

Geometric Morphometric Study of the Scapula in Thais ศึกษากระดูกสะบักในคนไทยด้วยวิธี จีโอเมตริก มอร์โฟเมตริก

Peeranon Tungnake (พรีนันท์ ถึงนาค)* Dr.Sitha Piyaselakul (ดร.สิทธา ปิยสีลกุล)**

ABSTRACT

This study aims to investigate shape, size of anterior and posterior aspects and glenoid fossa of the scapula in Thais by using geometric morphometric technique. Genders, sides and age groups were compared. One hundred and sixty cadaveric scapulae (mean age 54.44 years) were collected and dissected. Photograph of the anterior, posterior aspects and glenoid fossa of the scapula in the standardized position were analyzed shape discrimination and size by using CLIC99 (Collection of Landmarks for Identification and Characterization) program with outline base of geometric morphometric technique. The results showed significantly shape difference in anterior and posterior aspects of scapula between genders and age groups. The significant size difference was only found in gender comparison and shown larger in male. The shape of glenoid fossa showed significant difference in sides and age groups comparison but showed no significant difference between the genders. Size of glenoid fossa showed significant larger in male and elderly group.

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษารูปร่าง ขนาดพื้นผิวด้านหน้าและด้านหลัง และแอ่งกลีนอยด์ของกระดูกสะบักในคนไทยด้วยวิธีจีโอเมตริก มอร์โฟเมตริก เปรียบเทียบระหว่างเพศ ข้าง และกลุ่มอายุ กระดูกสะบักของอาจารย์ใหญ่จำนวน 160 ชิ้น (อายุเฉลี่ย 54.44 ปี) ถูกรวบรวมและชำแหละเนื้อเยื่อโดยรอบออกเพื่อให้เห็นพื้นผิวกระดูกอย่างชัดเจน จากนั้นกระดูกสะบักทั้งหมดถูกนำมาถ่ายภาพพื้นผิวทางด้านหน้าและด้านหลัง และแอ่งกลีนอยด์ และนำไปวิเคราะห์ความแตกต่างของรูปร่างและขนาดโดยโปรแกรม CLIC99 ด้วยวิธี Outline ของจีโอเมตริกมอร์โฟเมตริก ผลการศึกษาพบความแตกต่างของรูปร่างของกระดูกสะบักทั้งด้านหน้าและด้านหลังอย่างมีนัยสำคัญทางสถิติระหว่างเพศและกลุ่มอายุ ส่วนขนาดพบความแตกต่างอย่างมีนัยสำคัญในการเปรียบเทียบระหว่างเพศเท่านั้นและเพศชายมีขนาดใหญ่กว่า รูปร่างของแอ่งกลีนอยด์พบความแตกต่างอย่างมีนัยสำคัญเมื่อเปรียบเทียบในกลุ่มข้างและกลุ่มอายุ แต่ไม่พบความแตกต่างระหว่างเพศ ส่วนขนาดของแอ่งกลีนอยด์พบว่ามีความใหญ่อย่างมีนัยสำคัญในเพศชายและผู้สูงอายุ

Keywords: Geometric Morphometric, Scapula, Glenoid fossa

คำสำคัญ: จีโอเมตริก มอร์โฟเมตริก กระดูกสะบัก แอ่งกลีนอยด์

* Student, Master of Science Program in Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University

** Associate Professor, Department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University

Introduction

The scapula is a flat triangular-shaped bone and part of it form the glenohumeral or shoulder joint. It situates on a posterolateral aspect of chest wall and covering parts of the second to seventh ribs. The bone has two surfaces; anterior and posterior, three borders; superior, medial and lateral and three angles; superior, inferior and lateral (Ludvigsen, 2015).

A shoulder joint is formed by a hemispheric head of the humerus and a shallow socket glenoid fossa of the scapula. The articular surfaces of two bones are disproportion causing this joint instable but move freely and widely. However, the shoulder joint is the prime joint holding entire upper limb to the trunk. Therefore, the joint requires stability during movement and part of scapula is static stabilizer of the shoulder joint (Lugo et al., 2008). Shoulder joint is the most mobile joint and least stable of human body thus it leads to joint instability, subluxation, dislocation or pathologic change of shoulder (Romanes, 1981). Previous studies reported variation of costal surface of scapula may disrupt scapulothoracic rhythm and cause snapping scapula (Spiegl et al., 2015). The bony structure of the shoulder joint is an important component of shoulder stability especially the shape of the scapular body and glenoid fossa (Lugo et al., 2008).

Several studies have been reported morphometric information and morphology of scapula in cadaver and radiological imaging of various population and races. Dabbs and Moore-Jansen (2012) reported an age-related change of the scapula according to sex and ancestral group. They studied 804 human mature dry scapulae in black and white populations using linear measurement total twenty three observations the measurements were designed to determine the size and shape of scapula. The result showed age related changes in size and shape of the scapula and thickening of border. There were decrease overall size and length of spine in white male and female. Scholtz et al. (2010) studied the shape differences of scapula between genders by using landmark-based geometric morphometric technique. They plotted 21 landmarks on the dorsal aspect of scapula body except glenoid fossa, spine and acromion process. The result showed difference between genders especially the superior border of the female scapula was more convex than the male. There are quite a few works on morphology of scapula, mostly using linear measurement and recently geometric morphometric method in various ethnic groups. However, there is still scant in Thai.

Recently, a geometric morphometric has been used successfully and widely to describe shape and size of an object especially those having irregular form. The geometric morphometric is a method for analysis of shape variation by using the rigorous multivariate statistical combined with Procrustes analysis. This approach focus on analyzes and visualize shape variation between samples using Cartesian coordination system to register the shape data. Shape of specimen embodied by perimeter, contour, curve or landmarks are keeping as a two- or three-dimensional configuration. Geometric morphometric is divided into outline and landmark based according to the shape data obtaining method. The technique uses x/y coordinates of landmarks taken from the object to quantify the shape and give more accurate result than linear measurement (Adams et al., 2004; McKeown et al., 2013).

Objectives of the study

To investigate shape and size of the costal surface, dorsal surface and glenoid fossa of the scapula in Thais as comparison between genders, sides and age groups by using geometric morphometric technique.

Methodology

This study has been approved from the Siriraj Institutional Review Board (SIRB 059/2561). One hundred and sixty scapulae were obtained from the formalin embalmed Thais cadavers at department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University. The pair scapulae of 40 males and 40 females were used. Mean age 54.44 years (ranged 19- 93 years). Exclusion criteria are fracture or blemish bone and having pathological condition of the scapula. Scapulae are investigated in pair, specimens were collected both sides. Soft tissue was removed and shoulder joint was disarticulated. Later, all scapulae were soaked in 40% potassium hydroxide solution for 24 hours to macerate remain soft tissue. The specimens must be clean and clearly visible of all surfaces for taking a photo. The scapulae were grouped in genders sides and age (≤ 59 years and ≥ 60 years).

All scapulae were photographed by a digital camera (Canon EOS 1000d). The photo will have been taken in anterior, posterior surfaces and lateral aspect of glenoid fossa. The specimen was set at constant distance at 34 cm perpendicular away from the lens for anterior and posterior surface while the glenoid fossa was set 51 cm away from the lens as shown in figure 1a, 1b.

In order to ensure the same position and alignment, the scapulae were placed on the board and using scale grid system of the EOS utility 2.9 program for adjusting the constant scapula position the glenoid image was taken from scapula fastened vertically to the metal rod and the glenoid fossa faced parallel to the camera lens.

Geometric Morphometric

The digitized images were transferred to CLIC99 (Collection of Landmarks for Identification and Characterization) program for shape and size analysis. The CLIC99 program was developed by Dr. Jean Pierre Dujardin. Initially, all images were filed according to gender, sides and ages into folders. Each folder will be designated as male and female, left and right, and anterior view, posterior view and glenoid fossa respectively. After importing the image, the coordinate of scapular outline was collected via COO module by plotting the contour of the anterior and posterior scapula and glenoid fossa. The plotting always started at inferior angle and continued on the lateral border and finished at medial border. The glenoid fossa starts from supraglenoid tubercle to anterior border and finish at posterior border of the fossa. The plot always kept constant interval and more plot on the curve or irregular area. Later, the CLIC99 program generated shape co-ordinate of all images. Procrustes analysis was done by the program and finally generated the mean shape. The shape discrimination analysis was carried out by Elliptical Fourier analysis (EFA) and multivariate statistical analysis.

The comparison study between gender, sides and age groups were taken. The statistical significant was set at p-value < 0.05 .

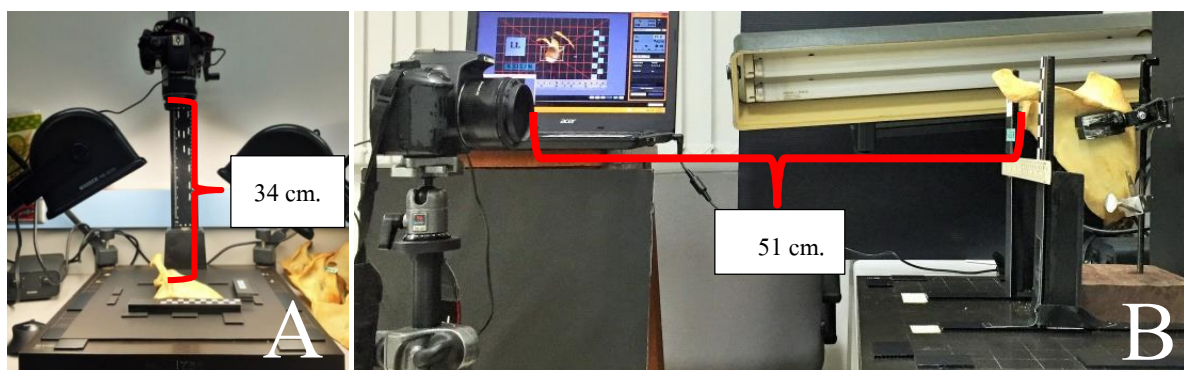


Figure 1 Illustration of instrument setting for photographs the anterior surface, posterior surface of scapula (A). And glenoid fossa (B) with monitoring screen with scale on the left top.

Results

The result of scapula contour on anterior aspect showed significant difference of shape between gender and male scapula was significant larger than female. Comparison between age groups also showed significant difference of shape but not for the side comparison. (Table 1, Figure 2). Similar results were found in the posterior aspect of scapula as shown significant difference of shape between gender and age groups but not in side comparison (Table 1, Figure 3).

Interestingly, the mean shape of glenoid fossa showed no significant difference between gender and age group but only in comparison between sides. The size of male and ages greater-Than or Equal to 60 was significant larger (Table 1, Figure 4).

Table 1 The comparisons of the anterior surface, posterior surface and glenoid fossa of scapula between gender, sides and age groups.

Comparison	Anterior surface		Posterior surface		Glenoid fossa	
	Shape	Size	Shape	Size	Shape	Size
Gender	0.000*	0.000*	0.000*	0.000*	0.522	0.000*
Sides	0.306	0.428	0.078	0.386	0.003*	0.557
Ages	0.000*	0.392	0.000*	0.095	0.000*	0.001*

Note: p-value < 0.05* is significant difference

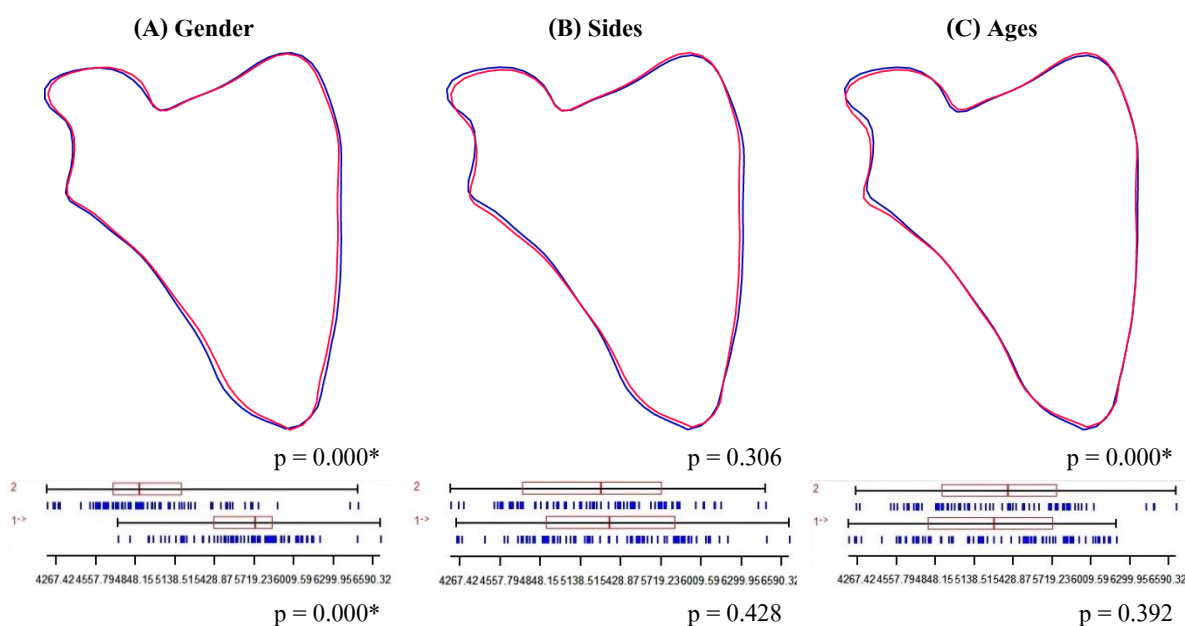


Figure 2 The mean shape of anterior surface of scapula showed different shape and size. The box scale (below) showed the size. (A) Between Male = ●, 1 / Female = ●, 2 (B) Between Right = ●, 1 / Left = ●, 2 (C) Between < 60 years = ●, 1 / ≥ 60 years = ●, 2

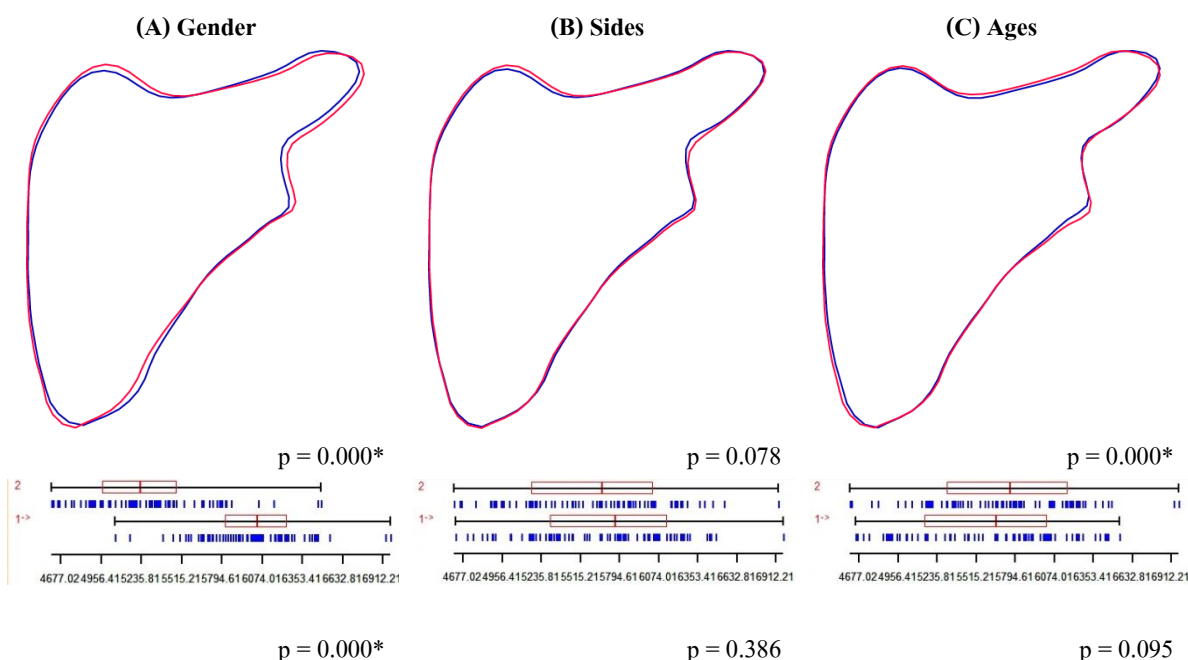


Figure 3 The mean shape of posterior surface of scapula showed different shape and size. The box scale (below) showed the size. (A) Between Male = ●, 1 / Female = ●, 2 (B) Between Right = ●, 1 / Left = ●, 2 (C) Between < 60 years = ●, 1 / ≥ 60 years = ●, 2

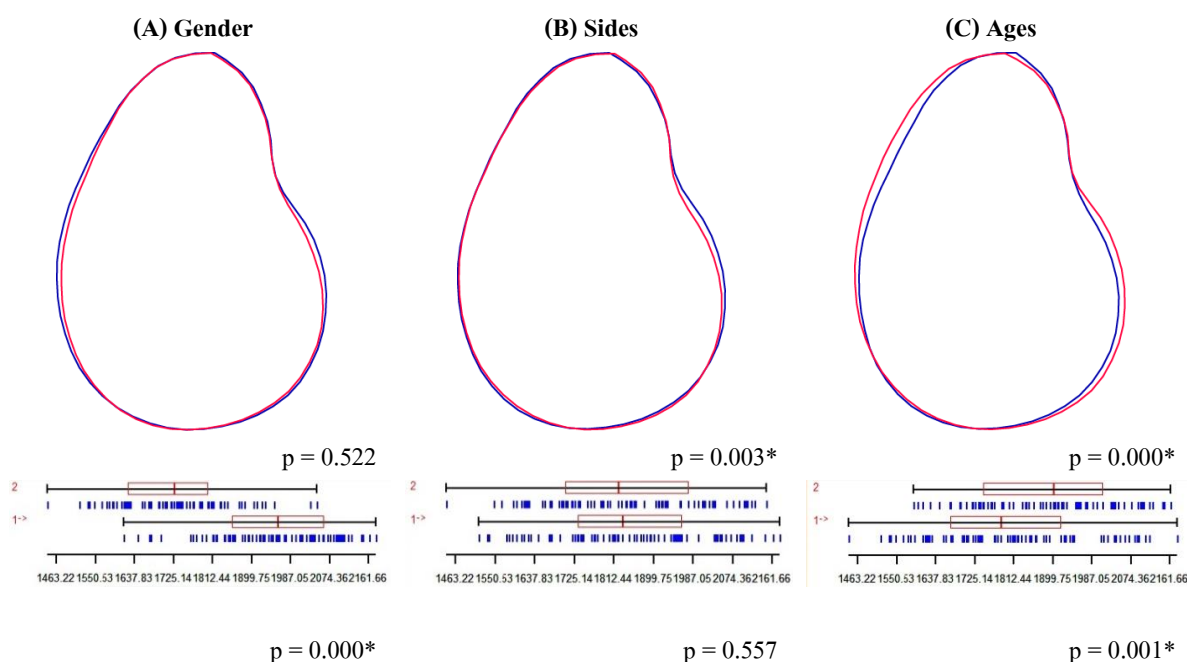


Figure 4 The mean shape of glenoid fossa of scapula showed different shape and size. The box scale (below) showed the size. (A) Between Male = ●, 1 / Female = ●, 2 (B) Between Right = ●, 1 / Left = ●, 2 (C) Between < 60 years = ●, 1 / ≥ 60 years = ●, 2

Discussion and Conclusions

This study revealed variable morphology of scapula in Thais cadavers which indicated significant difference of body contour between genders and age groups, similarly found in glenoid fossa and also different in sides comparison. Several studies on scapular morphology have been reported variable of size of scapular body and glenoid fossa which mostly using linear measurement or metrical method (Gopal et al., 2018; Shimozone et al., 2017; Torrens et al., 2008; Phonphok and Kulkamthorn, 2014). All the results came to general agreement as male scapula larger than female and different among ethnic groups (Cabezas et al., 2016; El-Din and Ali., 2015; Dabbs and Moore-Jansen, 2012). Although, the geometric morphometric study of human scapula was still rare, so far only one was found (Scholtz et al., 2010). The present study was using outline-based geometric morphometric method to verify the shape variable of comparable sex, side and age groups. As previous studies mostly reported the size variation of scapula which confirmed the size effect on shape variable, thus geometric morphometric method ensured the shape information by eliminating the size effect.

The result demonstrated significant difference in shape and size of the scapula between genders which corresponded to Scholtz et al. (2010) reported the broader shape, curved medial border and sharper inferior angle in male. The reasons for this could be the greater pulling force of the muscles attached on the scapular borders as well as ontogenetic or hereditary factors also played an important role in determining its shape (Chaijaroonkhanarak et al., 2018; Hrdlička, 1942).

Recent study of Chaijaroonkhanarak et al. (2018) reported significant larger scapula in male but no shape difference in terms of scapular index which disagreed with present study. This is one of the evidence a benefit of geometric morphometrics. Comparison between age groups, showed significant difference of scapula shape both anterior and posterior aspects but no size difference which corresponded to Totlis et al. (2014) reported significant shape difference of contour of scapula between oldest age and young group ($p < 0.001$). These could be caused by activity-related. During age advanced, physical activity declined and led to disrupt normal mechanobiological process and finally caused transformation of bony shape (Kuhns, 1945).

The glenoid fossa of scapula showed significant larger in male and ages greater-Than or Equal to 60 corresponded to previous studies. Phonphok and Kulkamthorn (2014) studied glenoid size in 160 Thai peoples using 3D CT reconstructed images and compared with Caucasian. They measured in anteroposterior (AP) and superoinferior (SI) dimensions and reported significantly larger glenoid in male. Similar to the results of Peckmann et al. (2017) studied glenoid cavity in Thais skeletal showed male glenoid fossa was larger than female.

The glenoid fossa result was analogous to that of scapular body. Interestingly, the significant difference of glenoid shape between sides but not the size, the right glenoid fossa showed broader fossa than the left which contributed to the dominant arm. The more movement on the dominant limb caused more mechanical force affected on greater bone formation.

In conclusion, this study revealed the difference in shape and size of scapular body and glenoid fossa between gender and age group in Thai population. Only the glenoid fossa showed significant difference between sides which showed the right glenoid was broader. This will be crucial information for shoulder arthroplasty and also further biomechanical study.

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