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A study of morphology and morphometry of scapula in North Indian population and its evolutionary significance

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Abstract. *Introduction.* Morphometrics can quantify a trait of evolutionary significance and deduce something of their ontogeny or evolutionary relationships. The present study intends to establish the morphometric criterion of scapula in North Indians. This is of definite significance as bone morphology is known to be influenced by cultural, environmental and racial factors. *Materials and methods.* The present study was carried on 100 adult scapulae of unknown sex obtained from Department of Anatomy, Government Medical College, Amritsar. The parameters studied were length of scapula; maximum breadth of scapula; superoinferior length, transverse breadth and depth of supraspinous fossa; length of infraspinous fossa, maximum breadth of infraspinous fossa, infraspinous fossa breadth, groove for circumflex scapular vessels and its distance from lateral angle and inferior angle, ridge between origin of teres minor and teres major on lateral border of infraspinous fossa, length of attachment of teres minor on infraspinous fossa, length of attachment of teres major on infraspinous fossa; scapular index and infraspinous index. *Results.* The values of the parameters were found to be more on the right side except superoinferior length of supraspinous fossa, mean distance of the groove from the lateral angle and inferior angle. Mean scapular index and mean infraspinous index were 68.30 and 76.40 respectively. *Discussion.* The various morphologic parameters studied and morphometric values measured in our study can be used to compare the racial characteristics and study the evolutionary aspects in different populations.

Keywords: length of scapula, breadth of scapula, supraspinous fossa, infraspinous fossa, scapular index.

INTRODUCTION

The four components of the biological profile include age, sex, ancestry and stature. These four factors are important to law enforcement officials as

they aid in the ability to positively identify human skeletal remains[1]. Morphometrics is a field concerned with studying variation and change in the form (size and shape) of organisms or objects. It can quantify a trait of evolutionary significance and deduce something of their ontogeny or evolutionary relationships. Also it adds a quantitative element to descriptions, allowing more rigorous comparisons[17].

Establishment of identity of an individual by studying skeletal remains has always posed a challenging problem for forensic experts[5] who are confronted with a single bone on which they are asked to give an opinion as to age, sex and stature of the individual[13].

The scapula is potentially useful in estimating stature for several reasons. First, in the absence of other intact bones, measurements taken from the scapula might be useful for estimating stature. Second, scapular measurements that can be reliably employed in estimating height are standardized and easy to locate[2]. Third, scapula might be useful in discriminant function analysis because the measurements can be taken from incomplete bones[9].

The present study intends to establish the morphometric criterion of scapula in North Indians. This is of definite significance as bone morphology is known to be influenced by cultural, environmental and racial factors.

MATERIALS AND METHODS

The material for the present study comprised of 100 adult scapulae of unknown sex, obtained from Department of Anatomy, Govt. Medical College, Amritsar. These scapulae were thoroughly cleaned and boiled and were free from any physical deformity or abrasion and were complete in all respects i.e. the upper and the lower ends were intact, so as to give the correct measurements. These were non pathological. They were labelled from 1-100 with suffix R (Right) or L (Left). The following morphological features were observed and morphometric measurements were taken.

1. **Length of Scapula:** It was measured with the help of vernier calipers from the superior angle to the inferior angle[12] (AB in Fig. 1)**.**
2. **Maximum breadth of scapula** (Termed as **Morphological Length** by **Corruccini and Ciochon**)[3]**:** It was measured with the help of vernier calipers as the maximum distance between the middle of the dorsal border of the glenoid fossa to the end of the spinal axis at the vertebral border (AB in Fig. 2).
3. **Supraspinous fossa:**

a. *Superoinferior length* (Termed as **Supraspinous Fossa Breadth** by **Corruccini and Ciochon**)[3] : It was measured with the help of depth bar of vernier calipers as the shortest distance between superior angle and superior surface of spine of scapula (CD in Fig. 2).

b. *Transverse breadth*: It was measured with the help of vernier calipers from spinoglenoid notch to a point on the medial border where the root of spine joins it (AB in Fig. 3).

c. *Depth*: For measuring the depth of supraspinous fossa, a scale was kept touching the superior angle of scapula and upper lip of crest of spine at a point opposite to the point where lateral end of deltoid tuberosity meets lower lip of the crest of the spine. Then the maximum depth was measured with the help of depth bar of vernier calipers as shown in photograph 1 .

4. **Infraspinous fossa:**

a. *Length*: It was measured with vernier calipers from spinoglenoid notch to inferior angle (EF in Fig.2).

b. *Maximum breadth:* It was measured with the help of vernier calipers from infraglenoid tubercle to root of spine (AG in Fig.2).

c. *Infraspinous fossa breadth*: It was measured as distance between inferior angle and midpoint of attachment of spine on medial border of scapula [16].

d. *Groove for circumflex scapular vessels*: It was observed on lateral border of infraspinous fossa. If demarcated, its distance from lateral and inferior angles were measured with the vernier calipers (HI & JK in Fig.2).

e. *Ridge between origin of teres minor and teres major on lateral border of infraspinous fossa*: It was observed for its presence or absence an if present whether it was inclined obliquely or transversely.

f. *Length of attachment of teres minor on infraspinous fossa*: It was measured with the help of vernier calipers (LM in Fig.2).

g. *Length of attachment of teres major on infraspinous fossa:* It was measured with the help of vernier calipers (NO in Fig.2).

5. **Scapular index : breadth/length *100**
6. **Infraspinous index : Breadth/infraspinous length*100**

RESULTS

1. Length/Height of bone

The mean length of scapula was found to be 140.55 mm (Range = 111.14 -162.58 mm) with 143.02 mm (Range = 112.97 – 162.58 mm) on the right side and 138.08 mm (Range = 111.14 – 158.51 mm) on the left side. When compared on both the sides, the length was larger on the right side as compared to the left side (Table 1).

Table 1.

Parameter	Mean (mm)			Range(mm)		
	R	L	Total	R	L	Total
Length of scapula	143.02	138.08	140.55	112.97-162.58	111.14-158.51	111.14-162.58
Breadth of scapula	96.79	95.22	96.00	84.19-114.66	82.69-110.54	82.69-114.66
Length of medial border	162.36	157.20	159.78	129-193	131-186	129-193
Supraspinous fossa						
a)Length	31.75	32.76	32.25	18.15-42.72	11.79-45.44	11.79-45.44
b)Transverse breadth	81.39	81.60	81.50	64.72-96.53	67.85-96.11	64.72-96.53
c)Depth	18.83	16.51	17.67	12.69-26.42	9.82-25.42	9.89-26.42
Infraspinous fossa						
a) Length	130.29	126.97	128.63	111.10-147.57	100.18-142.90	100.18-147.57
b) Maximum breadth	97.99	98.55	98.27	77.98-111.31	82.14-138.25	77.98-138.25
c) Breadth	106.38	103.12	104.75	80.59-119.32	85.40-126.64	80.59-126.64
d) Distance of groove from lateral angle	22.79	24.98	23.88	19.90-54.03	14.16-45.94	14.16-54.03
e) Distance of groove from inferior angle	61.85	62.57	62.21	74.70-110.14	69.57-113.96	69.57-113.96
f) length of attachment of teres minor	50.51	40.77	45.64	25.97-92.75	46.87-77.72	25.97-92.75
f) length of attachment of teres major	33.76	24.35	29.06	19.24-82.36	23.02-58.78	19.24-82.36
Scapular index	67.78	68.96	68.30			
Infraspinous index	75.21	77.62	76.40			

2. Maximum breadth

The mean breadth was found to be 96.00 mm (Range = 82.69 – 114.66 mm). On the right side it was found to be 96.79 mm (Range = 84.19 – 114.66 mm) and on the left side, it was found to be 95.22 mm (Range = 82.69 – 110.54 mm). On comparing both the sides, the mean breadth was more on the right side as compared to the left side (Table 1).

3. Supraspinous fossa

(a) Superoinferior length (supraspinous fossa breadth)

The mean for superoinferior length of supraspinous fossa (supraspinous fossa breadth) was found to be 32.25 mm (Range = 11.79 – 45.44 mm). On the right side, it was observed to be 31.75 mm (Range = 18.15 – 42.72 mm) and on the left side, it was found to be 32.76 mm (Range = 11.79 – 45.44 mm). Thus it was slightly greater on the left side than on the right side (Table 1).

(b) Transverse breadth (supraspinous fossa)

The mean value found for the transverse breadth of supraspinous fossa was 81.50 mm (Range = 64.72 – 96.53 mm). It was 81.39 mm (Range = 64.72 – 96.53 mm) on the right side and 81.60 mm (Range = 67.85 – 96.11 mm) on the left side (Table 1 and 4).

(c) Depth of supraspinous fossa

The mean depth of supraspinous fossa was found to be 17.67 mm (Range = 9.89 – 26.42 mm). On the right side it was found to be 18.83 mm (Range = 12.69 – 26.42 mm) and on the left side it was 16.51 mm (Range = 9.82 – 25.42 mm). Thus it was found to be more on the right side than the left side (Table 1).

4. Infraspinous fossa

(a) Length of infraspinous fossa from spinoglenoid notch to inferior angle

Its mean value was found to be 128.63 mm (Range= 100.18 – 147.57 mm). On the right side it was seen to be 130.29 mm (Range=111.10 – 147.57 mm) and on the left side it was 126.97 mm (Range = 100.18 – 142.90 mm). Thus it was seen that the values for the right side were higher than those for the left (Table 1).

(b) Maximum breadth of infraspinous fossa

The mean value for maximum breadth of infraspinous fossa was found to be 98.27 mm (Range = 77.98 –

138.25 mm). It was found to be 97.99 mm (Range = 77.98 – 111.31 mm) on the right side and 98.55 mm (Range= 82.14 – 138.25 mm) on the left side. So it was seen that the value for the left side were more than the right side (Table 1).

(c) Infraspinous fossa breadth

The mean value for infraspinous fossa breadth was observed to be 104.75 mm (Range = 80.59 – 126.64 mm). The mean observed on the right side was 106.38 mm (Range = 80.59 – 119.32 mm) and on the left side was 103.12 mm (Range = 85.40 – 126.64 mm). Thus the values on right side were more than the left side (Table 1).

(d) Groove for circumflex scapular vessels

The groove for circumflex scapular vessels was distinct in 33 (66%) bones and indistinct in 17 (34%) bones on the right side. It was distinct in 35 (70%) bones and indistinct in 15 (30%) bones on the left side.

The mean distance of the groove from the lateral angle was observed to be 23.88 mm (Range = 14.16 – 54.03 mm). On the right side, it was 22.79 mm (Range = 19.90 -54.03 mm) and on the left side, it was 24.98 (Range = 14.16 – 45.94 mm). Thus the value for left side was more than the right side.

The mean distance of the groove from the inferior angle was observed to be 62.21 mm (Range = 69.57 – 113.96 mm). It was observed to be 61.85 mm (Range = 74.70 – 110.14 mm) on the right side and 62.57 mm (Range = 69.57 – 113.96 mm) on the left side. Thus the value for this parameter was also more for the left side.

Thus it was seen that the distance of the groove was more from the inferior angle than the lateral angle.

(e) Ridge between origin of teres minor and major

On the right side, it was observed to be present in 38 (76%) bones and absent in 12 (24%) bones while on the left side, it was present in 32 (64%) bones and absent in 18 (36%) bones. Out of these, in majority, it was obliquely inclined (35 on the right side and 27 on the left side) while in the rest (3 on right side and 5 on left side), it was transversely inclined. Standring et al[15] has also mentioned this ridge to be obliquely inclined.

(f) Length of attachment of teres minor

The mean length of attachment of teres minor was found to be 45.64 mm (Range = 25.97 – 92.75 mm). On the right side it was 50.51 mm (Range = 25.97 – 92.75 mm) while on the left side it was 40.77 mm (Range = 46.87 – 77.72 mm). Thus the length occupied by teres minor was much more on the right side as compared to the left side (Table 1).

(g) Length of attachment of teres major

The mean length of attachment of teres major was observed to be 29.06 mm (Range = 19.24 – 82.36 mm). On the right side it was 33.76 mm (Range = 19.24 – 82.36 mm) while on the left side it was 24.35 mm (Range = 23.02 – 58.78 mm). Thus the length occupied by teres major was much more on the right side as compared to the left side (Table 1).

From the above two parameters it can be inferred that the length of attachment of teres minor on scapula is much more than that of teres major.

5. Scapular index

Mean scapular index was seen to be 68.30. It was observed as 67.68 on the right side and 68.96 on the left side (Table 1).

6. Infraspinous index

Mean infraspinous index was observed to be 76.40. It was observed as 75.21 on the right side and 77.62 on the left side (Table 1) .

DISCUSSION

Table 2 compares length of scapula in different races as mentioned in the literature. Von Schroeder et al[16], Piyawinijwong et al[12], Coskun et al[4], Ozer et al[10] (maximum scapular height), Paraskevas et al[11], Singhal et al[14], Krishnaiah et al[8], and Jacinth and Vikraman[7] studied the parameter before and there were some variations in their results. These variations could be attributed to racial factors. Our results are in consonance with those of Singhal et al[14].

Earlier Von Schroeder et al[16], Piyawinijwong et al[12], Singhal et al[14], Krishnaiah et al[8], and Jacinth and Vikraman[7] had measured the maximum breadth of scapula (Table 3). Our results were in consonance with those of Piyawinijwong et al[12], Singhal et al[14] and Jacinth and Vikraman[7].

Coskun et al[4] also worked upon the superoinferior length (supraspinous fossa breadth) and reported that mean length was 43 mm (Range = 24.6-58.4). Our values were less than those found by them. This could be attributed to racial factors.

Von Schroeder et al[16] and Piyawinijwong et al[12] measured transverse breadth of supraspinous fossa. The results observed in our study were more than Piyawinijwong et al[12] but less than Von Schroeder et al[16].

Table 2. Showing comparison of maximum length of human scapula.

Authors	Race	Mean (n) (mm)		Range(mm)	
		Right	Left	Right	Left
Von Schroeder et al[8]	Canadian	155 (30)		127-179	
Piyawinijwong et al[12]	Thais	131.1 (97)		115.7-159.6	
Coskun et al[4]	Turkish	98.8(90)		76-115	
Ozer et al[10]	Anatolian	144.41(186)			
Paraskevas et al[11]	Greek	147.6 (88)		129-168	
Singhal et al[14]	Gujarati	141.7			
Krishnaiah et al[8]	Nalgonda	143.27			
Jacinth and Vikraman[7]	Tamil	133			
Present study	North Indian	140.55 (100)		111.14 – 162.58	
		143.02(50)	138.08(50)	112.97-162.58	111.14-158.51

Table 3. Showing comparison of maximum breadth of human scapula.

Authors	Race	Mean (n) (mm)		Range (mm)	
		Right	Left	Right	Left
Von Schroeder et al[16]	Canadian	106.0 (30)		92-122	
Piyawinijwong et al[12]	Thais	95.7 (97)		86.6-114.7	
Singhal et al[14]	Gujarati	96.4			
Krishnaiah et al[8]	Nalgonda	105.6			
Jacinth and Vikraman[7]	Tamil	96.25			
Present study	North Indian	96.00		82.69-114.66	
		96.79(50)	95.22(50)	84.19-114.66	82.69-110.54

Table 4. Showing comparison of transverse breadth of supraspinous fossa.

Authors	Race	Mean (n) (mm)		Range (mm)	
		Right	Left	Right	Left
Von Schroeder et al[16]	Canadian	85.5 (30)		71-101	
Piyawinijwong et al[12]	Thais	76.2 (97)		70-90	
Present study	North Indian	81.50		64.72-96.53	
		81.39(50)	81.60(50)	64.72-96.53	67.85-96.11

Earlier Krishnaiah et al[8], and Jacinth and Vikraman[7] found the length of infraspinous fossa from spinoglenoid notch to inferior angle to be 107.71mm and 105.3 mm respectively. Our results observed larger length of infraspinous fossa than theirs.

Previously Coskun et al[4] have measured infraspinous fossa breadth and found it to be 113.5 mm (Range = 79.8-135.4 mm). The results of present study were less than theirs. This could be attributed to racial factors.

Singhal et al[14], Krishnaiah et al[8], and Jacinth and Vikraman[7] have calculated scapular index to be 68.5, 73.99 and 72.6 respectively. Our result was in consonance with Singhal et al[14]. They calculated infraspinous index as 94.6, 98.33 and 91.72 respectively. Our result was not in consonance with any of them.

The erect posture of humans has initiated many morphologic changes in the evolution of upper limb especially scapula, due to increase in functional demands of a prehensile limb. From massive scapula with laterally pointing glenoid, screw-shaped articular surface in Rachimatous amphibians to its relocation to a lower place in Reptilia, scapula underwent many changes. Slowly,

it was noticed that glenoid shifted from lateral to posterior and inferior position; scapular spine appeared and coracoid was reduced to coracoid process. The scapular shape depends on posture and functional requirements of muscles which are attached to it. It is similar in humans and those mammals which have partially or completely freed the pectoral limbs. These changes were brought as a result of change in posture from pronograde to orthograde and specialization as a prehensile limb. In pronogrades, the scapula is long and narrow whereas it becomes broader in man (especially seen in primates). The part of scapula below the spine shows the most conspicuous changes. The scapular index is seen to be higher in pronogrades than orthogrades, because of gradual increase in scapular breadth and increase in length of bone below the level of spine and hence, 'infraspinous index' significantly[7]. The change in length of scapula below the spine has also been reported by Inman, Saunders and Abbott, which is significant in mechanism of shoulder[6]. The various morphologic parameters studied and morphometric values measured in our study can be used to compare the racial characteristics and study the evolutionary aspects in different populations.

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