

# Comparison of the immediate effects of different stretching methods for the pectoralis minor muscle in individuals with shoulder protraction

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## ABSTRACT

**Aims:** This study aimed to compare the immediate effects of different stretching methods for the pectoralis minor (PM) muscle on acromial distance (AD), pectoralis minor length, Pectoralis Minor Index (PMI) and scapular upward rotation (SUR) in individuals with shoulder protraction.

**Methods:** The study included 12 individuals with shoulder protraction. Manual stretching, unilateral corner stretching and modified contract-relax proprioceptive neuromuscular facilitation (PNF) stretching were applied to the PM muscle in a single session randomly. Before and after stretching, AD, PM muscle length, PMI and SUR were recorded.

**Results:** It was determined that three stretching methods improved the AD, PM length and PMI values ( $p < 0.05$ ), modified contract-relax PNF stretching method was superior to unilateral corner stretching ( $p < 0.05$ ). In addition, it was determined that all three stretching methods had no effect on SUR values ( $p > 0.05$ ).

**Conclusion:** According to these results, adding any of the manual stretching, unilateral corner stretching or modified contract-relax PNF stretching methods for the PM muscle to the shoulder protraction treatment program may optimize the AD, PM length and PMI values affecting the scapular position. Especially, modified contract-relax PNF stretching technique is more effective than unilateral corner stretching. Therefore, it is recommended that the first preferred stretching method should be modified contract-relax PNF stretching for shoulder protraction treatment program.

**Keywords:** Pectoralis minor, PNF, rounded shoulder posture, stretching

## INTRODUCTION

Shoulder protraction is one of the common postural deviations seen in approximately 73% of healthy individuals, known as anterior translation of the shoulder complex from the lateral midline of the body.<sup>1</sup> It is characterized by abduction of the scapula and anterior deviation of the acromial process, which changes the rotational axis of the glenoid fossa, causing internal and upward rotation and anterior tilt of the scapula.<sup>2</sup>

Shoulder protraction can be caused by many factors such as static posture, muscle strength imbalance, soft tissue injuries or repetitive movements.<sup>3,4</sup> Static, abnormal postural changes cause adaptive lengthening of the soft tissues and shortening of the opposite side soft tissues.<sup>2,5</sup> Muscles responsible for protraction of the scapula, such as the shortened pectoralis major and pectoralis minor, play a major role in shoulder protraction.<sup>6</sup> In particular, it has been reported that the adaptive shortening of the pectoralis minor (PM) muscle due to its attachment to the scapula and thorax restricts normal scapulothoracic movement and changes the position of the

scapula.<sup>2,6</sup> In individuals with shoulder protraction, it has also been reported that lengthening of retractor muscles such as trapezius and rhomboid occurs.<sup>2,5,7</sup>

The PM muscle attaches to the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> ribs and the coracoid process of the scapula. The fibril orientation of the PM allows internal rotation, downward rotation and anterior tilt of the scapula. It elongates during elevation, allowing upward rotation, external rotation and posterior tilt of the scapula.<sup>8</sup> Individuals with a short PM muscle have decreased scapular external rotation and posterior tilt during arm elevation compared to individuals with a long PM.<sup>6</sup>

In the physiotherapy program of shoulder protraction, approaches such as teaching the correct position,<sup>9,10</sup> strengthening exercises,<sup>11,12</sup> use of orthosis,<sup>13,14</sup> taping,<sup>15</sup> soft tissue mobilizations and stretching exercises for PM are used.<sup>4,6,12,14,16</sup>

Stretching is applied as static, dynamic, ballistic and PNF.<sup>17</sup> These applications aim to increase the flexibility and length of

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the soft tissue by creating tension.<sup>18</sup> With stretching, changes such as an increase in the viscoelasticity of the muscle and tendon and relaxation of the agonist muscle through autogenic inhibition by stimulation of the Golgi tendon organ.<sup>19</sup>

In the literature, the effects of PM muscle stretching on PM muscle length, pectoralis minor index (PMI) and scapular position have been investigated,<sup>14,17,20-23</sup> but no study has been found on which stretching method is more effective among manual stretching, unilateral corner stretching and modified contract-relax PNF stretching techniques applied to PM. The aim of our study was to compare the immediate effects of manual, unilateral corner and modified contract-relax PNF stretching methods for the PM muscle on acromial distance (AD), PM muscle length, PMI and scapular upward rotation (SUR) in individuals with shoulder protraction.

## METHODS

### Study Design

This study is a prospective, randomized, controlled, crossover, single-blind study planned to compare the immediate effects of different stretching methods for the PM muscle on AD, PM muscle length, PMI, and SUR in individuals with shoulder protraction. In order to conduct the study, ethical approval was obtained from the Gazi University Rectorate Ethics Committee (Date: 04.04.2023, Decision No: E639069). The study was registered on ClinicalTrials.gov (Gazi University). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Voluntary individuals who met the inclusion criteria for the study conducted at Gazi University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation and Gülhane Faculty University of Health Sciences were asked for their consent to participate in the study with the 'Informed Voluntary Consent Form'.

**The inclusion criteria were as follows:** individuals were between 18-40 years of age, had a shoulder protraction posture, had a short PM muscle, and agreed to participate in the study. Individuals with cervical and shoulder pain, adhesive capsulitis, thoracic outlet syndrome, shoulder instability, history of shoulder surgery and numbness or tingling in the upper extremity were excluded from the study.

Firstly, demographic information and physical characteristics of the individuals who met the inclusion criteria were recorded, and manual stretching, unilateral corner stretching and modified contract-relax PNF stretching methods for the PM muscle were randomly applied to all individuals 2 days apart. All stretching methods were performed by an investigator blinded to the evaluations.

**Randomization method:** The order of manual stretching (Manual), unilateral corner stretching (unilateral) and modified contract-relax PNF stretching methods applied to the volunteers included in the study was assigned using simple randomization method with the "Research Randomizer" program (<https://www.randomizer.org/>).

### Assessments

AD, PM length, PM index and SUR measurements were taken before and after stretching by a researcher blinded to the interventions. All assessments were performed on the dominant side of the individuals.

**Determination of shoulder protraction posture (AD measurement):** The distance between the posterolateral aspect of the acromion on the dominant side and the bed was measured in cm with a caliper in the supine position, with the arms free next to the trunk and the knees slightly flexed. A distance of 2.5 cm or more was recorded as shoulder protraction posture.<sup>24</sup> Additionally, AD measurement was taken before and after stretching.

**Pectoralis minor length:** While the individuals were in a comfortable position, standing with their arms at their sides, the distance between the caudal corner of the 4<sup>th</sup> rib and the inferomedial surface of the coracoid process was measured twice with a tape measure and recorded in cm.<sup>25</sup>

**Pectoralis Minor Index:** This measure was used to determine the PM shortness of individuals. PMI was calculated as the ratio of the length of the pectoralis minor to the height of the individuals multiplied by 100. A value below 7.44 was considered as PM shortness.<sup>25</sup>

**Scapular upward rotation measurement:** This measurement was evaluated with a digital inclinometer (Baseline® Digital Inclinometer 12-1057) in the resting position, 45°, 90° and 135° shoulder abduction position. Two inclinometers were used in the measurements. One of the inclinometers (Jtech, American Fork, UT) was fixed to the humerus with tape just above the lateral epicondyle for shoulder abduction angle. The second inclinometer was positioned on the spina scapula for SUR measurement. Individuals were asked to stand in a comfortable standing position with elbow extension. They were then asked to abduct the shoulder with the thumb pointing upwards and wait in that position for the measurement where the evaluator told them to stand. The SUR angles of the individuals in resting position, 45°, 90° and 135° shoulder abduction were read from the inclinometer and recorded. Three measurements were taken with a 30 s rest interval and the mean value was calculated.<sup>26</sup>

### Interventions

A 48-hour interval was given between stretching methods due to the wash-out effect. All stretching methods were performed by a blinded researcher to assessments. Before stretching, individuals were instructed how to rate the discomfort felt during stretching to determine the severity of stretching (0: no discomfort, 10: severe discomfort). During stretching, individuals were asked to report discomfort at a score of 4 out of 10 points.

**Manual stretching:** Individuals were positioned supine with the shoulder in 90° abduction and external rotation, elbow in 90° flexion position, with the side to be stretched out of the bed. A towel was placed on the interscapular region of the individual to increase the effect of stretching. While the practitioner stabilized the trunk over the coracoid process of the contralateral side with one hand, the other hand passively abducted the individual's shoulder to horizontal abduction just proximal to the elbow on the side to be stretched. At the point where the individual reported a discomfort level of 4 out of 10 points, the horizontal abduction position was maintained for 30 s. This method was repeated 4 times with 30 s rest between repetitions.<sup>20,27</sup>

**Unilateral corner stretching:** Individuals were asked to stand with the elbow in 90° flexion and shoulder in 90°

abduction, placing the palm and forearm on the wall. Angles were determined with a digital inclinometer (Jtech, American Fork, UT). The contralateral leg of the side to be stretched was positioned anterior to the other leg. For stretching, individuals were asked to increase shoulder horizontal abduction by bringing the trunk anteriorly and in contralateral rotation until the discomfort level was 4 out of 10. Then, individuals held this position for 30 s and repeated 4 times with 30 s rest between repetitions.<sup>17,20,23,27</sup>

**PNF stretching:** The modified contract-relax technique was adapted to the PM muscle by Birinci et al.<sup>27</sup> and proved to increase both PM length and PMI values. Therefore, this technique was preferred in our study. The modified contract-relax PNF stretching technique was performed with the individual sitting on an unsupported chair with the hands clasped behind the head. The practitioner stabilized the trunk at the interscapular region with a knee while standing posterior to the individual. With the practitioner's hands placed anterior to the elbows, the PM muscle was stretched passively and slowly in the horizontal abduction direction until the individual reported a level of 4 out of 10 for discomfort. Passive stretching was maintained for 10 seconds. Then, without changing the position of the hands, the practitioner applied resistance in horizontal abduction and obliquely in the upward direction to achieve a maximum voluntary isometric contraction of the PM muscle for 6 seconds. Afterwards, the subjects rested for 4 seconds. The application was completed with passive stretching by maintaining the new position of the stretched PM muscle for 10 seconds with a discomfort level of 4 out of 10. This procedure was repeated four times with 30 seconds rest.<sup>27</sup>

### Statistical Analysis

SPSS (Statistical Package for Social Sciences) version 22.0 was used to evaluate the data obtained from the study and to create tables. Shapiro-Wilk test was used to determine the distribution of the data. Descriptive statistics of normally distributed numerical variables were expressed as  $X \pm SD$ , descriptive statistics of non-normally distributed numerical variables were expressed as median and (IQR), and descriptive statistics of categorical variables were expressed as frequency and percentage (%). Paired sample T test was used for intra-group comparison of normally distributed data and Wilcoxon test was used for intra-group comparison of non-normally distributed data. Kruskal Wallis analysis was used to compare both the pre-application values of the three groups and the change difference values of all three groups before and after the application. Statistical significance level was set as  $p < 0.05$  and post-hoc multiple comparisons test with Bonferroni correction was performed.

## RESULTS

### Demographic and Physical Characteristics of Individuals

The study included 12 individuals, 5 females (41.7%) and 7 males (58.3%), with a median age of 22 (20/29) years. It was determined that 83.3% of the individuals were dominant on the right side, while 16.7% were on the left side. In addition, the individuals' PMI values were 6.98 (6.84/7.20), and they had pectoralis minor muscle shortness (**Table 1**).

	n (%)	
Gender	Female	5 (41.7)
	Male	7 (58.3)
Dominant side	Right	10 (83.3)
	Left	2 (16.7)
<b>Median (IQR 25/75)</b>		
Age (year)	22 (20/29)	
Height (cm)	172 (160/182.50)	
Weight (kg)	69 (51/77)	
BMI (kg/m <sup>2</sup> )	22.12 (19.88/25.69)	
AD (cm)	6.75 (6.00/7.30)	
PM (cm)	11.95 (11.37/12.36)	
PMI	6.98 (6.84/7.20)	

cm: Centimeter, IQR: Interquartile range, kg: Kilogram, BMI: Body-mass index, kg/m<sup>2</sup>: kilogram/meter<sup>2</sup>, AD: Acromial distance, PM: Pectoralis minor, PMI: Pectoralis Minor Index

### Comparison of Acromial Distance Values of Individuals

AD values before the application were similar between the groups ( $p > 0.05$ ), and decreased in all three groups after the application ( $p < 0.05$ ). While manual and unilateral corner stretching were similar ( $p > 0.05$ ), modified contract-relax PNF stretching method was more effective than unilateral stretching ( $p < 0.05$ ) (**Table 2**).

### Comparison of Pectoralis Minor Length Values of Individuals

Before the applications, there was no significant difference in PM muscle length between the groups ( $p > 0.05$ ). Following the applications, PM length increased significantly in all three groups ( $p < 0.05$ ). No significant difference was observed between manual and unilateral corner stretching ( $p > 0.05$ ) but modified contract-relax PNF stretching was superior to unilateral corner stretching ( $p < 0.05$ ) (**Table 3**).

Acromial distance (cm)	Before median (IQR 25/75)	After median (IQR 25/75)	p <sup>a</sup>	Change difference ( $\Delta_{\text{before-after}}$ )	Post-hoc analysis	
					Groups	p <sup>c</sup>
Manual	6.75 (6.00/7.35)	5.25 (4.93/6.43)	0.002	-1.15 (-1.52/-0.55)	Manuel-unilateral	0.448
Unilateral	6.65 (5.70/7.40)	5.45 (5.00/6.65)	0.002	-0.90 (-1.15/-0.60)	Unilateral-PNF	0.003
PNF	6.80 (6.13/7.60)	5.30 (4.48/6.08)	0.002	-1.75 (-1.95/-1.25)	Manuel-PNF	0.025
p <sup>b</sup>	0.728			0.008		

cm: Centimeter, IQR: Interquartile range, PNF: Proprioceptive neuromuscular facilitation, a: Wilcoxon test, b: Kruskal-Wallis H test, c: Mann-Whitney U test

**Table 3. Comparison of pectoralis minor length values of individuals**

PM length (cm)	Before median (IQR 25/75)	After median (IQR 25/75)	p <sup>a</sup>	Change difference ( $\Delta_{\text{before-after}}$ )	Post-hoc analysis	
					Groups	p <sup>c</sup>
Manual	11.95 (11.25/12.37)	13.25 (12.40/13.80)	0.002	1.35 (1.05/1.47)	Manuel-unilateral	0.437
Unilateral	11.95 (11.33/12.67)	13.10 (12.40/13.97)	0.002	0.90 (0.65/1.75)	Unilateral-PNF	0.003
PNF	11.55 (11.25/12.20)	13.50 (13.32/14.17)	0.002	1.80 (1.42/2.17)	Manuel-PNF	0.026
p <sup>b</sup>	0.673			0.008		

PM: Pectoralis minor, cm: Centimeter, IQR: Interquartile range, PNF: Proprioceptive neuromuscular facilitation, a: Wilcoxon test, b: Kruskal-Wallis H test, c: Mann-Whitney U test

### Comparison of Pectoralis Minor Index Values of Individuals

PMI values were similar among the three groups before the applications ( $p > 0.05$ ), and showed a significant increase in all groups following the application ( $p < 0.05$ ). In the comparison between the groups, PMI values after the manual and unilateral corner stretching applications were similar ( $p > 0.05$ ), and were more higher after PNF stretching compared to unilateral corner stretching ( $p < 0.05$ ) (Table 4).

### Comparison of Scapular Upward Rotation Values of Individuals

The upward rotation of the scapula in the 0°, 45°, 90° and 135° abduction positions were similar in all three groups before ( $p > 0.05$ ). All three treatments were not effective on SUR after application compared to pre-application values. When the groups were compared, there was no superiority of any of the three groups over each other ( $p > 0.05$ ) (Table 5).

**Table 4. Comparison of Pectoralis Minor Index values of individuals**

PMI	Before median (IQR 25/75)	After median (IQR 25/75)	p <sup>a</sup>	Change difference ( $\Delta_{\text{before-after}}$ )	Post-hoc analysis	
					Groups	p <sup>c</sup>
Manual	6.98 (6.76/7.11)	7.64 (7.54/7.89)	0.002	0.76 (0.62/0.81)	Manuel-unilateral	0.456
Unilateral	7.04 (6.80/7.27)	7.59 (7.27/8.19)	0.002	0.51 (0.39/1.00)	Unilateral-PNF	0.003
PNF	7.03 (6.55/7.14)	7.89 (7.72/8.33)	0.002	1.06 (0.79/1.28)	Manuel-PNF	0.028
p <sup>b</sup>	0.622	0.193		0.009		

PMI: Pectoralis Minor Index, IQR: Inter quartile range, PNF: Proprioceptive neuromuscular facilitation, a: Wilcoxon test, b: Kruskal-Wallis H test, c: Mann-Whitney U test.

**Table 5. Comparison of scapular upward rotation values of individuals**

SUR (°)	Before median (IQR 25/75)	After median (IQR 25/75)	p <sup>a</sup>	Change difference ( $\Delta_{\text{before-after}}$ )
<b>Rest position</b>				
Manual	-2.10 (-3.30/-1.22)	-2.15 (-3.05/0.00)	0.556	0.87 (-1.37/2.07)
Unilateral	-1.95 (-2.15/-1.41)	-2.50 (-3.58/-0.30)	0.367	-1.37 (-2.16/1.40)
PNF	-2.03 (-2.33/-1.50)	-0.95 (-2.95/1.12)	0.136	0.92 (-1.01/2.32)
p <sup>b</sup>	0.660			0.204
<b>45° abduction position</b>				
Manual	6.75 (6.09/7.50)	6.05 (5.17/7.15)	0.182	-1.47 (-2.00/1.28)
Unilateral	6.13 (5.81/6.88)	6.40 (5.59/7.45)	0.480	0.20 (-0.84/0.90)
PNF	6.25 (6.03/6.98)	7.20 (5.50/8.15)	0.346	0.95 (-1.40/1.80)
p <sup>b</sup>	0.281			0.162
<b>90° abduction position</b>				
Manual	13.72 (12.55/15.26)	12.80 (12.12/15.11)	0.533	-0.20 (-2.80/1.99)
Unilateral	12.83 (11.39/15.22)	13.87 (12.53/15.28)	0.754	2.27 (-2.85/2.64)
PNF	12.90 (11.23/14.71)	14.71 (13.55/16.67)	0.077	2.54 (0.69/4.30)
p <sup>b</sup>	0.348			0.080
<b>135° abduction position</b>				
Manual	19.20 (18.43/20.38)	19.60 (18.47/20.75)	0.583	0.30 (-1.62/2.10)
Unilateral	20.50 (18.59/22.87)	22.35 (19.49/23.38)	0.433	0.90 (-1.62/2.97)
PNF	20.35 (19.63/22.60)	21.68 (20.06/22.83)	0.272	0.54 (-0.99/2.74)
p <sup>b</sup>	0.202			0.856

SUR: Scapular upward rotation, IQR: Interquartile range, PNF: Proprioceptive Neuromuscular Facilitation, a: Wilcoxon test, b: Kruskal-Wallis H test

## DISCUSSION

The aim of this study was to compare the immediate effects of 3 different stretching techniques applied to the PM muscle on AD, PM muscle length, PMI and SUR. Briefly, manual stretching, unilateral corner stretching, and modified contract-relax PNF stretching methods applied to the PM muscle in individuals with shoulder protraction posture resulted in decreased AD values and increased PM length and PMI values. Additionally, the modified contract-relax PNF stretching method was found to be more effective than unilateral corner stretching. However, none of the three stretching methods had an effect on SUR.

### Acromial Distance

Scapular anterior tilt, internal rotation and downward rotation are seen in shoulder protraction posture. Treatment focuses on correcting this changing position of the scapula. AD provides information about both the detection of shoulder protraction and the position of the scapula and provides feedback on the effect of treatment.<sup>15,28</sup> It has been recorded that exercise and stretching techniques are effective in correcting shoulder protraction posture.<sup>14</sup>

In our study, we observed that manual stretching, unilateral corner stretching and modified contract-relax PNF stretching methods for PM significantly reduced AD, and PNF stretching applications had superiority over unilateral corner stretching. It has been previously stated that the decrease in AD indicates an increase in the posterior tilt and external rotation of the scapula.<sup>14</sup> It can be concluded that all three stretching methods we used are effective in reducing the increase in the anterior tilt and internal rotation of the scapula seen in individuals with shoulder protraction posture and in correcting shoulder protraction. When the PM muscle is short, the scapula tends to tilt anteriorly.<sup>6</sup> With stretching, the muscle responds to the stretching by lengthening due to the viscoelastic properties of the muscle. With the lengthening of the muscle, its flexibility increases and the anterior tilt of the scapula decreases. Considering the effect mechanism of stretching, all three stretching methods we applied to the PM muscle may affect AD by causing biomechanical changes in the myotendinous unit of the muscle.<sup>29</sup> According to the results of our study, the reason why the modified contract-relax PNF stretching technique is the most effective method in reducing AD may be due to the neurophysiological mechanism of the PNF stretching technique. Autogenic inhibition mechanism is activated by PNF stretching. With increased inhibitory information from the Golgi tendon organ of the contracting muscle (PM), excitability in the same muscle decreases and the muscle relaxes. In this way, the extensibility of the muscle and the posterior tilt of the scapula increase.<sup>30</sup>

### Pectoralis Minor Length and Pectoralis Minor Index

One of the determinants of shoulder protraction is the shortness and tightness of the PM muscle. Therefore, interventions aimed at increasing the length and flexibility of the PM muscle should be included in the treatment of shoulder protraction. One of these interventions is stretching applications.<sup>16</sup> In our study, we found that all three stretching methods applied to the PM muscle of individuals with shoulder protraction significantly increased the PM length and PMI values, and the PNF stretching method was found to be superior to the unilateral corner stretching method.

Williams et al.,<sup>20</sup> in a study conducted on 29 healthy swimmers, reported that there was a significant increase in PM muscle length with the gross stretching method, while there was no change with focused PM stretching. The gross stretching applied in the mentioned study is very similar to the manual stretching method used in our study. We observed that PM length increased significantly with manual stretching in our study. Laudner et al.,<sup>21</sup> reported that the muscle energy technique applied twice a week for 6 weeks to the PM muscle in swimmers with shoulder protraction caused a significant increase in PM length compared to the control group. Methodologically, the muscle energy technique used in this study is similar to the modified contract-relax PNF technique applied in our study. Similar to the mentioned study, we found an increase in PM length with the PNF stretching method. Lee et al.<sup>14</sup> showed that there was a significant increase in PMI values in the stretching group applied in addition to scapular posterior tilt exercise, compared to scapular posterior tilt exercise group alone in individuals with shoulder protraction posture, immediately after the application. In another study, Lee et al.<sup>22</sup> noted that PMI values were higher after stretching in the scapular posterior tilt exercise additional stretching group in individuals with PM muscle shortness. Borstad et al.<sup>17</sup> stated that the stretching that produced the most lengthening in the PM muscle of healthy individuals was unilateral corner stretching, followed by manual stretching in the supine position and manual stretching in the sitting position, respectively. In our study, we used unilateral corner stretching and manual stretching methods in the supine position. Unlike the mentioned study, in our study, we observed a significant increase in PM muscle length before and after stretching with both methods, and when we compared the two methods, we found that this increase was similar to each other. The stretching method applied in the mentioned study is very similar to the stretching method used in our study, and we found that manual stretching significantly increased the PMI value. The fact that all three stretching methods we applied showed an increase in both PM length and PMI values supports the mechanism of action of stretching. With stretching, the passive tension of the muscle decreases and its flexibility increases as a result of the viscoelastic response of the muscle-tendon unit, resulting in lengthening of the muscle.<sup>29</sup> Among the 3 stretching methods we applied, PNF stretching was more effective in increasing PM length and PMI values than unilateral corner stretching. The neurophysiological mechanism, which is one of the mechanisms of PNF stretching, may underlie this result. With PNF stretching, the Golgi tendon organ of the contracting muscle is stimulated and the muscle is inhibited, relaxed and its elongation increases.<sup>30</sup> As expected, with the lengthening of the PM, there is an increase in PMI. As a result, we recommend that any of the manual stretching, unilateral corner stretching and modified contract-relax PNF stretching applied to the PM muscle should be added to the program in the treatment of shoulder protraction posture. Since modified contract-relax PNF stretching is the most effective method, it is recommended that this method be the first choice.

### Scapular Upward Rotation

Lee et al.<sup>14</sup> reported that the manual stretching did not change the SUR. On the other hand, Williams et al.,<sup>20</sup> in a study, they conducted on 29 healthy swimmers, did not perform any application to the control group, but applied

gross stretching technique for the PM muscle to one group and focused stretching technique for the PM muscle to the other group, and stated that there was no statistically significant difference in SUR in all three groups. Similarly, Rosa et al.<sup>23</sup> observed that daily unilateral corner stretching of the PM muscle for 6 weeks in 25 individuals with shoulder pain and 25 individuals without shoulder pain with PM shortness did not change the SUR values in either group. In our study, we found that manual stretching, unilateral corner stretching and modified contract-relax PNF stretching methods applied to the PM muscle were not effective on SUR. The reason for not finding a significant difference in SUR in all 3 stretching applications may be that a single session of stretching may be insufficient and as Williams et al.<sup>20</sup> stated, weakness of periscapular muscles such as upper, middle, and lower trapezius, rhomboids, levator scapula and serratus anterior may also prevent the change in SUR. In future studies, it is recommended to examine the effect of repeated PM stretching on SUR and to compare all 3 stretching applications in individuals with PM muscle shortness with different shoulder pathologies.

### Limitations

Since our study is a pilot study, the number of individuals is small. Therefore, a study with a sufficient sample size is needed. In addition, the effects of PM stretching methods after a single session were examined in our study. Long-term effects should be investigated in future studies.

### CONCLUSION

While it was observed that manual stretching, unilateral corner stretching and modified contract-relax PNF stretching methods applied to the PM muscle in individuals with shoulder protraction posture decreased AD values and increased PM length and PMI values, it was determined that modified contract-relax PNF stretching method was superior to unilateral corner stretching. In addition, it was determined that all three stretching methods had no effect on SUR. According to the results, incorporating any of the manual stretching, unilateral corner stretching, or modified contract-relax PNF stretching techniques for the PM muscle into a shoulder protraction treatment program may optimize AD, PM muscle length, and the PMI, all of which influence scapular positioning. Among these methods, the modified contract-relax PNF stretching technique was found to be the most effective, particularly when compared to unilateral corner stretching. Therefore, it is recommended that the modified contract-relax PNF stretching method be the first choice in shoulder protraction treatment programs.

### ETHICAL DECLARATIONS

#### Ethics Committee Approval

The study was carried out with the permission of the Gazi University Rectorate Ethics Committee (Date: 04.04.2023, Decision No: E639069).

#### Informed Consent

All patients signed and free and informed consent form.

#### Referee Evaluation Process

Externally peer-reviewed.

### Conflict of Interest Statement

The authors have no conflicts of interest to declare.

### Financial Disclosure

The authors declared that this study has received no financial support.

### Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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