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CLINICAL STUDY

Change of pectoralis minor length, and acromial distance, during scapular retraction at 60° shoulder elevation

Nitaya Viriyatharakij, PT, PhD*, Chatchada Chinkulprasert, PT, PhD, Navarat Rakthim, PT, Jetjaree Patumrat, PT, Butsarin Ketruang, PT

Department of Physical Therapy, Faculty of Health Science, Srinakharinwirot University, Thailand

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Posture;
Active stretch;
Pectoralis minor;
Acromial distance

Summary As the pectoralis minor muscle is inserted into the coracoid process, an improper length of this muscle would affect scapular and shoulder motions. Therefore, this study is proposed to assess the effects on pectoralis minor's length and acromial distance after active scapular retraction in scaption at 60° elevation. Sixty right-hand-dominant participants (11 males, 49 females) were randomized into an intervention group and a control group. The intervention group performed pectoralis minor muscle stretching by active scapular retraction, while the control group were asked to sit in an upright position. The result shows that, the mean lengths of pectoralis minor in the intervention group were significantly increased when compared with those of the control group ($p = 0.004$ and $p = 0.014$ respectively). Simultaneously, the reduction in acromial distance of this intervention group was substantially greater than the control group's ($p < 0.001$ and $p = 0.001$ respectively). However, it should be noted that the results reported only relate to the period immediately following muscle stretching.

Introduction

Postures that cause shoulder problems include forward head posture, thoracic kyphosis, and rounded shoulder posture (RSP)/anterior shoulder position (Kendall et al., 2005; Thigpen et al., 2010). RSP occurs when the position of the acromion process has abnormally shifted forward with the scapula in protraction, downward rotation, and anterior tilt (Borstad, 2008), causing the pectoralis minor muscle (PMi)'s function to change and shorten (Kendall et al., 2005). The PMi is the only muscle of the scapulothracic joint that is situated at the front of the shoulder joint. It has four insertions starting from the third, fourth, and fifth rib, continuing diagonally upward to the coracoid process (CP). The length of the PMi muscle is related to RSP (Wong et al., 2010). It also affects scapular movements and

* Corresponding author.
E-mail address: nitayav@g.swu.ac.th (N. Viriyatharakij).

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elevation (Borstad, 2008; Borstad and Ludewig, 2005) and is related to the pathology of the shoulder joint (Ludewig and Reynolds, 2009; Tate et al., 2009). Clinical measurement of the PMi can be performed in two ways:

1) Measuring by referencing the anatomy of the PMi. This is done by measuring the distance between the CP and the fourth costosternal (Borstad, 2006; Borstad and Ludewig, 2005) or sternal notch (Nitaya et al., 2015). This method is adapted from Borstad's (2006) method to acquire the pectoralis minor index.
2) Measuring acromial distance (AD) that is the distance from the acromial angle (AA) to the bed or wall. This method is able to produce intraclass correlation (ICC) with reliability ranging from good to excellent. Measurement via this method can be done while lying face up (Lewis and Valentine, 2007) or while standing straight (Struyf et al., 2009).

Stretching the PMi is a method used to correct abnormal posture or shoulder impingement (Kendall et al., 2005; Kuhn, 2009; Struyf et al., 2013). This consists of stretching with or without assistance (Borstad and Ludewig, 2006; Kuhn, 2009). The effectiveness of such stretching depends on the duration, stretching position, and method. The appropriate duration for stretching is around 20–30 s, because muscle relaxation occurs during the first 20 s of stretching (Knudson, 2006). As for the stretching position and method, they must be specific to the muscle. According to previous studies, stretching the PMi by performing active scapular retraction with 60° flexion can increase the length of the PMi by an average of 1.99 mm (95% CI 1.27, 2.72) (Nitaya et al., 2015). Due to the alignment of the scapular on the chest, muscle stretching in the scaption position—the position with arm elevation at 30–45° between the scapular and the frontal plane—has three benefits:

1) Causing the highest point of the greater tubercle to be in the subacromial space with width greater than other plane of shoulder abductions.
2) It reflects the working of the supraspinatus muscle (Neumann, 2002).
3) It has a significant effect on the length of the PMi. A study using a cadaver has shown that shoulder abduction done via scaption has better results in increasing muscle length than via flexion (Muraki et al., 2009).

Methods

The participants consisted of 60 volunteers (aged 18–50 years old) who are right-handed or mainly use the right hand for daily activities. Eligible participants had no history of a broken clavicle, scapula, or humerus; surgery around the upper extremities or neck area; scoliosis; cerebral or spinal nervous system abnormalities; cardiovascular system abnormalities; or signs of arm, shoulder, or elbow pains during the study period (Table 1).

The participants were notified of the research procedures and went through an informed consent process. They were systematically randomised into an intervention group and a control group, with 30 participants each. This study was authorised by the Human Research Ethics committee of the Health Science Faculty of Srinakharinwirot University (HSPT 2014-013).

Markings were made on participants at the AA and sternoclavicular joint (SC). Measurement of the PMi (Fig. 1) was done by lining a long paper strip from the SC to the CP and then measuring it with a Vernier caliper with precision of ±0.03 mm. Measurement of the AD while sitting could be done by using an L-square ruler with water level to measure the length from the AA at the point perpendicular to the wall by adapting Struyf et al.'s (2009) method (Fig. 2). The participants had a digital inclinometer, with precision of ±0.10°, attached to their arm to measure the angle while performing shoulder abduction at 60° by referencing the line between the AA and the lateral epicondyle. To measure the length of the PMi and AD, the participants were placed in a sitting straight posture according to the postural chart, with the femur paralleling the chair, knees bent at 90°, and both arms lying beside the body. Errors were controlled by training the researchers in palpating the bone location, marking, and measuring. All researchers adhered to the measurement procedure throughout the study. The test-retest reliability of the PMi length measurement had an ICC 3,1 = 0.995 (95% CI 0.998, 0.999), while the measurement for AD had an ICC3,1 = 0.993 (95% CI 0.983, 0.998).

The research steps and procedures of the intervention group and control group are shown in Flowchart 1. After the

Table 1 Characteristics of volunteers (N = 60).

Characteristic	Control (N = 30)			Intervention (N = 30)			p-value
	x̄	SD	Min–max	x̄	SD	Min–max	
Age (yrs.)	24.00	6.98	18–50	24.17	8.12	18–48	0.93
Weight (kg.)	56.40	10.38	40–85	55.85	8.22	40–70	0.82
Height (cm.)	161.07	6.89	152–175	162.63	9.38	145–185	0.46
BMI (kg/m^2)	21.66	2.88	16.02–26.35	21.12	2.65	17.09–31.22	0.48
PMi resting length (mm.)	116.09	9.25	99.63–141.48	113.17	9.73	90.60–133.28	0.24
AD at resting (cm.)	7.17	1.48	4.55–10.75	7.38	1.59	4.45–11.15	0.59

PMi = Pectoralis minor; AD = Acromial distance.

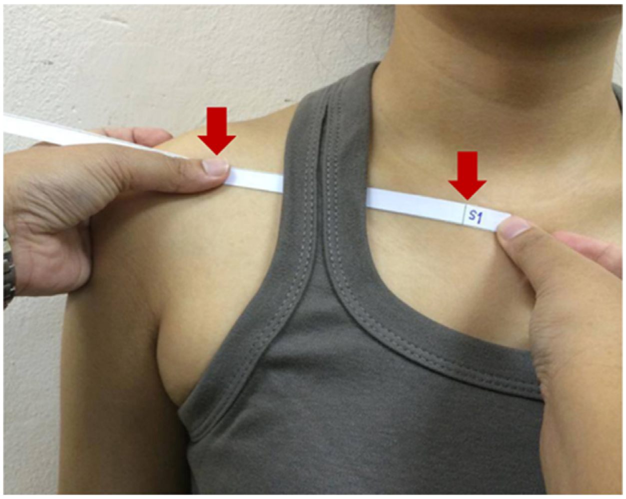


Figure 1 Shows the measurement of Pectoralis minor (PMi) length by marking landmarks on a paper strip at the sternoclavicular joint and coracoid process. The distance between 2 landmarks is then measured using a Vernier caliper and recorded in millimeters.

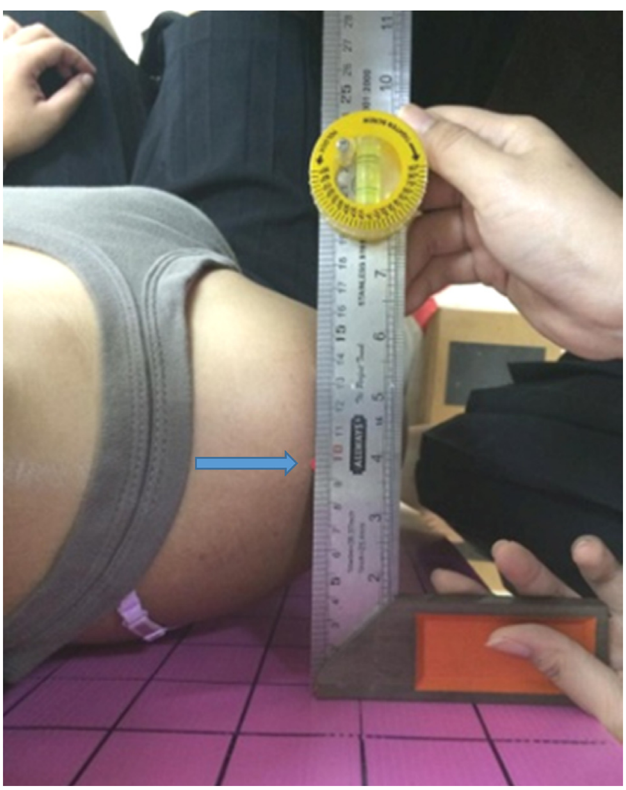


Figure 2 Shows the measurement of Acromial distance (AD) when a participant is sitting. The distance was calculated from posterior aspect of acromion process to the postural chart using a standard L-square ruler with water level.

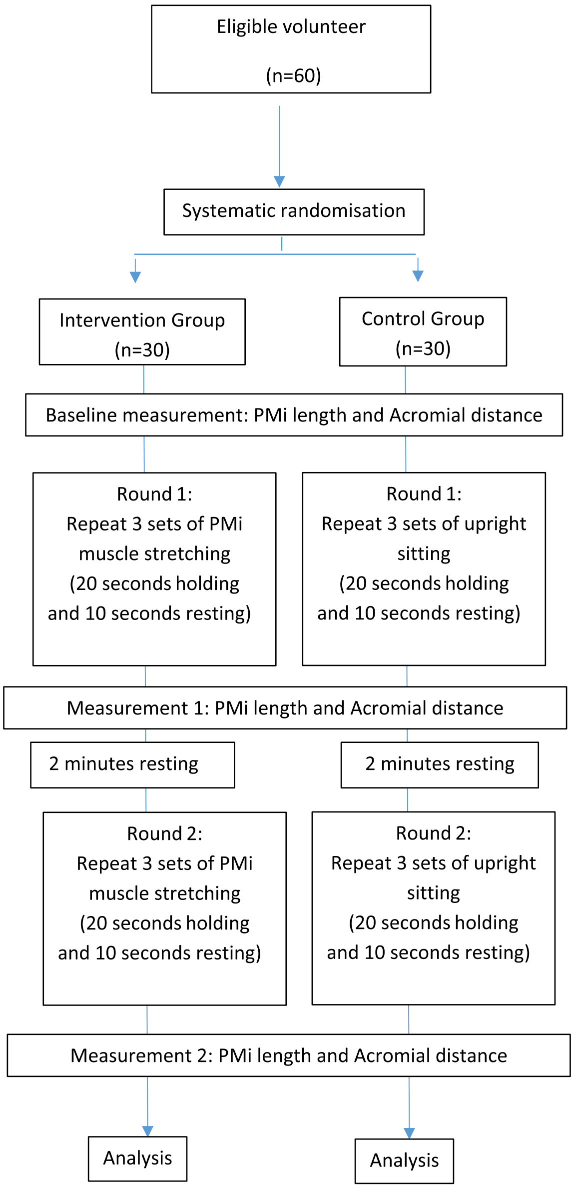
randomisation process, participants in the control group were placed in the sitting straight posture, which involves sitting with the body straight, facing forward, and placing both arms leisurely beside the body for 20 s and then resting for 10 s. This was repeated three times, totaling 90 s for one round and then resting for 2 min before continuing for one more round. In the intervention group, the participants performed shoulder abduction at 60° along with bending the elbow while the forearm was placed against a desk (Fig. 3) to ensure that the arm is in scaption 35° from the frontal plane. Stretching of the PMi was performed by having the participants perform active scapular retraction, which involves pulling both scapulae towards each other as much as possible, staying in that position for 20 s, and then resting for 10 s. This was repeated three times for a total of 90 s for one round. No signs of pain should emerge while performing the active scapular retraction process. The participants rested for 2 min in the sitting straight posture with both arms relaxed at the side before continuing the muscle stretching for another round. This was adapted from the same stretching method as for shoulder flexion (Nitaya et al., 2015).

The analysis was done by making a before/after comparison of the length of the PMi and AD values via repeated measure ANOVA. The standard error of measurement (SEM) was calculated with the equation $SEM = SD \times \sqrt{(1\text{-}ICC)}$, while the minimum detectable change at the 95% confidence level was $MDC_{95} = SEM \times 1.96 \times 2$ (Weir, 2005).

Results

The study results showed significant statistical differences for both the mean length of the PMi and the mean value of the AD after active scapular retraction in the scaption position with a 60-degree elevation angle for the intervention group and sitting straight for the control group. The differences in the mean length of the PMi between both

Figure 3 Shows active scapular retraction in Scapular Plane Elevation (Scaption) at 60-degree elevation. Both elbows are placing against 2 desks with an inclinometer wrapped around right arm.



Flowchart 1 Process of the study.

Table 2 Average pectoralis minor (PMi) length and acromial distance (AD) in control and intervention groups.

PMi length (mm.)	Control		Intervention		p-value
	$\bar{x}$	95% CI	$\bar{x}$	95% CI	
1st Measurement	115.53	114.91, 116.15	116.85	116.23, 117.47	0.004*[a]
2nd Measurement	115.83	115.12, 116.54	117.11	116.40, 117.82	0.014*[a]
AD (cm.)					
1st Measurement	7.19	7.00, 7.38	6.69	6.50, 6.88	$<$0.001*[b]
2nd Measurement	7.23	6.99, 7.47	6.62	6.42, 6.90	0.001*[b]

* = $p < 0.05$.
[a] Average PMi resting length = 114.63 was adjusted as covariate.
[b] Average AD at resting = 7.27 was adjusted as covariate.

Table 3 Change of pectoralis minor (PMi) length and acromial distance (AD) at 2nd measurement.

	Mean change	95% CI	SEM[a]	MDC[b]
PMi length (mm.)				
Control	1.16	0.46, 1.87	0.58	1.59
Intervention	2.51	1.81, 3.22		
AD (cm.)				
Control	−0.04	0.20, −0.28	0.13	0.36
Intervention	−0.62	−0.38, −0.85		

[a] SEM = standard error of mean as calculated from SD × (1-ICC).
[b] MDC_{95} = minimal detectable change with 95% confidence bounds calculated from SEM × 1.96 × 2.

groups for both times were $p = 0.004$ and $p = 0.014$, respectively, whereas the differences in the mean value of the AD were $p < 0.001$ and $p = 0.001$, respectively (Table 2). Measurement of the PMi's length showed an SEM of 0.58 mm and MDC_{95} of 1.59 mm, whereas the AD's measurement showed an SEM of 0.13 cm and MDC_{95} of 0.36 cm (Table 3).

Discussion

The changes in the PMi's length and the AD after active scapular retraction in scaption at a 60-degree angle were greater than MDC_{95}, which reflects the efficiency of this research's PMi stretching method. The result from this stretching is thought to involve reciprocal inhibition. Because performing active scapular retraction in scaption causes upward rotation (around the sagittal axis), posterior tilting (around the frontal axis), and external rotation (around the vertical axis) of the scapula, leading to the posterior shift of the CP and sending of a neural signal to suppress the stimulation of the motor neuron of the PMi, it induces the muscle to relax, which results in its increase in length. This result complies with the study from a cadaver by Muraki et al. (2009) which showed that while either performing arm elevation at 60–150° in scaption or while performing retraction with arm elevation at 0–30°, the length of the PMi would statistically significantly increase ($p < 0.01$).

The position of sitting straight against the wall as well as the postural chart used show great capability in controlling deviation throughout the research process, which can be seen from the SEM of 0.58 in this session's PMi measurement, which decreased from 1.69 mm from a previous study session (Nitaya et al., 2015). The posture of the thoracic vertebrae is another factor that affects the shift of the scapula to a posterior tilt, external rotation, and retraction (Kebaetse et al., 1999). This complies with the result from the control group, where the PMi length changed and the AD decreased when in a sitting straight position. Nevertheless, these changes are less than the MDC_{95} of this study.

The limitations of this study are due to the fact that measuring of the AD is suitable for anteroposterior direction, whereas real movement happens in many directions. The method of measuring PMi length by measuring the distance from the SC to the CP can be considered an indirect method, where the measured value is the closest value to the PMi length ($r = 0.48$, $p < 0.05$), with a statistically significant difference ($p = 0.0037$) between a long and short length of the PMi (Borstad, 2006). This is also an advantage, as accurate measurement of bony prominence from an anatomical position can be put to practical use. Finally, the effect of self-stretching shows better results than passive stretching (Borstad and Ludewig, 2006).

Conclusion

Active scapular retraction in scaption at a 60-degree angle was found to be an effective position and method for stretching the PMi. The intervention group showed a statistically significant increase in PMi length, decrease in the AD, and over MDC_{95} after the stretching. However, these are only results from immediately after PMi stretching. As such, further studies should be conducted in regards to the long-term effect of muscle stretching and posture correction to be used later in rounded shoulder clinical operation.

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