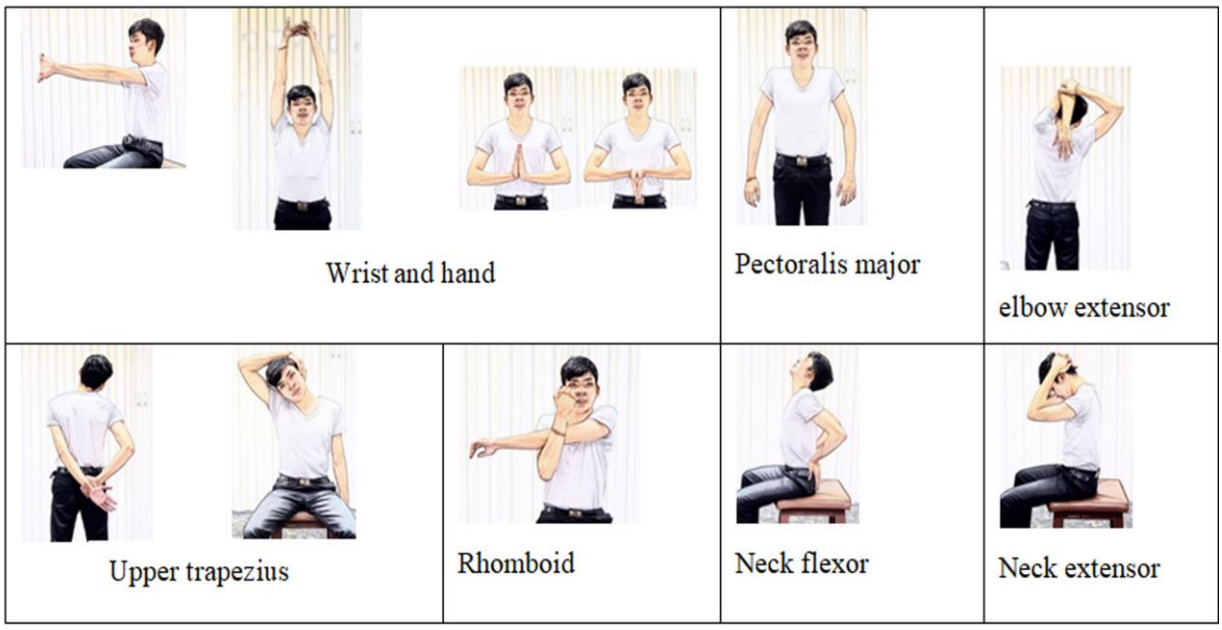

Figure 2 The stretching exercises

Statistical analysis

The data was entered using the Epidata for questionnaire and outcome variables. The distribution of pain within each of the 6 body parts (left/right neck, left/right shoulder, and left/right upper back) was a dichotomous scale (yes/no). Data were analyzed with R package version 3.5.3. General characteristics of the participants were presented as mean (standard deviation), median (interquartile range) and percentage. The characteristics between control and intervention groups were compared using independent sample t-tests for normally distributed variables, Wilcoxon rank-sum tests for continuous variables that were not normally distributed, and the Chi-square or Fisher's exact tests for discrete variables. We compared the VAS score, NDI score, and muscle contraction force between the control and intervention groups using a t-test and Wilcoxon rank-sum test. The data before and after programs within a group were compared during paired t-test and Wilcoxon test. The significance level was set at $p < 0.05$.

Results

A total of 46 participants met the inclusion criteria and were randomly allocated into a control group and intervention group. One participant in the control group had to leave the study due to a discontinued exercise program. The forty-five participants have completed the measurement and intervention period (Figure 3).

The general characteristics and electronic device use of participants were not statistically different between the control and intervention groups (Table 1). The pain position in the body part of the questionnaire was highest at the shoulder part in both groups, but not significantly different between the control and intervention groups after 6 weeks (Table 2). The VAS was decreased 4.6-3.3 cm in the control group, 5.3-2.23 cm in the intervention group. The

NDI score was decreased 6-4 scores in the control group and 6-3.5 scores in the intervention group. A significant difference was observed before and after the program, but not significant between the control and intervention groups. A significant difference was observed for muscle contraction force at the right upper trapezius and serratus anterior in the intervention group before and after the program. Significant differences between groups were observed at the upper trapezius, rhomboid, and serratus anterior muscles (Table 3).

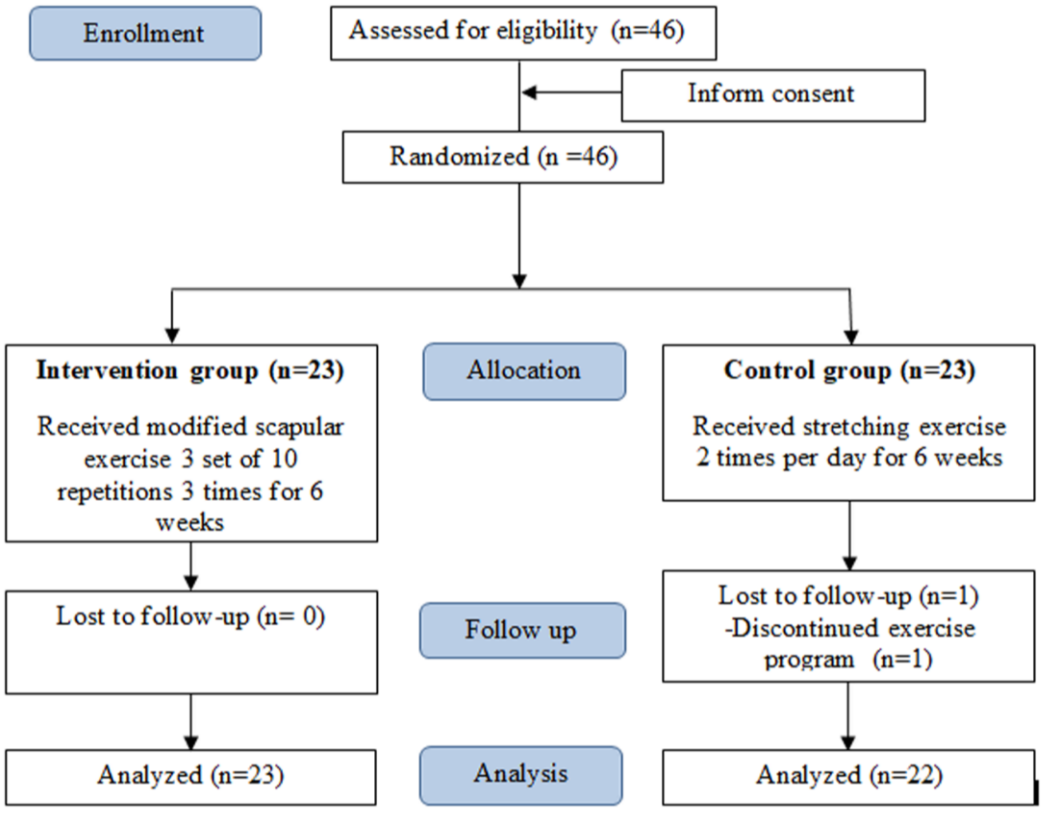

Figure 3 The flow chart of the study

Table 1 General characteristic of the participants in the control and intervention group.

Characteristics	Control (n=23)	Intervention (n=22)
[b]Age (years) median(IQR)	20 (20,21.5)	20 (20,22)
[d]Sex (%)		
Male	11 (47.8)	6 (27.3)
Female	12 (52.2)	16 (72.7)
[b]Body mass index (kg/m^2)		
median(IQR)	21.6 (19.7,23.7)	22.7 (20.7,24.4)
[d]Underlying of disease (%)		
No	21 (91.3)	21 (95.5)
Yes	2 (8.7)	1 (4.5)
[d]Smoking behavior (%)		
Never smoker	20 (87)	19 (86.4)
Current smoker	3 (13)	3 (13.6)
[c]Drinking behavior (%)		
Never drinker	15 (65.2)	17 (77.3)
Current drinker	8 (34.8)	5 (22.7)
[c]Exercise behavior (%)		
Never exercise	6 (26.1)	6 (27.3)
Currently exercise	17 (73.9)	16 (72.7)
[d]Hand dominance (%)		
Left	4 (17.4)	1 (4.5)
Right	19 (82.6)	21 (95.5)
[d]Hand to use smartphone (%)		
Left	1 (4.3)	1 (4.5)
Right	8 (34.8)	9 (40.9)
Both hand	14 (60.9)	12 (54.5)
[d] Using position (%)		
sitting	15 (65.2)	14 (63.6)
standing	1 (4.3)	1 (4.5)
sit and stand	7 (30.4)	7 (31.8)
[b]Duration of electronic device use (hours/day)		
median(IQR)	8 (6,9)	7 (6,8)

Note: [a]Wilcoxon signed rank test, [b] Mann-Withey -U test, [c]Chisq.test, [d] Fisher's exact test, n: number, IQR: interquartile

Table 2 characteristics of pain position in the body part

Pain region	Control, n (%)	Intervention n (%)
[c]Left neck regions		
No	16 (69.6)	11 (50)
Yes	7 (30.4)	11(50)
[c]Right neck regions		
No	18 (78.3)	15 (68.2)
Yes	5 (21.7)	7 (31.8)
[d]Left upper back regions		
No	20 (87)	18 (81.8)
Yes	3 (13)	4 (18.2)
[d]Right upper back regions		
No	22 (95.7)	19 (86.4)
Yes	1 (4.3)	3 (13.6)
[d]Left shoulder regions		
No	5 (21.7)	4 (18.2)
Yes	18 (78.3)	18 (81.8)
[d]Right shoulder regions		
No	2 (8.7)	3 (13.6)
Yes	21 (91.3)	19 (86.4)

Note: [c]Chisquare .test, [d] Fisher's exact test, n: number

Discussion

Modified scapular exercise and stretching exercise could decrease pain and neck disability after 6 weeks of the exercise program. It is similar to Karlsson and collagenous in 2014 that compared strengthening exercise program with a stretching program for 6 months. The result showed NDI was decreased by2 scores but not significantly different between group.[27] In addition, the knowledge about maintaining a suitable posture in daily life, sitting/standing posture, smartphone/computer use, and regular exercise could decrease pain intensity and improved physical activity.[28] The effect of exercise and stretching on pain could be described by two mechanisms. In the group received exercise, the muscles contract and relax against a certain amount of force, resulting in vasodilation within the muscle due to stimulation of the sympathetic system. During exercise, the rate of blood flow to the muscles increases by 8 to 10 times, causing the muscles to loosen and reduce the initial pain. When exercising for longer time, there will be secretion of analgesics from periaqueductal gray (PAG) matter to inhibit pain at presynaptic junction.[29,30] While stretching, the nerves near the

Table 3 Comparisons the medians of visual analog score (VAS), neck disability index score (NDI) and muscle contraction force before and after program in control and intervention groups

Measure	Within groups[a]						Between groups[b]
	Control (n=23) median (IQR)			Intervention (n=22) median (IQR)			
	before	after	p-value	before	after	p-value	
Pain and disability							
VAS	4.6 (3.4,6.3)	3.3(1.75,5)	**<0.001**	5.3 (3.35,6.08)	2.35 (1.43,2.85)	**<0.001**	0.059
NDI	6 (3,7)	4 (2,4.5)	**0.005**	6(4.25,9)	3.5 (1.25,6)	**0.009**	0.106
Muscle contraction force (kg)							
Upper trapezius							
Left	13 (10, 16)	13 (10, 15)	0.081	12.5 (10.25,14.75)	2.5 (10.25,14.75)	0.052	**0.015**
Right	13 (11.5,15)	13 (11.5, 14)	0.856	12 (11,14)	14 (10.25,17.5)	**0.012**	**0.006**
Rhomboid							
Left	11 (8, 15.5)	10(8.5,13)	0.954	10 (7,11.75)	9.5 (7.25,12)	0.403	0.070
Right	11 (9, 14)	9(8,13)	0.989	9.5 (7.25,11)	10 (8,12)	0.272	**0.036**
Serratus anterior							
Left	8 (7, 10)	8 (6.5, 10)	0.941	7 (6,9.75)	7.5 (5,10)	0.105	**0.037**
Right	9 (7, 11)	9 (7, 10)	0.777	7 (6,8)	7 (6,9.75)	**0.013**	**0.013**

Note: [a]Wilcoxon signed rank test, [b] Mann-Withey -U test, VAS: visual analog score, IQR: interquartile range, NDI: neck disability index, kg: kilogram, n:number

Ends of the muscle fibers, called Golgi tendon organ and pressure sensing receptors, respond to stretch movement resulting in the inhibition of the nerve signals leading to reducing contractions in the tendon. The muscles are loosened in the right length, which can cause the muscles to loosen/relax and can reduce pain perception.[31] However, the participants in this study were university students. The pain intensity did not disturb to daily activity leading to a little change in VAS and NDI score after the program. Further study should be conducted in the participants with moderate to severe pain and neck disability scores. The modified scapular exercise could improve the strength of the upper trapezius, rhomboid and serratus anterior. Upper trapezius and serratus anterior muscles are important to rehabilitation in a participant with neck/shoulder pain caused by an abnormal posture.[13,32] Since upper trapezius and serratus anterior are the important scapular stabilizers, the proper position and improvement of these muscles' length-tension are essential.[13,32] The exercise program in this study was a stabilization exercise of the scapular.

It could improve the strength of the stabilizing muscles of the scapula. However, the dominant hand might affect muscle strength. The previous studies found that the posture, when used smartphone/computer, required the user to look forward, downward position and held their arms out in front of them, resulting in muscle imbalance[2,11,33] and affected respiratory muscle work.[34,35] Modified scapular exercise with breathing control might improve postural control and stretch the muscles in front of the thorax. This exercise program could facilitate upper trapezius and serratus anterior contraction to resist gravity or body weight. The benefit of this exercise program could improve the normal alignment of scapula and forward head posture. A previous study found 120 degrees of shoulder flexion during exercise could stimulate serratus anterior work.[36] It was similar to this study that quadruped position with arm press could recruit serratus anterior muscle contraction but not for the improvement of the rhomboid muscle strength. The scapular retraction exercise can improve rhomboid muscle contraction in a prone position with 90 degrees of the shoulder and elbow flexion.[37] According to our exercise program, it could improve the strength of the upper trapezius and serratus anterior rather than that of rhomboid muscle. Increased muscle strength caused by neural adaptation increased nerve impulse to the muscle resulting in greater motor unit recruitment and higher muscle contraction[38]. Previous studies on the shoulder and neck muscle exercises focused on pain rather than the strength of the muscles.[17,21,39] The result of this study aimed to evaluate scapular exercise on pain and muscle strength. We expected that the benefit of this program could be used to prevent neck, scapular and shoulder pain in smartphone and computer user. However, mobile users with neck and shoulder pain should focus on scapular stabilization exercise for prevent musculoskeletal problems in the future.

Conclusion

Modified scapular exercise for 6 weeks could decrease pain, neck disability index score, increase the strength of the upper trapezius, rhomboid, and serratus anterior muscles.

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