

The normative values for resting length of pectoralis minor muscle among individuals with asymptomatic shoulder in South Bengaluru: a cross-sectional pilot study

S.S. SUBRAMANIAN¹, D. RAVINDRA², K.C. VINOD KUMAR², P. SENTHIL¹, S.A. KAJAMOHIDEEN³, R.A.M. GAOWGZEH⁴, S.S. ALFAWAZ⁴, T.A. ALTAIM⁵, Z. NEAMATALLAH⁴, M. ALBADI⁴, U.M. ALABASI⁴

¹Chettinad School of Physiotherapy, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India

²College of Physiotherapy, School of Health Sciences, Dayananda Sagar University, Bangalore, Karnataka, India

³Senior Lecturer, AIMST University, Malaysia

⁴Department of Physical Therapy, Faculty of Medical Rehabilitation Sciences, King Abdulaziz University, Jeddah, Saudi Arabia

⁵Physical Therapy Division-Allied Medical Sciences Department, Aqaba University of Technology, Aqaba, Jordan

Abstract. – OBJECTIVE: The aim of the study was to determine the normative values for resting length of pectoralis minor muscle among males and females with an asymptomatic shoulder in South Bengaluru.

PATIENTS AND METHODS: Two hundred and forty-six subjects with asymptomatic shoulders were taken by convenience sampling. The subjects were divided into two groups: Group A (123 males) and Group B (123 females). Pectoralis minor muscle resting length was measured on their dominant side in all subjects. Post measurement, the PMI was calculated. The normative values for both groups were determined. The mean PMI was compared between Group A and Group B and was analyzed using statistical tools.

RESULTS: In Group A, the mean average Pectoralis minor length (PML) was 14.59 ± 1.61 cm and in Group B, the mean average PML was 12.95 ± 1.42 cm which was statistically significant (p -value <0.00001). In Group A, the mean Pectoralis Minor Index (PMI) was 8.54 ± 0.88 and in Group B, the mean PMI was 8.22 ± 0.90 which was statistically significant (p -value <0.005).

CONCLUSIONS: The normative values for resting length of pectoralis minor muscle for males are 8.54 ± 0.88 and for females 8.22 ± 0.90 with an asymptomatic shoulder. There is a difference in the normative values for the resting PML in the asymptomatic shoulder by gender.

Key Words:

Pectoralis minor muscle, Resting length, Pectoralis minor index, Asymptomatic shoulder.

Introduction

Musculoskeletal diseases are thought to impact nearly 1.7 billion people worldwide. Symptoms of musculoskeletal issues include persistent pain, activity limitations, low efficacy, and low quality of life¹. Shoulder pain has a prevalence ranging between 7% and 26% in India². The alignment-impairment model describes how a variety of factors lead to shoulder dysfunction and discomfort. Pertinacious postures and recurrent actions which position the shoulder in protraction are hypothesized to cause adaptive muscular shortening, which can lead to malalignment, discomfort, and eventually movement dysfunction. These impairments are thought to work together to cause shoulder pain and dysfunction^{3,4}.

The Pectoralis minor (PM) muscle is thought to be a key muscle in the positioning and mobility of the shoulder girdle⁵. It originates from the third, fourth, and fifth ribs, which run superolateral, converge, and insert at the medial aspect of the coracoid process^{6,7}. The functions of the PM are abduction, depression, downward rotation, and the upward tilt of the scapula⁷. It is the only muscle that connects the scapula to the thoracic region's anterior surface. As a result, it is anticipated that shortening this muscle may limit scapular motions in the superior and posterior direction, which reduces the subacromial space and

generates a pathological environment leading to forward shoulder posture or shoulder impingement^{6,8}. Therefore, during arm elevation, an adaptively shortened PM may restrict the scapula from completely performing upward rotation, external rotation, posterior tipping, or elevation⁸.

These movement patterns appear to be the same as those seen in people with shoulder impingement, rotator cuff pathology, and glenohumeral instability, all of which can cause shoulder pain. Previous researchers have found many clinical syndromes that are related to the shortening of PM. To recognize an adaptive shortening of PM related to the above-mentioned conditions, a test for muscle length was proposed. There are primarily two pectoralis minor length (PML) tests in the literature. The study stated “when the patient is supine with arms by the side and elbows flexed, the distance between the treatment table and posterior aspect of the acromion should not be more than 2.54 cm (1 inch) assuming the PM muscle is of normal length”⁹. Since the effect of the PM on the measurement is negligible, the implication of this method is contradictory¹⁰. Direct measurement of the resting PML with a vernier caliper is another test¹¹. It is reported to have good to excellent intra-tester reliability and moderate inter-tester reliability¹². Anyhow, the definite resting PML providing a precise scale of muscle extensibility remains questionable^{13,14}.

Borstad et al⁸ devised the Pectoralis Minor Index (PMI) as a normalization index to eliminate the variability caused by the differences in body height and muscle length among individuals. The cutoff reference value was found to be 7.44 (Mean PMI - 1 Standard Deviation), below which the subjects were considered to have a relatively short PM¹¹. Several researchers^{8,11,12,15,16} have conducted studies on PM, comparing its various variables by considering its measurement. Following a study of the findings of various investigations, it was determined that even in normal subjects, different studies have reported various PMI values. This means that there is no global PMI standard value that can be applied to everyone. As a result, no PMI cut-off value may be used to define a shorter PM, limiting PMI's overall applicability. This research was conducted on the assumption that to use the PMI as a legitimate and reliable criterion for determining the source of shoulder pain, each ethnic group must have a standard PMI value¹⁷.

The height of the person is one of the determining factors of the resting length of a muscle. In

India, the average male height is greater than the average female height. So, a single cut-off value is inappropriate to be used as a reference value for both genders. To the best of our knowledge, there are no studies conducted to determine the normative values for resting length of pectoralis minor muscle among males and females with an asymptomatic shoulder in the South Bengaluru population. So, the objective of our study is (a) to determine the normative values for resting length of pectoralis minor muscle among males and females with an asymptomatic shoulder in South Bengaluru and (b) to compare the normative values for resting length of pectoralis minor muscle between males and females with an asymptomatic shoulder. This study provides the normative values for both males and females that can be clinically used.

Patients and Methods

Participants

The sample size (N) was calculated to be 246 at a 95% confidence interval (CI), using the formula $4Z\alpha^2S^2/W^2$. A total of 294 subjects were screened for the study (Figure 1). Two hundred and forty-six subjects were taken into the study considering all the inclusion and exclusion criteria. A convenience sampling technique was used in the study. Considering the need and objective of the study, 246 subjects were then divided into two groups: Group A (123 males) and Group B (123 females). The procedure was explained to all in detail.

Inclusion criteria included: (a) Male and female with an asymptomatic shoulder within the ages of 18 to 40 years³; (b) Shoulder Pain and Disability Index scale score of 0%^{18,19}; (c) subjects readily took part in the study and sign the consent form. Exclusion criteria included: (a) history of shoulder trauma or current shoulder pathology (traumatic injury, glenohumeral joint dislocation, acromioclavicular joint separation, a history of shoulder and chest surgery, fracture or dislocation of the affected shoulder, inflammatory joint disease, fibromyalgia)^{3,8}; (b) Individuals under flexibility training for shoulder girdle muscles²⁰; (c) Pregnancy²¹.

At the beginning of the study, demographic details such as age, gender, height, weight, dominant arm, and shoulder activity level were obtained. All subjects had their pectoralis minor muscle resting length measured on their dominant side.

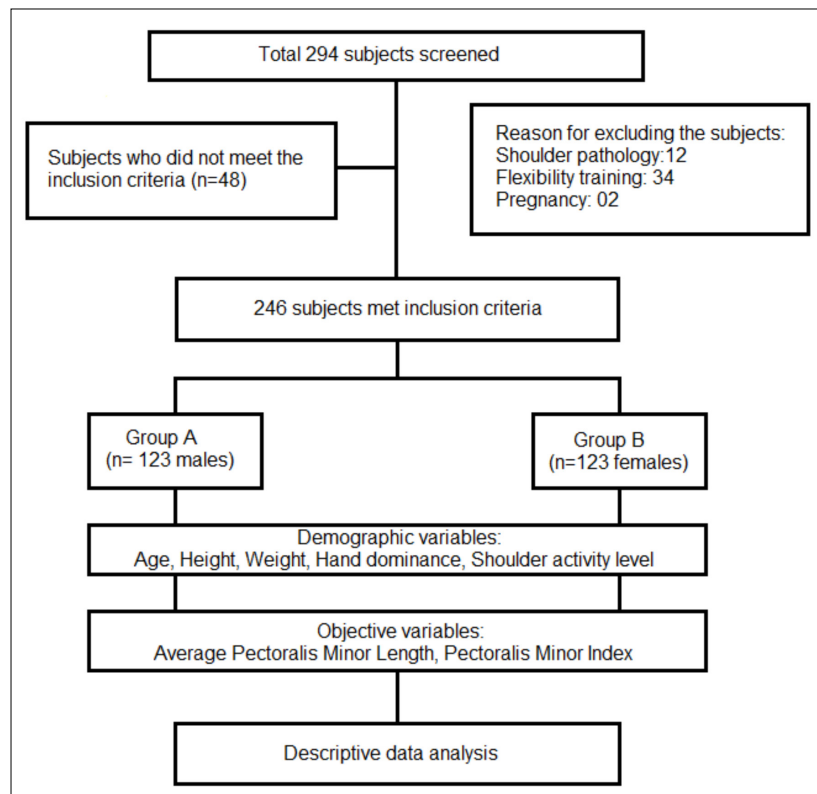


Figure 1. Consort flowchart.

Three measurements were taken, and the average was considered for the analysis. Post measurement, the PMI was calculated. The normative values for both groups were determined. The mean

PMI was compared between Group A and Group B and was analyzed using statistical tools.

Procedure

The Institutional Ethics Committee provided ethical approval. Informed consent was taken from all subjects after giving due consideration to inclusion criteria. A 4-point Likert scale was used to assess shoulder activity. For the measurement of resting PML, the procedure explained by John D. Borstad¹¹ was adopted in this research. All the subjects were made to stand in their usual posture. The following bony landmarks were marked with a semi-permanent marker: (1) medial-inferior angle of the coracoid process; (2) inferior aspect of the fourth rib. The fourth rib landmark was defined as the anterior inferior edge of the rib, 1 finger width lateral to the sternum (Figure 2). An inch tape with a 0.10 cm resolution was used to measure resting PML (Figure 3). Three measurements were taken between the two landmarks. The average of PML (AVG PML) was considered for analysis. A normalization index was developed to account for differences in muscle length and height among subjects. By dividing the resting muscle length (in cm) measurement by the



Figure 2. Landmarks.

Table I. Baseline characteristics of the participants.

Sl. No:	Variables	Range	Mean	SD	Minimum	Maximum
1	Age (years)	22	27.05	6.23	18	40
2	Height (cm)	51	164.23	9.72	137	188
3	Weight (kg)	72	62.97	13.33	34	106
4	BMI	25.88	23.32	4.44	13.79	39.67
5	Likert	3	1.90	1.04	1	4
6	AVG PML (cm)	9.35	13.77	1.73	9.18	18.53
7	PMI	5.26	8.38	0.91	5.90	11.16

height of the subject (in cm) and multiplying by 100, the pectoralis minor index (PMI) was determined. The mean PMI for the sample was calculated with the standard deviation (SD).

$$\text{Pectoralis Minor Index (PMI)} = \frac{\text{Resting Pectoralis Minor Length (PML)}}{\text{Height}} \times 100$$

Results

Statistical Analysis

The Statistical Product for Service Solution version 17 (SPSS, Inc., Chicago, IL, USA) was used to analyze the data. The value of Alpha was set to 0.05. The Mean, Standard Deviation (SD) of the demographic variable such as age, height, weight, BMI, shoulder activity level (Likert scale), and objective variables, such as average PML and PMI were determined using descriptive statistics. Normality for PML was analyzed separately in both the groups - male and female - using the Shapiro-Wilk test. In addition, Skewness, kurtosis, and its shape were also assessed. The mean, median, and mode were computed to check



Figure 3. Measuring the resting PML.

normality. The significance of PML between the groups was determined using an unpaired *t*-test. Statistical significance was set at $p < 0.05$.

Data are presented as mean \pm standard deviation (SD). Table I shows the baseline characteristics of the participants. The mean of the AVG PML was 13.77 ± 1.73 , which gives the cutoff val-

Table II. Normative value for male group.

Sl. No:	Variables	Range	Mean	SD	Minimum	Maximum
1	AVG PML (cm)	7.43	14.59	1.61	11.10	18.53
2	PMI	4.52	8.54	0.88	6.64	11.16

Table III. Normative value for female group.

Sl. No:	Variables	Range	Mean	SD	Minimum	Maximum
1	AVG PML (cm)	6.15	12.95	1.42	9.18	15.33
2	PMI	4.08	8.22	0.90	5.90	9.98

Table IV. Comparison between male and female groups.

Sl. No:	Variables	Male	Female	p-value	t-value
1	Age	26.15±6.21	27.95±6.13	<0.023	-2.29277
2	Height	170.87±7.12	157.59±7.08	<0.00001	14.66811
3	Weight	66.73±13.57	59.20±12.00	<0.00001	4.61114
4	BMI	22.77±3.92	23.88±4.86	<0.050	-1.97286
5	Likert	1.92±1.14	1.88±0.93	>0.760	0.30627
6	AVG PML	14.59±1.61	12.95±1.42	<0.00001	8.47763
7	PMI	8.54±0.88	8.22±0.90	<0.005	2.82123

ue of 12.04 irrespective of gender. The mean PMI was 8.38 ± 0.91 , which gives the cutoff value of 7.47 irrespective of gender.

Table II shows the normative value for the male group. In this study, the mean AVG PML was 14.59 ± 1.61 , which gives the cutoff value of 12.98 and the mean PMI was 8.54 ± 0.88 , which gives the cutoff value of 7.66 for short PM in males.

Table III shows the normative value for the female group. In this study, the mean AVG PML was 12.95 ± 1.42 , which gives the cutoff value of 11.53 and the mean PMI was 8.22 ± 0.90 , which gives the cutoff value of 7.32 for short PM in females.

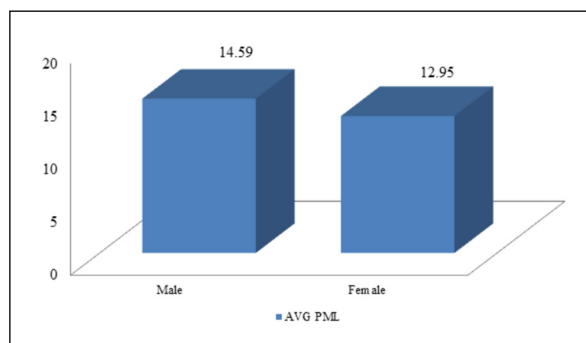
Table IV shows the comparison between male and female groups. In the Male group, the mean Likert was 1.92 ± 1.14 and in the Female group, the mean Likert was 1.88 ± 0.93 which was not statistically significant (p -value >0.760) (t -value is 0.30627). In the Male group, the mean AVG PML was 14.59 ± 1.61 and in the Female group, the mean AVG PML was 12.95 ± 1.42 which was statistically significant (p -value <0.00001) (t -value is 8.47763). (Graph I). In the Male group, the mean PMI was 8.54 ± 0.88 and in the Female group,

the mean PMI was 8.22 ± 0.90 which was statistically significant (p -value <0.005) (t -value is 2.82123) (Graph II).

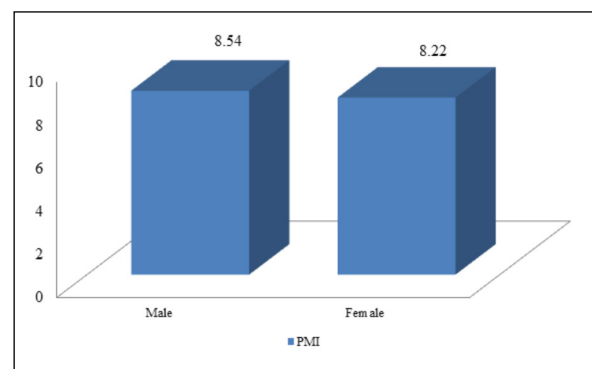
Discussion

This study has succeeded in determining the normative values for resting PML in the asymptomatic shoulder by gender in South Bengaluru and it demonstrates different values, providing separate cut-off reference values for males and females with an asymptomatic shoulder which can be used clinically. This proves the gender variability in resting PML. We found that the PMI cutoff value for short PM in our study is close to the cutoff value of 7.44 proposed by Borstad et al¹¹.

The result of our study shows a significant difference in the mean height between male and female groups (p -value <0.00001) with high variance (t -value is 14.66811), suggesting that the males were taller than females (Table IV). The shoulder activity level between the groups was not statistically significant, which clearly shows



Graph I. Mean AVG-PML among both the groups.



Graph II. Mean PMI among both the groups.

that the male and female groups exhibit the same shoulder activity level (p -value >0.760), (t -value is 0.30627). The mean AVG PML between the groups was statistically significant (p -value <0.00001), (t -value is 8.47763), suggesting that the resting PML of males was greater when compared to females. The mean PMI between the groups was statistically significant (p -value <0.005), (t -value is 2.82123), which again proved the variation of resting length of PM muscle between the two genders.

According to a study done by Perkins et al²² the mean height of Indian men is 164.74 cm (95% CI 164.67- 164.81) and Indian women are 151.92 cm (95% CI 151.88- 151.97). This study shows that Indian males are taller than females, and our results were similar to their results. According to a study conducted by Watts et al²³ body height contributes to all the anthropometric measures. They compared the adult regional body lengths and circumferences to height using a three-dimensional body imaging scanner. They discovered that as body height rises, limb lengths increase disproportionately more than head and trunk heights.

There was a study conducted in India by Amit Sharma et al¹⁷ in which they tried to estimate the cutoff reference value for short PM and correlate it with the individual's hand length. The cutoffs proposed by them are in contrast with our findings. Though the methodology used was the same in both studies, this difference in our results shows that ethnicity plays a major role. In our study, the difference in values between the groups could be because of various factors. Nonetheless, the authors believe that height could be the major rationale along with ethnicity.

Conclusions

According to the findings of this study, the normative values for resting length of pectoralis minor muscle for males are 8.54 ± 0.88 and for females 8.22 ± 0.90 with an asymptomatic shoulder. The cut-off reference values are 7.66 and 7.32 for males and females respectively, below which the subjects are characterized to have a short pectoralis minor. There is a difference in the normative values for the resting PML in the asymptomatic shoulder by gender.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethics Approval

The study protocol was approved by Institutional Ethics Committee IEC/IRB No: DSU/MPT/2020/003.with Clinical Trial Registry India: REF/2021/03/041794.

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