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VARIATIONS IN THE PRESENCE AND PROMINENCE OF THE FEATURES IN THE LONG BONES OF LIMBS

Sayee Rajangam, Vidhya R, Siva Charan, Safeer Khan, Flossie Jayakaran

Department of Anatomy, International Medical School, Bangalore, KA, India

E-mail of Corresponding Author: drsayee@gmail.com

ABSTRACT

Objectives: The present study was undertaken, to report the subjectively observed variations in the presence and / or prominence of features in the long bones of limbs.

Material and Method: The observed features multiplied with the total number of bones were: humerus 576(16x36); radius 240(8x30); ulna 270(9x30); femur 1008(16x63); tibia 380(10x38), fibula 152(4x38). The features were graded for their presence or prominence and analyzed for their combined/ individual total; total between and within the right and left sides.

Results: The combined total of the presence and prominence of the features were greater for the right femur (576/1008, 57.1%). The individual total showed that the presence of features was greater in tibia (259/380, 68.2%) and prominence of features in ulna (164/270, 60.8%). Between sides, the prominence of the features was greater for right femur (355/603, 59%). Within the sides, the prominence of the features was high for ulna (82/126, 65%). X^2 value indicated that the prominence of the features for femur could be of value in side determination. The observations on the prominence of individual features in long bones of the limbs showed a high percentage value for the nutrient foramen in femur (56/63, 88.9%).

Conclusion: From the present study, it is seen, that features could have become prominent due to genetic and/or environmental factors such as nutrition and biomechanics during the process of the formation of the features.

Keywords: features, humerus, radius, ulna, femur, tibia, fibula

INTRODUCTION

The long bones of the upper limb are the humerus, radius and ulna and that of the lower limb are the femur, tibia and fibula. Being long bones, they possess a shaft, body, upper or proximal and lower or distal ends. The two ends have articular areas and bony projections. The articular areas are considered under the category of 'pressure epiphysis' and the bony projections (tubercles, trochanters) are included under the category of 'traction epiphyses'. The projections, lines and facets of long bones are molded by the attachments of muscles, tendons, ligaments and the axis and planes of movements. From standard

text books in Anatomy, it is seen that the side to which the bone belongs could be determined by the presence of well-defined features on the bones.^{1,2} In spite of the presence of individual and racial variations in shape and prominence, earlier studies have shown that these well-defined structures in long bones, contribute either subjectively or objectively to sex determination.³ During the teaching of osteology in Anatomy, the well-defined features of long bones are described and explained as the general and specific features. At that time, the teaching faculty have observed and felt the prominence or lack of it in some of those features. Hence, the present study was

undertaken, to subjectively report the observed variations in the features of the long bones of the upper and lower limbs, both for their presence and / or prominence.

MATERIALS AND METHODS

Long limb bones that are used for teaching and learning Osteology at the International Medical School, Bangalore, were sorted according to their side. The total numbers of the selected bony

features were multiplied with the total number of bones and it was: humerus 576 (16x36); radius 240 (8x30); ulna 270 (9x30); femur 1008 (16x63); tibia 380 (10x38), & fibula 152 (4x38). The features were graded as single + for their presence and double ++ for their prominence. The features are listed in Appendix 1. The statistical analysis applied to the obtained values was percentage occurrence and the X^2 test.

Appendix 1: List of features on the long bones of upper & lower limbs			
Serial Nos	Bones and the features	Serial Nos	Bones and the features
I	Humerus: 16	I	Femur: 16
1	Anatomical neck	1	Head – Fovea capitis
2	Lesser tubercle	2	Intertubercular line
3	Greater tubercle	3	Quadrangle tubercle
4	Intertubercular sulcus	4	Trochanteric fossa
5	Deltoid tubercle	5	Gluteal tuberosity
6	Lateral supracondylar line	6	Lateral lip of linea aspera
7	Medial supracondylar line	7	Popliteal groove
8	Lateral lip of bicipital groove	8	Posterior cruciate ligament attachment
9	Spiral groove	9	Lesser trochanter
10	Capitulum	10	Nutrient foramen
11	Trochlea	11	Lateral supracondylar line
12	Medial epicondyle	12	Medial epicondyle
13	Lateral epicondyle	13	Adductor tubercle
14	Olecranon fossa	14	Lateral epicondyle
15	Coronoid fossa	15	Patellar surface
16	Radial fossa	16	Depth of Intercondylar fossa
II	Radius: 08	II	Tibia: 10
1	Head	1	Obliquity of the articular facets
2	Neck	2	Prominence of intercondylar area
3	Radial tuberosity	3	Fibular facet
4	Interosseous border	4	Gerdy's tubercle
5	Styloid process	5	Tibial tuberosity
6	Carpal articular surface	6	Soleal line
7	Lister's tubercle	7	Articular facet on medial malleolus
8	Ulnar notch	8	Groove on posterior surface of lower end
III	Ulna:09	9	Fibular notch
1	Olecranon process	10	Depth of distal articular surface
2	Coronoid process	III	Fibula
3	Trochlear notch	1	Articular facet in the upper end
4	Radial notch	2	Styloid process
5	Ulnar tuberosity	3	Articular facet of lower end
6	Interosseous border	4	Depth of malleolar fossa
7	Supinator crest	-	-
8	Head	-	-
9	Styloid process	-	-

RESULTS

The obtained values from the bones were analyzed under 6 categories for the 'presence and prominence' of the features: 1) the combined total of the presence and prominence; 2) the individual

total of the presence and prominence; 3 and 4) the total of the presence or prominence for the right and left sides; 5 and 6) the total of the presence and or prominence within the right and left sides.

Table 1: The combined total of the 'presence and/or prominence' features from the bones. Note: The 16 features for 36 humerii become 576; the 8 features for the 30 radius become 240 and the 9 features for the 30 ulna become 270. Likewise, the 16 features for the 63 femur become 1008; the 10 features for the 38 tibia become 380 and the 4 features for the 38 fibula become 152.

Table 1: The combined total of the 'presence and/or prominence' features from the bones

Grading	Humerus			Femur		
	Right (n 17)	Left (n 19)	Total (n 36)	Right (n 36)	Left (n 27)	Total (n 63)
+	177	191	368/576 (64%)	221	184	405/1008 (40.2%)
++	95	113	208/576 (36%)	355	248	603/1008 (59.8%)
Total	272/576 (47.2%)	304/576 (52.8%)	576	576/1008 (57.1%)	432/1008 (42.9%)	1008
Grading	Radius			Tibia		
	Right (n 14)	Left (n 16)	Total (n 30)	Right (n 17)	Left (n 21)	Total (n 38)
+	57	69	126/270 (52.5%)	113	146	259/380 (68.2%)
++	55	59	114/270 (47.5%)	57	64	121/380 (31.8%)
Total	112/240 (46.7%)	128/240 (53.3%)	240	170/380 (44.7%)	210/380 (55.3%)	380
Grading	Ulna			Fibula		
	Right (n 14)	Left (n 16)	Total (n 30)	Right (n 20)	Left (n 18)	Total (n 38)
+	44	62	106/270 (39.2%)	61	48	109/152 (71.7%)
++	82	82	164/270 (60.8%)	19	24	43/152 (28.3%)
Total	126/270 (46.7%)	144/270 (53.3%)	270	80/152 (52.6%)	72/152 (47.4%)	152

The combined total of the selected features for their presence and prominence are observed to be **greater** in the left humerus (304)/ radius (126)/ ulna (144)/ tibia (210) right femur (576)/ and fibula (80). The individual total for the presence of the features was observed to be **greater** in humerus (368)/ radius (126)/ tibia (259)/ fibula (109); whereas 'the total of the prominent features were greater for ulna (164)/ femur (603).

Table 2: Limb Bones – X² / ‘p’ value chart

Sl.No	Bones	X ² value	‘p’ value
1	Femur (right v/s left)	1.840	> 0.1
2	Tibia (right v/s left)	0.3991	> 0.5
3	Fibula (right v/s left)	1.7377	> 0.1
4	Humerus (right v/s left)	0.3187	> 0.5
5	Radius (right v/s left)	0.2174	> 0.5
6	Ulna (right v/s left)	1.8875	> 0.1

Statistical analysis has shown that side determination could be dependent on the ‘prominence’ of the features for femur; whereas for the other bones it is the ‘presence’ of the features.

Table 3: The presence and prominence of features in the right and left sides

Presence			Prominence		
Right	Left	Total	Right	Left	Total
Humerus			Humerus		
177 (48%)	191 (52%)	368	95 (45.7%)	113 (54.3%)	208
Radius			Radius		
57 (45.2%)	69 (54.8%)	126	55 (48.2 %)	59 (51.8%)	114
Ulna			Ulna		
44(41.5%)	62(58.5%)	106	82 (50%)	82 (50%)	164 (60.8%)
Femur			Femur		
221 (54.6%)	184 (45.4%)	405	355 (59%)	248 (41%)	603
Tibia			Tibia		
113 (43.6%)	146 (56.4%)	259	57 (47%)	64 (53 %)	121
Fibula			Fibula		
61 (56%)	48 (44%)	109	19 (44%)	24 (56%)	43

Between the sides, the **presence** of the features were more on the left side of the upper limb bones [humerus (191)/ radius (69)/ ulna (62)] and tibia (146) and on the right side of the lower limb bones (femur (221)/ fibula (61)).

The features were more prominent on the **left** side of the humerus (113)/ radius (59)/ tibia (64)/ fibula and the **right** side of the femur (355). Values were same for the right (82) as well as the left sides of the ulna.

Table 4: The presence & the prominence of the features within right and left sides

Grading	Right	Left	Right	Left
	Humerus		Femur	
+	177 (65%)	191 (63%)	221 (38.4%)	184 (43%)
++	95 (35%)	113 (37%)	355 (61.6%)	248 (57%)
Total	272	304	576 (57.1%)	432 (42.9%)

	Radius		Tibia	
+	57 (51%)	69 (54%)	113 (66.5%)	146 (69.5%)
++	55 (49%)	59 (46%)	57 (33.5%)	64 (30.5%)
Total	112	128	170	210
	Ulna		Fibula	
+	44 (35%)	62 (43%)	61 (76.3%)	48 (66.7%)
++	82 (65%)	82 (57%)	19 (23.7%)	24 (33.3%)
Total	126	144	80	72

Between the sides, for the occurrence of presence and prominence of features, a high value was seen for the **presence** of features on the left humerus (191), radius (69), tibia (146) and right fibula (61) and **prominence** of features on the right ulna (82) and femur (355).

Table 5: The observed values for selected individual features on the bones

Humerus	Grading	Left	Right	Total	Radius	Grading	Left	Right	Total
		n19	n17	n36			n16	n14	n30
1	+	19	17	36	1	+	16	14	30
	++	0	0	0		++	0	0	0
2	+	9	8	17	2	+	11	9	20
	++	10	9	19		++	5	5	10
3	+	15	13	28	3	+	3	5	8
	++	4	4	8		++	13	9	22
4	+	9	5	14	4	+	7	4	11
	++	10	12	22		++	9	10	19
5	+	8	10	18	5	+	8	5	13
	++	11	7	18		++	8	9	17
6	+	9	9	18	6	+	7	8	15
	++	10	8	18		++	9	6	15
7	+	9	14	23	7	+	8	4	12
	++	10	3	13		++	8	10	18
8	+	12	9	21	8	+	9	8	17
	++	7	8	15		++	7	6	13
9	+	19	17	36	Ulna	Grading	Left	Right	Total
	++	0	0	0			n16	n14	n30
10	+	11	7	18	1	+	7	8	15
	++	8	10	18		++	9	6	15
11	+	7	8	15	2	+	6	5	11
	++	12	9	21		++	10	9	19
12	+	19	17	36	3	+	9	7	16
	++	0	0	0		++	7	7	14
13	+	19	17	36	4	+	7	5	12
	++	0	0	0		++	9	9	18
14	+	3	8	11	5	+	10	5	15

	++	16	9	25		++	6	9	15
15	+	11	6	17	6	+	4	3	7
	++	8	11	19		++	12	11	23
16	+	12	12	24	7	+	12	9	21
	++	7	5	12		++	4	5	9
-	-	-	-	-	8	+	6	2	8
-	-	-	-	-		++	10	12	22
-	-	-	-	-	9	+	1	0	1
-	-	-	-	-		++	15	14	19
Femur	Grading	Left n27	Right n36	Total n63	Tibia	Grading	Left n21	Right n17	Total n38
1	+	8	11	19	1	+	21	17	38
	++	19	25	44		++	0	0	0
2	+	10	9	19	2	+	8	2	10
	++	17	27	44		++	13	15	28
3	+	14	11	25	3	+	21	16	37
	++	13	25	38		++	0	1	1
4	+	7	2	9	4	+	19	13	32
	++	20	34	54		++	2	4	6
5	+	7	14	21	5	+	4	3	7
	++	20	22	42		++	17	14	31
6	+	6	10	16	6	+	20	17	37
	++	21	26	47		++	1	0	1
7	+	12	9	21	7	+	14	13	27
	++	15	27	42		++	7	4	11
8	+	10	14	24	8	+	11	13	24
	++	17	22	39		++	10	4	14
9	+	20	22	42	9	+	12	9	21
	++	7	14	21		++	9	8	17
10	+	4	3	7	10	+	11	10	21
	++	23	33	56		++	10	7	17
11	+	14	20	34	Fibula	Grading	Left	Right	Total
	++	13	16	29			18	20	38
12	+	19	20	39	1	+	14	19	33
	++	8	16	24		++	4	1	5
13	+	11	15	26	2	+	9	12	21
	++	16	21	37		++	9	8	17
14	+	14	13	27	3	+	17	19	36
	++	13	23	36		++	1	1	2
15	+	12	24	36	4	+	8	11	19
	++	15	12	27		++	10	9	19
16	+	16	24	40	-	-	-	-	-
	++	11	12	23		-	-	-	-

The highest observed values for 1 or 2 individual features and their prominence were listed: = humerus: feature no. 12 and 14: medial epicondyle (25/36,69.4%) and olecranon fossa (22/36,61.1%) = radius: features no. 3 and 4: radial tuberosity (22/30,73.3%) and interosseous border (19/30(63.3%); = ulna: feature no. 6 and 8: interosseous border (23/30(76.6%) and head of the ulna (22/30, 73.3%); = femur: feature no 4 and 10: trochanteric fossa (54/63,85.7%) and nutrient foramen (56.63,88.9%); = tibia: feature no 2 and 5: prominence of intercondylar area (28.38,73.7%) and tibial tuberosity (31/38,81.6%); = fibula: feature no 4: depth of malleolar fossa (19/38,50%)

DISCUSSION

Early reports in literature studied and reported sex differences in the skeleton and its various components based on the morphological features and morphometry.² The general and specific features of the long bones of the limbs could become prominent especially if they belong to the category of traction or pressure epiphysis. Of course, it depends on the attachments, tension and the pull of the muscles / tendons / ligaments of the joints and its movements; weight transmission as well the genetic and / or environmental factors affecting the process of ossification.

In the present study, features were selected randomly for their presence and / or prominence.

Present study: Interpretations

- i) Among the bones, the combined total features have occurred more on the left side
- ii) Between presence and prominence of features, the total value of prominent features were greater for ulna and femur
- iii) When considered separately between the sides, prominent features were greater on the right femur
- iv) Within the same side, the value of the prominent features was greater in the right ulna
- v) From the study on the prominence of the individual features, a high percentage was seen for the nutrient foramen in femur and this indeed is a surprising finding.
- vi) In their presence and/or prominence, the features seemed to contribute to the determination of side in any given fragment of these bones.
- vii) The prominence of the features in the right femur may indicate that weight transmission is

preferentially more on the right side in the standing and sitting positions of the body; while in the right as well as in the left ulna, the movements may be more bilateral (pronation and supination). The observations of the present study could not be discussed further in view of the absence of any published literature relevant to this article / research.

CONCLUSION

It may be concluded that the present study has reported the subjectively observed variations in the features of long bones of the limbs, both for their presence and / or prominence.

It was thought, that in spite of the features' presence and / or prominence and also being subjective, still they could become a study of academic interest. The variations in features could be because of the biomechanics and the phenomenon of the ossification process at the primary (diaphysis) and secondary (epiphysis) centres.

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