

# Change of Serratus Anterior Muscle Thickness According to Knee Flexion Angle During Knee-Push Up Plus Exercise on Sling

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## Abstract

**Background/Objectives:** The purpose of this study is to compare the change of thickness of serratus anterior muscle to different angles of knee flexion when knee push up plus (KPP) exercise is conducting on an unstable surface (sling).

**Method/Statistical Analysis:** There were 30 healthy young male and female students randomly selected and divided into 3 different groups along different knee flexion angles on an unstable surface (sling). The three groups of ten did KPP exercises on the sling. The muscle was measured before and after the exercise.

**Findings:** All three groups showed some changes in the thickness of the muscle. The group with the biggest change was the 60° knee flexion, followed by 75° and 90° groups.

**Improvements/Applications:** Based on the results, all experimental groups showed some differences with KPP exercise conducted on an unstable surface (sling) and especially the group with the lowest angle had the most effect. Therefore, it is concerned that a lower knee flexion angle can be more effective on the KPP exercise.

**Keywords:** *Serratus anterior muscle, push up plus exercise, unstable support surface, knee flexion angle, thickness change, ultrasonography.*

## Introduction

Neck pain is also very common following backache symptoms, and patients with neck pain can improve forehead posture. The posture gives some effects on the position of the shoulder joint and its kinematics<sup>[1]</sup>. To treat the pain and the abnormal stance, it can be helpful to do stabilizing exercises for shoulder and retraining serratus anterior(SA) muscle to control muscle<sup>[2]</sup>.

SA is quite important to make shoulder muscle stable. Also, the proper function of SA muscle helps

to keep normal scapulohumeral rhythm while raising arms up. When the humerus is flexion and external rotation, SA muscle has the shoulder blade remain in a stable position. Moreover, SA muscle can stop winging scapular and help the shoulder blade stay in posterior tilt while practicing upward rotation. SA muscle has an important role for stabilizing the scapula and its settlement influence on shoulder stabilization. Thus, many treatments and exercise therapy protocols have been studied to activate SA muscle for prevention and rehabilitation of shoulder joint dysfunction<sup>[3]</sup>.

Recently PUP (Push-Up Plus) exercise has been widely used as a type of exercise to rotator cuff. PUP is the exercise to increase the function of SA muscle and decrease extremity muscle activity. Also it is highly recommended because it shows the highest average of muscular activation compared to other activation exercises for SA muscle<sup>[4]</sup>. There are several ways of

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PUP exercise such as Standard Push-up Plus (SPP), Knee Push-up (KPP) with kneeling SPP, Wall Push-up (WPP) with standing and putting hands against the wall, and other exercises with applying SPP. These alternative ways applied SPP are to help patients to put less or limitation on weight load when they cannot repeat SPP at the early stage of rehabilitating program<sup>[5]</sup>.

PUP exercise is an exercise through repetition of the scapula’s protraction and retraction with hands supporting either unstable or stable support sling. It is used as a therapy for the patients who have injured or damaged shoulders to improve the rehabilitation and various kinesitherapies have been developed with different flexural angles of the shoulder, many types of support surfaces and the positions of supporting hands.

According to previous studies, PUP exercise on an unstable support surface (sling) has more effective than that on a stable support surface (sling)<sup>[6,7]</sup>. Additionally, there was another result showing that shoulder 110 flexion has more efficacious than other shoulder angles<sup>[8]</sup>. However, there was no study to show us which knee flexion angle can be the most efficient to do PUP exercise. Therefore, the aim of this study was to find out the most effective way for stabilizing shoulder muscle comparing the thickness of SA when trying different knee flexion angles for KPP exercise on an sling.

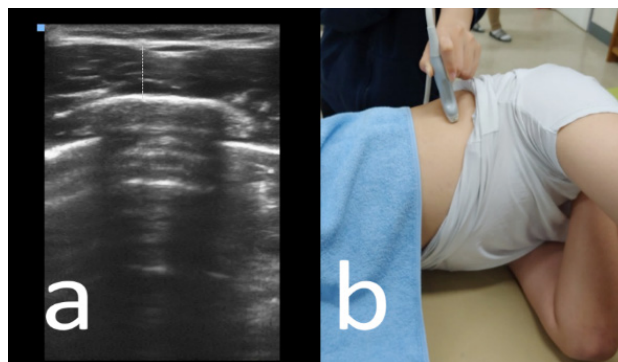
**Materials and Method**

**1. Subjects of Study:** The subjects were healthy young adults who volunteered to participate in the study. The experiment was conducted with a short orientation about its purpose and its process. Thirty healthy young male and female adults in their 20’s, who do not have any pain on shoulder or knee joints for the past 6 months, musculoskeletal system disorder on shoulder or knee joints in the past or now, any experience of surgical procedure, physical damages or disorders on other parts of the body, were randomly selected. This study proceeded with

the bioethical approval of IRB. (Approval number: SM-2018-05-034-2)

**2. Instrument and Method:**

- (a) **Instrument:** eZono 3000 was used to measure the thickness of SA muscle in the study. Ultrasonography imaged the structural feature of muscle in the body<sup>[9]</sup>.
- (b) **Method:** The measurements were conducted by the tester who fully knew about the study and the tester measured the subjects 3 times to reduce errors and then measured the thickness of SA muscle on the clearest image [Figure 1.(a)].



**Figure 1: (a) Ultrasonography by imaging of SA muscle (b) Measurement posture using ultrasonography**

For the measuring process, the subjects lay down on their side and put one of their arms up. Then we put the ultrasonography horizontally around the fifth rib and measured the thickness of serratus anterior muscle which is located right above its rib shadow<sup>[10]</sup> [Figure 1.(b)].

**3. Analysis:** In this study, 30 adult males and females who had no abnormality in their shoulders were randomly selected and divided into 3 groups. The first group, Group 1 for knee flexion 90°, the second group, Group 2 for 75°, and the third, Group 3 for 60° [Table 1], [Figure 3].

**Table 1: General Characteristics of the subject (N = 30)**

Characteristic	group 1 (n=10)	group 2 (n=10)	group 3 (n=10)
Age (y)	21.05±1.72	20.80±1.03	22.00±3.12
Height (cm)	168.78±10.69	170.12±9.06	165.42±9.38
Weight (kg)	71.56±11.37	69.35±12.09	73.13±10.98

group 1: knee flexion 90°, group 2: knee flexion 75°, group 3: knee flexion 60°

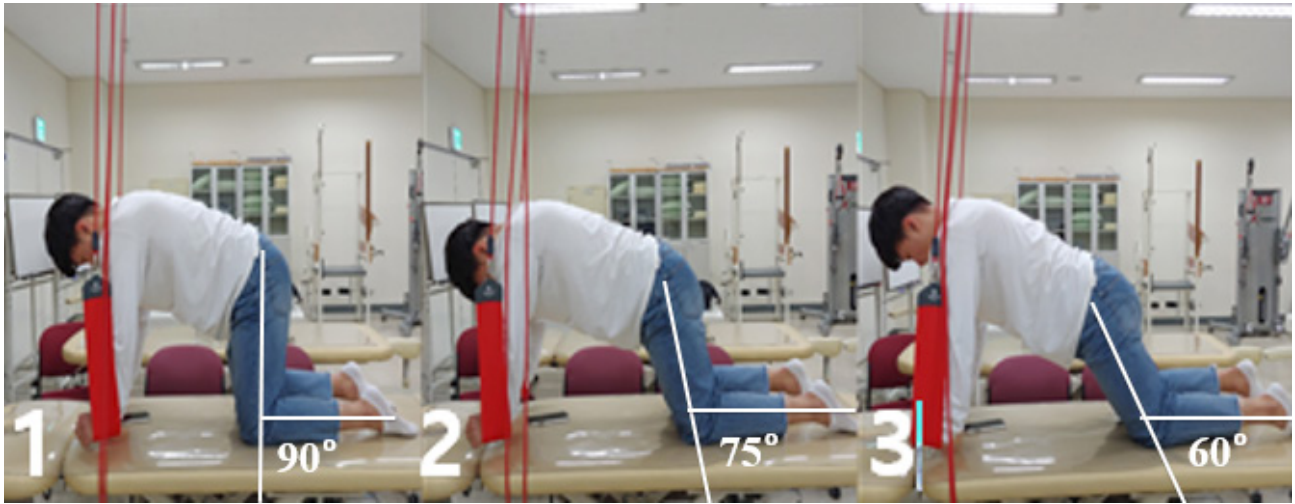


Figure 3. Posture by group. group 1: knee flexion 90°, group 2: knee flexion 75°, group 3: knee flexion 60°

The groups were divided by different angles of knee flexion and degrees of the lines between the distance of fibula lateral line and femur lateral epicondyle and the distance from femur lateral epicondyle to femur lateral line in crawling position. Each group had 10 people; 3 were female and the rest were male.

Before the experiment started, there was an orientation to explain about the study and teach the participants about the exercising postures. For PUP exercise, they put the knees down and bent shoulder in right angle with their hands on an unstable surface (sling). To make 90° of shoulder flexion, hands were put as wide as shoulders and posed in an external rotation which performs optimal muscle activation<sup>[8,11,12]</sup>. In this position, the protraction and retraction of the shoulder blades were repeated in 10 times for 10 seconds per set. During 3 sets, there was a 30-second break between sets. The three groups had done the exercise with different settings of the knee flexion angles twice a week.

The results of the differences of the thickness of SA muscle before and after the PUP exercise were compared to study the change of the muscle along the different angles of knee flexion for PUP exercise on an unstable supporting surface (sling). The instrument, ultrasonography measured the thickness for three times then the clearest image was chosen to look [Figure 4] below shows the process of the experiment.

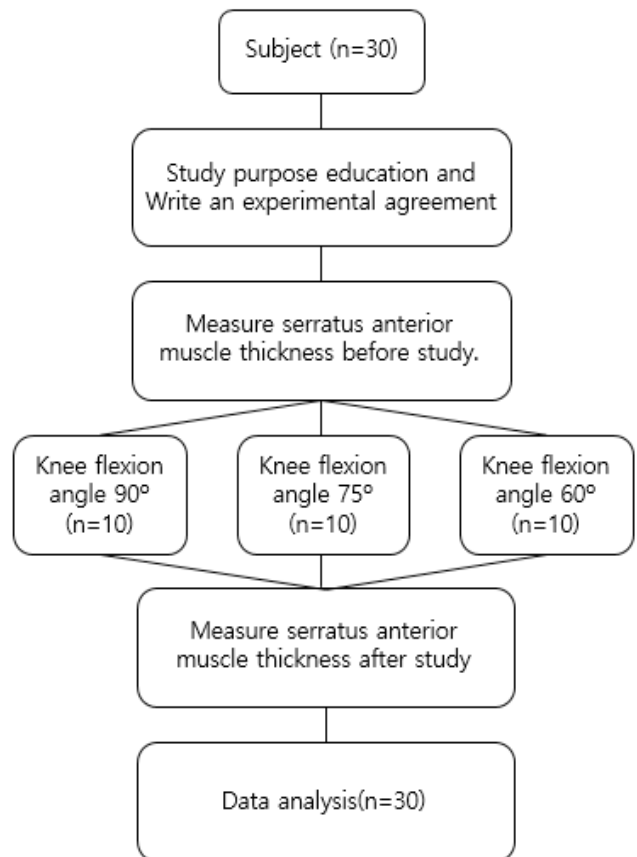


Figure 4. Experiment protocol flow chart

4. **Statistical Analysis:** All the values of the experiment were calculated with SPSS/PC ver. 20.0 for window program. Matching sample T-test was used to compare the groups before and after. For the comparison of the average of the groups, one-

way-layout analysis of variance was used and post verification method was used to show the difference between factors. Significant levels were set  $p < .05$  to verify statistics.

### Result

[Table 2] shows the different thickness of SA muscle of each group when the KPP exercise had done on an unstable supporting surface (sling) twice a week.

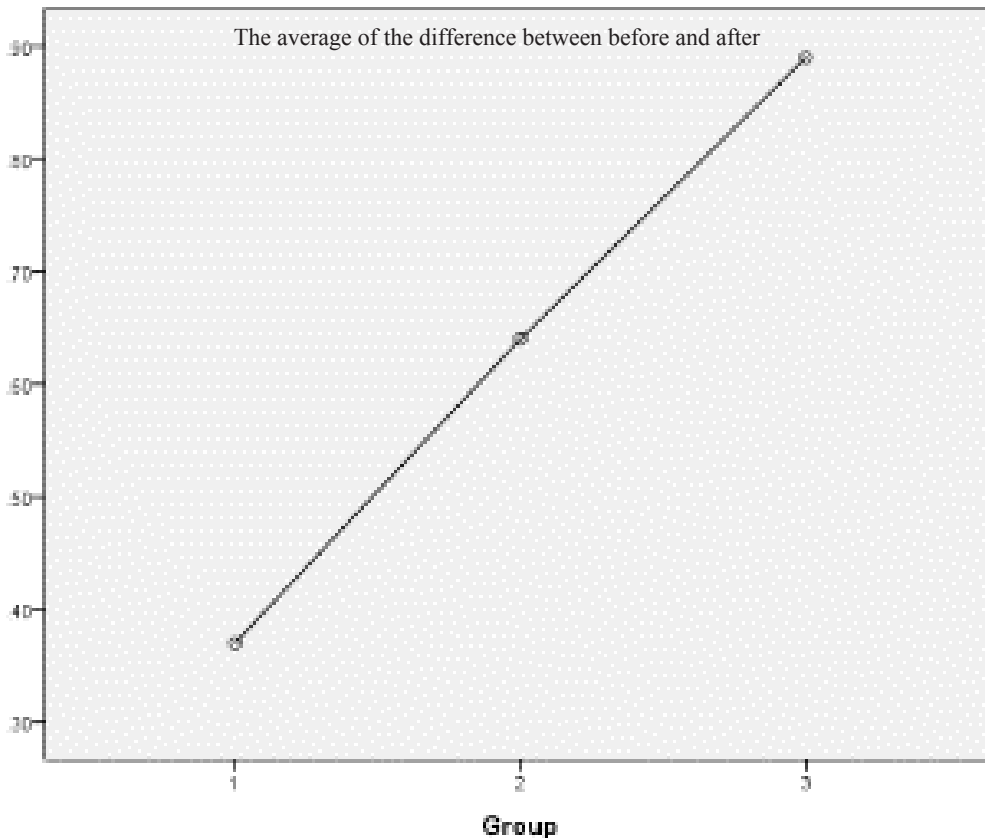
**Table 2: Before and after each exercise group serratus anterior muscle thickness Average (N = 30)**

	Before exercise	After exercise	Response difference	t	p
Group 1	5.27±1.96	5.64±1.99	.37	-12.33	.00***
Group 2	5.97±1.63	6.61±1.87	.64	-6.12	.00***
Group 3	5.66±1.57	6.55±1.62	.89	-11.40	.00***

group 1: knee flexion 90°, group 2: knee flexion 75°, group 3: knee flexion 60°, \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Before the exercise, Group 1 with right angle got the average of 5.27±1.96, Group 2 with 75° got 5.97±1.63 and Group 3 of 60° had 5.66±1.57 for the average value. After the exercise, the first group with 90° got 5.64±1.99 on the average of the muscle change, the second got 6.61±1.87 and the third had 6.55±1.62 average. Therefore, there was some difference in comparing the change of the thickness of SA muscle ( $p < .05$ ).

Moreover, like [Figure 5] shows the increase on average before and after conducting the exercise, the changes between Group 1 and 2 and between Group 2 and 3 did not show enough compared to no difference between Group 1 and 3 on the thickness change of SA muscle.



**Figure 5. The mean of the before and after difference of each group**

## Discussion

This experiment was done to show the difference of the SA muscle thickness before and after the exercise. The three groups all got some positive results after conducting KPP exercise on an unstable supporting surface (sling). The biggest difference was shown from the knee flexion 60°.

The SA muscle observed in the study can stabilize the shoulder muscle and its exercise can help to release the neckache and control and relax forward head posture pain<sup>[1]</sup>. According to one study found that applied PUP exercise can be generally used to treat patients for shoulder rehabilitation and when doing the exercise in kneeling position, the shoulder blades protraction can more activate serratus anterior muscle<sup>[4]</sup>. Additionally, based on another experiment by Ludewig, P. M. et al. SSP exercise has shown the highest level of SA muscle activity among Standard Push-Up Plus Exercise (SPP), Wall Push-Up Plus Exercise (WPP), Elbow Push-Up Plus Exercise (EPP), and Knee Push-Up Plus Exercise (KPP) had done on stable surface (sling), followed by KPP, EPP, and WPP. In addition, these exercises can be good alternatives for SPP exercise<sup>[5]</sup>. Jeong, S. Y. et al. found that PUP exercise with a sling (as unstable supporting surface) increased SA muscle activation more than that on stable supporting surface. Also, this showed a sling can bring more positive activation on the shoulder muscles<sup>[7]</sup>.

Based on the studies above, the study we conducted focused on serratus anterior muscle which stabilizes muscles on the shoulders, doing PUP exercise to help muscle movement. Although Ludewig, P. M. et al. said that SPP exercise showed the most muscle activation in her study, upon consideration of female participants in this experiment, the study we conducted chose KPP exercise which is a little bit easier to do and has the second highest muscle activation results in her study. KPP exercise was conducted on unstable supporting condition (sling) because muscle activity of SA muscle is higher when PUP exercise is conducted on unstable surface.

Cho, S. B. et al. and his researchers found shoulder external rotation made the highest level of SA muscle activity compared to other shoulder angles, internal rotation and neutral position<sup>[3]</sup>. In the current study, when the PUP exercise was performed at 10, 20, and 30% wider than shoulder width and 10%, 20%, and 30% narrower than the shoulder width and shoulder width,

The SA muscle activity was the highest at the shoulder width<sup>[11]</sup>. There was another experiment by Lee, S. Y. et al. to find which shoulder flexion angle can have higher level of SA muscle activity. 110° of the flexion showed the most activation rate on the muscle followed by 90° and 70°<sup>[8]</sup>. The experiment we did accepted the factors from the previous studies which could make the highest activation of SA muscle, shoulder external rotation and hand position as the shoulders apart. Also 90° of shoulder flexion could be one of the factors for this experiment. Even though they showed the result that 110° had the most activation when PUP exercise was done, we chose 90° which showed the second better activation on SA muscle considering the truth that all participants in the study by Lee, S. Y. et al. were healthy male adults. To check the factor about different weight load, we had an experiment on knee flexion angles. There was a significant difference on knee flexion 60°.

The result showed that unstable surface stimulates ones' proprioception to encourage SA muscle activation. The sense of proprioception and the stability of joints can be improved through weight load<sup>[13]</sup>. This can bring 20% more of maximum voluntary contraction of SA muscle through gradual load and PUP exercise stimulating the proprioception<sup>[14]</sup>.

The limitation of this study is that it is not possible to generalize research to people of all ages because they have been experimented with healthy men and women in their 20s. Also, during the exercise, there are some difficulties to keep balance on unstable supporting surface (sling) and to have hard exercise intensity along narrower knee flexions. Lastly the experiment has been done with a fewer study subjects.

Later studies will increase the number of subjects to obtain more reliable research results. We propose additional studies that can maintain a constant posture such as fixing the position of the head by placing the bar on the head during KPP. Moreover, due to the exercise in unstable supporting surfaces (slings) when establishing treatment plans, continuous study will be required by a variety of subjects to consider musculoskeletal patients with knee or shoulder problems or a nervous system patient with a problem with balance.

## Conclusion

For the study, healthy female and male adults in 20s participated in the exercise with each knee flexion option like 60°, 75°, and 90° on the unstable surface. Then it

showed that the group with 60° had the biggest change, .89mm, on the thickness of SA muscle comparing before and after the exercise. The second group performed on 75° flexion was following with the average .64mm change. Lastly, Group 3 had got the smallest change .37mm on the thickness of the muscle. Between the groups of 60° and 90° of knee flexion, there was a significant difference in the averages they got. Thus, the experiment showed that PUP (Push-up Plus) exercise was the most effective with the 60° of knee flexion which put the most weight load on.

**Ethical Clearance:** Not required

**Source of Funding:** Self

**Conflict of Interest:** Nil

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