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Effect of Pectoralis Minor Length on Scapular Endurance and Core Endurance in Young Women

Efecto de la Longitud del Músculo Pectoral Menor en la Resistencia Escapular y de Base en Mujeres Jóvenes

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SUMMARY: Pectoralis minor (PM) are muscle groups that play a role in stabilizing the scapula. The aim of this study is to evaluate the effects of PM muscle length on scapular and core muscle endurance in the dominant and non-dominant limb. A total of 93 women were included in the study. Demographic data were recorded. PM length was measured with a caliper. Scapular muscle endurance was evaluated using the scapular isometric compression test and core endurance using McGill's torso-muscular endurance test battery. Multiple linear regression analysis revealed that dominant pectoralis minor length and pectoralis minor index and non-dominant pectoralis minor length and pectoralis minor index can affect trunk flexion and trunk extension. The longest muscle endurance time was found in the scapular test (46.32), followed by the core tests performed in extension (30.37 s), flexion (26.17 s), dominant side bridge position (10.06 s), non-dominant side bridge position (9.36 s). PM length had no effect on scapular and core muscle endurance measured in the side bridge position. In the trunk flexion and extension positions was directly related to the dominant and non-dominant PM muscle length.

KEY WORDS: Pectoralis minor length; Scapular muscle endurance; Core muscle endurance; Dominant arm.

INTRODUCTION

The shoulder joint has the largest range of motion among all the body structures. The acromioclavicular, glenohumeral, sternoclavicular, and scapulothoracic joints that constitute the shoulder joint should work in coordination with each other (Lugo *et al*., 2008). The position and movements of the scapula on the thorax have great importance for the quality of movements related to the shoulder joint. In addition, the scapula acts as a pivot in transferring the movement from proximal to distal (Moezy *et al*., 2014). The muscular and nervous system surrounding the scapula plays an essential role in this stable surface characteristic of the scapula. The trapezius, levator scapulae, rhomboid major, rhomboid minor, serratus anterior, and pectoralis minor (PM) are muscle groups involved in the stabilization of the scapula (Wong *et al*., 2010). PM is the only muscle involved in scapulothoracic stabilization in front of the shoulder joint, and the shortness of this muscle extending between the third, fourth, and fifth ribs and the coracoid process may have negative effects on the kinematics of the scapula (Umehara *et al*., 2017). It has been reported that a decrease in scapular external rotation and posterior tilt is observed in patients with a short PM, and this may be associated with posture. Therefore, it has been suggested that a short PM is also closely related to scapular dyskinesia (Provencher *et al*., 2017).

Good stabilization in the proximal region ensures the better quality of movement in distal segments (Kibler *et al*., 2006). In a previous study, it was determined that the muscles in the core region were activated before limb movements (Hodges & Richardson, 1997). It was stated that the core muscles were connected to each other with the hip and shoulder muscles through spiraling lines (the serape effect), and as a result, the contraction that occurred in core muscles was transferred to those in the hip and shoulder regions (Santana, 2003). In addition, studies have shown that the tension created

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by the movement in the spine with tensegrity has an effect on the thorax and upper limb (Lessard *et al*., 2018).

Our literature search revealed studies investigating the relationship between PM length and various parameters, such as scapular kinematics, trapezius muscle strength, and hand length in both healthy individuals and patients with shoulder-related pathologies (Borstad & Ludewig, 2005; Yesilyaprak *et al*., 2016; Sharma *et al*., 2020). However, we did not find any study exploring the relationship of PM with both scapular muscle endurance and core muscle endurance. However, in this system, which concerns the entire body kinematics, each muscle has its own importance. PM has been a muscle that has been overlooked until now. Recently, with increasing awareness, the importance of the length of this muscle has been emphasized. Determining the exact function and effect of this muscle in healthy individuals will also shed light on pathological conditions. Therefore, in the current study, we aimed to determine whether PM length was associated with scapular and core muscle endurance in young adults.

MATERIAL AND METHOD

Study protocol and participants. A total of 93 young women were included in the study. Prior to the study, ethical approval was obtained from the local ethics committee of Selcuk University (decision number: 2022/269). The study was conducted in accordance with the principles of Declaration of Helsinki. Individuals older than 18 years, who volunteered to participate in the study were included. Those that did not want to participate in the study and those with previous neurological or orthopedic upper limb disorders, pain problems in any part of their body, previous abdominal surgery, and had communication problems were excluded.

The demographic data of the participants [age, height, weight, body mass index (BMI), and dominant limbs] were recorded. To determine the dominant side, the participants were asked which hand they used while writing.

Evaluation Methods

Pectoralis Minor Length and Index. PM length was measured with a caliper. The distance between the starting (origin) and ending (insertion) points of the PM muscle was measured, with the participant in supine position and the shoulder joint free (Fig. 1). The starting point of the muscle was the inferior part of the fourth rib, 1 cm lateral to the sternocostal junction, and the ending point was the inferior part of the coracoid process. Before the measurement, the dominant limb was determined by asking the participants which hand they used to write. After the dominant limb was determined, the measurements were performed bilaterally and recorded as dominant and non-dominant side values (Lewis & Valentine, 2007).

Pectoralis minor index (PMI) was obtained by dividing the PM length recorded in cm by the person's weight and multiplying the result by 100. PMI was determined by dividing the obtained value by weight (Borstad & Ludewig, 2005).

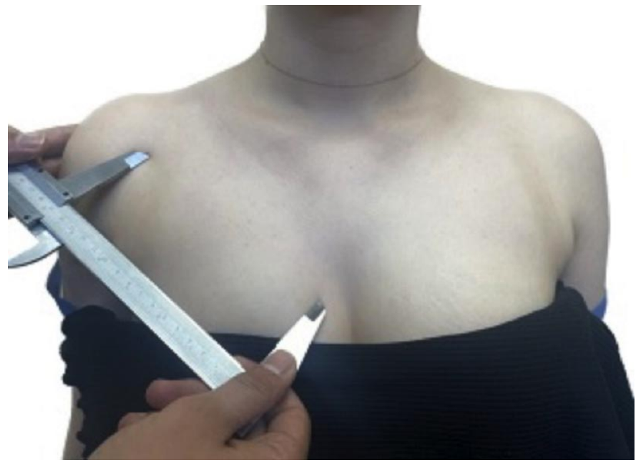

Fig. 1. Measurement of pectoralis minor muscle length taken with vernier caliper.

Scapular Muscle Endurance. Scapular muscle endurance was evaluated with the scapular isometric compression test. The participants were asked to stand upright with their arms on their sides and bring both shoulder blades closer together by maintaining this position as long as they could. When the position could no longer be maintained, the stopwatch was stopped, and the time elapsed was recorded in seconds (Fig. 2). In this test, burning and pain in the scapular region before 15 seconds indicates that scapular muscles are weak (Kibler, 2000).

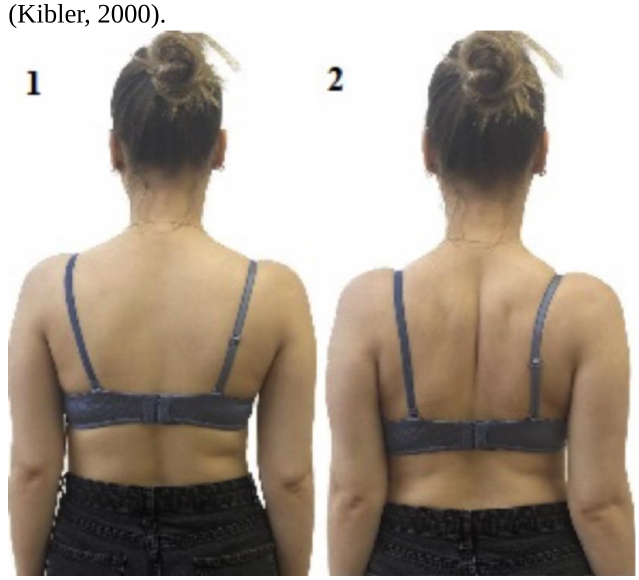

Fig. 2. The scapular isometric compression test. 1: relax position; 2:test position

Core Muscle Endurance. This evaluation was performed using McGill's torso muscular endurance test battery consisting of endurance tests in the trunk flexion, trunk extension (Sorensen), and right/left side bridge positions (McGill *et al*., 1999) (Fig. 3). In all these tests, the time that the person statically maintained the given position was recorded in seconds as described in the instructions. If the person was able to continue to perform the test by maintaining the given position, the test was terminated by the researcher at the end of 180 seconds.

In the trunk flexor endurance test, the trunk was placed at 60° flexion, the hips and knees at 90° flexion, and the foot in a stable position. The individual in the starting position was placed in the test position and asked to try to keep the trunk at 60° flexion for as long as possible. This duration was recorded.

In the Sorenson test, the individual was placed in the prone position, and the pelvis and lower limbs were positioned in a way that the anterior superior iliac spine would be aligned with the edge of the table, allowing the trunk to be free over the table. The individual was asked to cross over the shoulders and lift the trunk backwards. The test was terminated when the individual could no longer hold this position.

In the right/left side bridge position endurance test, the individual was positioned on the right/left side facing forward, with the arm perpendicular to the body and the forearm positioned parallel to the bed. The right/left leg was flexed, and the free arm was crossed over the shoulder. The individual was asked to lift the hip (trunk lateral bridging) with support from the elbows and feet. The stopwatch was started when the test position was taken, in which the shoulders, hips, and feet were in the same direction, and the time that the individual was able to maintain this position was recorded.

Statistical Analyses. The normality of the distribution of values was examined using visual and analytical methods. As descriptive analyses, mean and standard deviation values were used for normally distributed data and median (minimum-maximum) values for non-normally distributed data. Multiple regression models were constructed to determine regression coefficients and 95% confidence intervals for the relationships between dominant and non-dominant, PM length and index and LSST, scapular muscle endurance, trunk flexion, trunk extension and side bridge position. IBM SPSS Statistics v. 20.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) was used for statistical analyses. The significance level was accepted as $p < 0.05$.

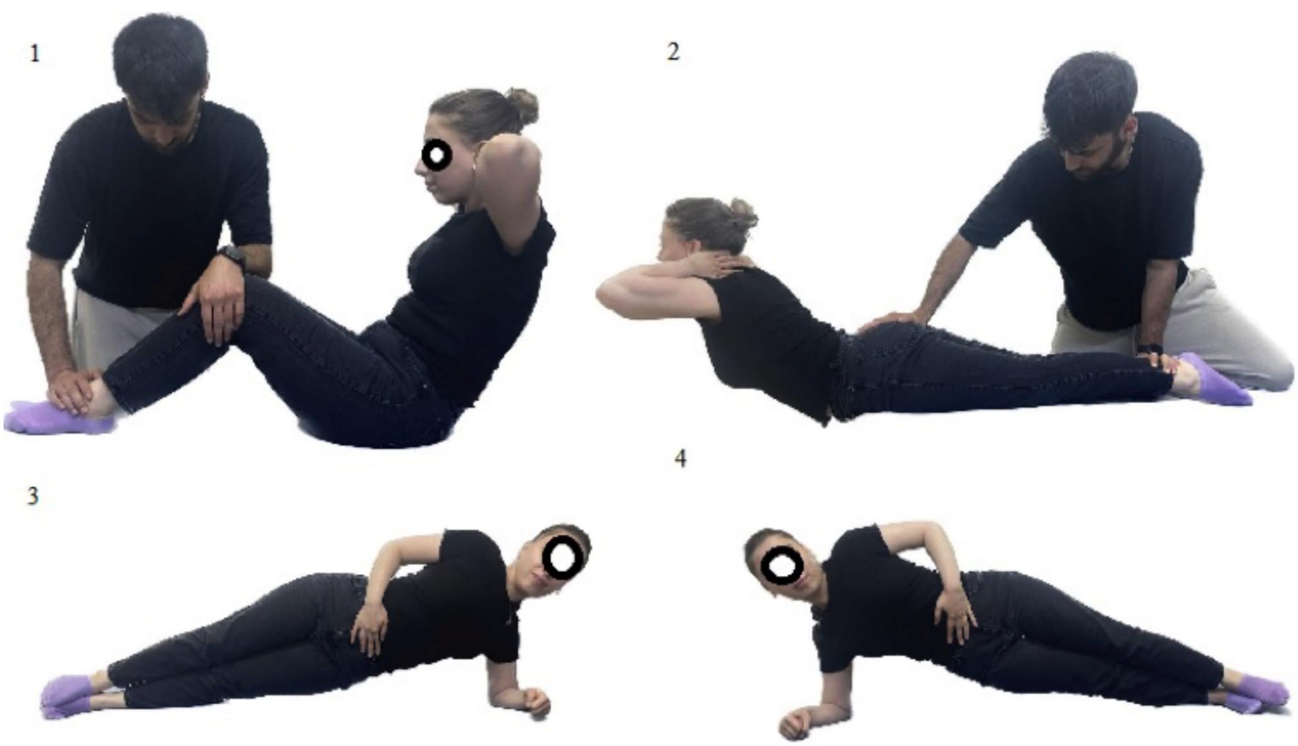

Fig. 3. Core muscle endurance test. 1: trunk flexion; 2: trunk extension (Sorensen); 3/4: right/left side bridge positions.

RESULTS

A total of 93 individuals participated in the study (Fig. 4). The mean age of the participants was 23.28 years, and their mean BMI was 22.98 kg/m^2. The demographic data of the participants are shown in Table I.

The mean scapular muscle endurance of the participants was found to be 46.32 s. PMI was calculated as 7.55 for the dominant limb and 7.58 for the non-dominant limb. In the core muscle endurance tests, trunk flexion endurance time was determined as 26.17 s, trunk extension endurance time as 30.37 s, dominant trunk endurance time as 10.06 s, and non-dominant trunk endurance time as 9.36 s. Table II presents the scapular muscle endurance, and core muscle endurance values of the participants.

A multiple linear regression was used to predict Scapular muscle endurance based on Dominant limb PM length and Dominant limb PMI. No significant regression equation was found (F(2,52)= 0.194, p=0.824), with an R^2_{adj} of 0.032. It was found that scapular muscle endurance did not significantly predict Dominant limb PM length (β = 0.123; *p* = 0.853; *η*2/p = 0.026, neither did Dominant limb PMI (β = 0.036; *p* 0.956; *η*2/p = 0.008) (Table III).

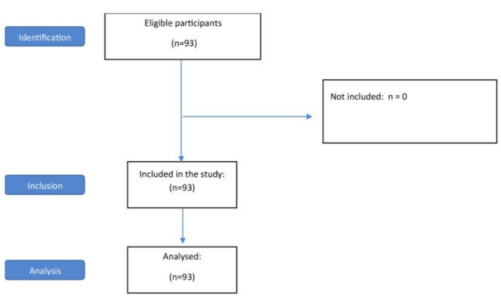

Fig. 4. STROBE flowchart.

Table I. Demographic data of the participants

	X ± SD (n = 93)	Median (min-max) (n = 93)
Age (years)	23.28 ± 7.90	20 (18-48)
Height (cm)	163.41 ± 7.03	163 (145-178)
Weight (kg)	61.28 ± 12.80	60 (44-100)
BMI (kg/m^2)	22.98 ± 4.76	21.97 (16.65-36.73)

A multiple linear regression was used to predict Trunk flexion based on Dominant limb PM length and Dominant limb PMI. A significant regression equation was found (F(2,52)= 4.09, *p*=0.023), with an R^2_{adj} of 0.106. It was found that Trunk flexion did not significantly predict Dominant limb PM length (β = 0.506; *p* = 0.414; *η*2/p = 0.116), neither did Dominant limb PMI (β = 0.854; *p* 0.171; *η*2/p = 0.193) (Table III).

A multiple linear regression was used to predict Trunk extension (Sorenson) based on Dominant limb PM length and Dominant limb PMI. A significant regression equation was found (F(2,52)= 5.49, p=0.007), with an R^2_{adj} of 0.147. It was found that Trunk extension (Sorenson) did not significantly predict Dominant limb PM length (β = 0.675; *p* = 0.266; *η*2/p = 0.157), neither did Dominant limb PMI (β = 1.059; *p* = 0.084; *η*2/p = 0.226) (Table III).

A multiple linear regression was used to predict Dominant side bridge position based on Dominant limb PM length and Dominant limb PMI. No significant regression equation was found (F(2,52)= 0.37, p=0.691), with an R^2_{adj} of 0.147. It was found that Dominant side bridge position did not significantly predict Dominant limb PM length (β = 0.083; *p* = 0.900; *η*2/p = 0.018), neither did Dominant limb PMI (β = 0.201; *p* = 0.761; *η*2/p = 0.043) (Table III).

A multiple linear regression was used to predict Scapular muscle endurance based on non-dominant limb PM length and non-dominant limb PMI. No significant regression equation was found (F(2,52)= 0.147, p=0.863), with an R^2_{adj} of 0.106. It was found that Scapular muscle endurance did not significantly predict non-dominant limb PM length (β = 0.111; *p* = 0.868; *η*2/p = 0.024), neither did non-dominant limb PMI (β = 0.036; *p* = 0.957; *η*2/p = 0.008) (Table IV).

A multiple linear regression was used to predict Trunk flexion based on non-dominant limb PM length and non-dominant limb PMI. A significant regression equation was found (F(2,52)= 3.95, p=0.026), with an R^2_{adj} of 0.102. It was found that Trunk flexion did not significantly predict non-dominant limb PM length (β = 0.504; *p* = 0.422; *η*2/p= 0.114),

Table II. Scapular muscle endurance, and core muscle endurance values of the participants.

		Mean ± SD	Median (min-max)
Scapular muscle endurance (s)		46.32 ± 20.48	45 (15-88)
Pectoralis minor length and index	Dominant limb length (cm)	12.32 ± 2.48	12.50 (6-17)
	Dominant limb index	7.55 ± 1.52	7.62 (3.61-10.63)
	Non-dominant limb length (cm)	12.38 ± 2.51	12.50 (6-17.20)
	Non-dominant limb index	7.58 ± 1.55	7.75 (3.61-10.75)
Core muscle endurance tests (s)	Trunk flexion	26.17 ± 14.65	25 (1-75)
	Trunk extension (Sorenson)	30.37 ± 14.87	27 (2-60)
	Dominant side bridge position	10.06 ± 10.71	6 (1-43)
	Non-dominant side bridge position	9.36 ± 8.97	6 (1-32)

neither did non-dominant limb PMI (β = 0.847; *p* = 0.180; *η*2/p = 0.189) (Table IV).

A multiple linear regression was used to predict Trunk extension (Sorenson) based on non-dominant limb PM length and non-dominant limb PMI. A significant regression equation was found (F(2,52)= 5.32, p=0.008), with an R^2_{adj} of 0.175. It was found that Trunk extension (Sorenson) did not significantly predict non-dominant limb PM length (β = 0.682; *p* = 0.268; *η*2/p = 0.157), neither did non-dominant limb PMI (β = 1.060; *p* = 0.088; *η*2/p = 0.239) (Table IV).

A multiple linear regression was used to predict non-dominant side bridge position based on Non-dominant limb PM length and non-dominant limb PMI. No significant regression equation was found (F(2,52)= 0.29, p=0.797), with an R^2_{adj} of 0.147. It was found that Non-dominant side bridge position did not significantly predict non-dominant limb PM length (β = 0.088; *p* = 0.896; *η*2/p = 0.019) neither did non-dominant limb PMI (β = 0.192; *p* = 0.775; *η*2/p = 0.041) (Table IV).

Table III. Multiple regression analysis for dominant-limb independent variables

Multiple regression analysis for scapular muscle endurance						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Dominant limb PM length	-1.015	-11.973	9.942	0.123	0.853	0.026
Dominant limb PMI	0.488	-17.285	18.261	0.036	0.956	0.008
R^2adj=0.032; F(2,52)=0.194; p=0.824						
Multiple regression analysis for trunk flexion						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Dominant limb PM length	2.993	-4.302	10.287	0.506	0.414	0.116
Dominant limb PMI	-8.185	-20.017	3.648	0.854	0.171	0.193
R^2adj=0.106; F(2,52)=4.09; p=0.023						
Trunk flexion = 51.102 + DLPML*2.993 – DLPMI*8.185						
Multiple regression analysis for trunk extension (Sorenson)						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Dominant limb PM length	4.048	-3.184	11.280	0.675	0.266	0.157
Dominant limb PMI	-10.299	-22.028	1.431	1.059	0.084	0.226
R^2adj=0.147; F(2,52)=5.49; p=0.007						
Sorenson= 58.263 +DLPML*4.048 – DLPMI*10.299						
Multiple regression analysis for dominant side bridge position						
Variables	B (SE)	Lower 95% CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Dominant limb PM length	0.360	-5.351	6.072	0.083	0.900	0.018
Dominant limby PMI	-1.411	-10.675	7.852	0.201	0.761	0.043
R^2adj=0.025; F(2,52)=0.37; p=0.691						

B: Unstandardized coefficients; Beta: Standardized coefficient (SC); R2: Coefficient of determination; SE: Standard Error; CI: Confidence, DEPML: dominant limb pectoralis minor length, DEPMI: dominant limb pectoralis minor index, Interval 1: Partial eta squared effect size() ; p<0.05 is considered as statistically significant.

Table IV. Multiple regression analysis for non-dominant limb independent variables.

Multiple regression analysis for scapular muscle endurance						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Non Dominant limb PM length	-0.908	-11.857	10.040	0.111	0.868	0.024
Non Dominant limb PMI	0.475	-17.250	18.200	0.036	0.957	0.008
R^2adj=0.106 F(2,52)=0.147; p=0.863						
Multiple regression analysis for trunk flexion						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Non Dominant limb PM length	2.944	-4.356	10.245	0.504	0.422	0.114
Non Dominant limb PMI	-8.001	-19.820	3.818	0.847	0.180	0.189
R^2adj=0.102 F(2,52)=3.947; p=0.026						
Trunk flexion = 50.434 + NDLPML*2.944 – NDLPMI*8.001						
Multiple regression analysis for trunk extension (Sorenson)						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Non Dominant limb PM length	4.039	-3.201	11.279	0.682	0.268	0.157
Non Dominant limb PMI	-10.164	-21.885	1.557	1.060	0.088	0.239
R^2adj=0.175; F(2,52)=5.316; p=0.008						
Sorenson = 57.495 + NDLPML*4.039 – NDLPMI*10.164						
Multiple regression analysis for dominant side bridge position						
Variables	B (SE)	Lower 95 % CI for B	Upper 95 % CI for B	Beta	p	Effect size[1]
Non Dominant limb PM length	0.374	-5.336	6.084	0.088	0.896	0.019
Non Dominant limb PMI	-1.325	-10.569	7.920	0.192	0.775	0.041
R^2adj=0.028; F(2,52)=0.293; p=0.747						

B: Unstandardized coefficients; Beta: Standardized coefficient (SC); R2: Coefficient of determination; SE: Standard Error; CI: Confidence, DEPML: non dominant limb pectoralis minor length, DEPMI: non dominant limb pectoralis minor index, Interval 1: Partial eta squared effect size() ; p<0.05 is considered as statistically significant.

DISCUSSION

This study showed the effects of PM length on scapular and core muscle endurance. The scapular muscle endurance of the participants was longer than the core endurance, and their core muscle endurance was affected by the dominant and non-dominant PM length depending on positioning.

Although there is information in the literature on how to increase core muscle endurance in which PM is primarily effective (Roche *et al*., 2015), the relationship between PM length and core muscle endurance has not yet been fully elucidated. In a study evaluating the symptomatic shoulders of female swimmers, Tate *et al*. (2012) showed that PM tension reduced core muscle endurance in the side bridge position. On the other hand, in a study conducted with athletes of different sports, Seven *et al*. (2017) reported a positive correlation between PM length and core muscle endurance. In light of these studies including symptomatic and healthy shoulders, it can be stated that a muscle of normal length, which is not tense, also positively affects core endurance. This may be related to the supply of kinetic chain biomechanics between the shoulder girdle and the lumbar region. This chain formed by the thoracolumbar fascia affects the relationship between scapular and core stabilizers by providing load and energy transfer. As a result, while the core region creates a pivot point for upper limb movements, it also affects the upper limb anatomy (Gunaydin, 2021).

Our findings showed that the time during which the participants were able to maintain in the side bridge position was considerably shorter compared to the flexion and extension positions. However, core muscle endurance in the side bridge position was not affected by the PM length. PM length affected core muscle endurance, especially in trunk flexion and extension positions. This is because while dominant and non-dominant PM muscles work together in flexion and extension positions and exhibit similar activity, in lateral raise, dominant and non-dominant PM may contract differently depending on the movement of the right/left shoulder. In other words, muscular endurance in the side bridge position is related to the harmony of the shoulder girdle and core endurance. It requires glenohumeral and scapular control in addition to external oblique abdominis and rectus abdominis control (Ludewig *et al*., 2004; Tate *et al*., 2012).

Day *et al*. (2015) reported that arm dominance did not affect scapular muscle endurance and strength. In contrast, Seven *et al*. (2017) determined that PM length positively affected scapular muscle endurance. We also found that arm dominance did not affect scapular muscle endurance. Due to the shoulder pathophysiology we excluded, the shoulder muscles may have operated within their normal biomechanical limits, and as a result, we observed no positive or negative impact on scapular muscle endurance.

As a limitation, the sports history of the participants was not questioned. Future studies should take these limitations and their possible effects into account.

This study investigated the effect of pectoralis minor length on scapular and core endurance in healthy young women. In conclusion, PM length does not have a clear effect on scapular and core muscle endurance measured in side bridge position. Core muscle endurance in the trunk flexion and extension positions is directly related to the dominant and non-dominant PM muscle length. Dominant and non-dominant side PM length should be taken into consideration in rehabilitation protocols to be applied for pathologies in the shoulder girdle in clinical practice. Physiotherapy modalities that will improve core muscle endurance should also be included in these protocols.

Highlights

• As the dominant pectoralis minor length increases, trunk core endurance decreases in flexion and extension positions.
• As non-dominant pectoralis minor length increases, trunk core endurance decreases in flexion and extension positions.
• Scapular endurance is higher than trunk endurance in healthy individuals.

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CIHAN, E.; PIRINÇÇI, S. C.; GERÇEK, H.; ÖZKUNDURACI, M. & KARASOY, O. Ö. Efecto de la longitud del músculo pectoral menor en la resistencia escapular y de base en mujeres jóvenes. *Int. J. Morphol., 43(2)*:344-350, 2025.

RESUMEN: El musculo pectoral menor (MPM) forma parte de un grupo de músculos que desempeña un papel en la estabilización de la escápula. El objetivo de este estudio fue evaluar los efectos de la longitud del MPM en la resistencia de los músculos escapulares y de base, en el miembro dominante y no dominante. Se incluyó a un total de 93 mujeres en el estudio. Se registraron datos demográficos y la longitud del MPM se midió con un calibrador. La resistencia del músculo escapular se evaluó utilizando la prueba de compresión isométrica escapular y la resistencia central utilizando la batería de pruebas de resistencia muscular del torso de McGill. El análisis de regresión lineal múltiple reveló que la longitud del MPM dominante y el índice del MPM y la longitud del MPM no dominante y el índice del MPM pueden afectar la flexión y extensión del tronco. El mayor tiempo de resistencia muscular se encontró en la prueba escapular (46,32), seguido de

las pruebas de base realizadas en extensión (30,37 s), flexión (26,17 s), posición de puente lateral dominante (10,06 s) y posición de puente lateral no dominante (9,36 s). La longitud del MPM no tuvo efecto sobre la resistencia de los músculos escapular y de base, medida en la posición de puente lateral. En las posiciones de flexión y extensión del tronco, la longitud del músculo MPM dominante y no dominante se relacionó directamente con la longitud del músculo MPM.

PALABRAS CLAVE: Longitud del músculo pectoral menor; Resistencia del músculo escapular; Resistencia muscular de base; Miembro superior dominante.

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