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A Comparative Study of Third and Fourth Ribs using Anthropometric Parameters and their Relevance to Forensic Medicine.

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ABSTRACT

Forensic science and anthropometry are inseparable as evidence from most anthropometrical analysis can be used for decision making. Anthropometric details of the ribs are important in defining the relationship between them and how they apply to forensic studies. The aim of this study is to determine the anthropometrical relationship between two morphologically similar ribs (rib 3 and 4) and its relevance to forensic medicine. One hundred and Seventy three (173) macerated rib bones of Nigerian origin; comprising of eighty four (84) third ribs (R₃) [48 right (R₃) and 36 left (L₃) ribs] and eighty nine (89) fourth ribs (R₄) [55 right (R₄) and 34 left (L₄) ribs] from different Universities in Nigeria were used for this study. Three anthropometrical parameters using a digital vernier caliper were measured (Maximum Superior-Inferior Height [MSIH], Maximum Anterior-Posterior Width [MAPW] and Maximum Pit Depth [MPD]). The mean±S.D of R₃-MSIH was 11.417±2.533 (R₃ = 11.171±2.236 and L₃ = 11.604±2.742) while R₄-MSIH was 11.843±2.880 (R₄ = 11.618±2.984 and L₄ = 12.210±2.706); R₃-MAPW was 5.548±1.492 (R₃ = 5.646±1.644 and L₃ = 5.420±1.273) while R₄-MAPW was 5.753±1.237 (R₃ = 5.836±1.229 and L₃ = 5.621±1.256); R₃-MPD was 2.060±1.176 (R₃ = 2.309±2.008 and L₃ = 5.621±1.256) while R₄-MPD was 2.258±1.755 (R₄ = 2.309±2.008 and L₄ = 2.18±1.267). No statistical difference exists between the left rib and its corresponding right side (P>0.05). There was no significant difference between the MSIH, MAPW and MPD of R₃ and R₄ (P>0.05); hence rib three and four are anthropometrically similar for the measured parameters which indicates a possibility of a reconstruction of R₄ from R₃ and vice-versa. Evidence from this study can aid in decision making for possible reconstruction of damaged skeletal part and Identification; which can be partial or complete.

Key words: Forensic Medicine, Anthropometry, Nigerians, Ribs.

INTRODUCTION

Anthropometrical data have been used as evidence in forensic studies to trace the, sex, statue and origin of various races in the world, although morphological evidence may be limited due to error; the most common errors in anthropometry are the positioning of the body or bones.^{1,2,3,4} Though, a number of bones such as pelvis, skull femur and so on, have contributed significantly to this endeavor, these indicative bones are not always found at such scenes. In such situations, forensic anthropologists and bioarcheologists have to depend on less elements of the human skeleton such as bones of the thoracic region.^{3, 4, 5,6} Nevertheless, such studies can provide useful clues and information to scientifically prepare experts to face such situations in the future wherein bones like pelvis and skull may not be part of the skeletal remains recovered for examination.⁷ The anterior thoracic cage, with sternum in its median aspect, is frequently encountered in the forensic anthropological contexts.^{3, 8, 9,10.} Data on anthropometric parameters of the ribs of Nigerians is scarce. Thus the present study aimed at providing database on the above

parameters for the third and fourth ribs of Nigerians for the purpose of Forensic Medicine.

The present study investigated the anthropometric parameters of rib three and four of Nigerians to create a range of values of the third and fourth left and right ribs for the Nigerian population; to compare the range of values of the third and fourth right ribs with the third and fourth left ribs and to determine the usefulness of the third and fourth ribs in forensic context.

MATERIALS AND METHODS

Anthropometrical measurement of macerated rib three and rib four (R₃ and R₄) of human skeleton was carried out. One hundred and seventy three (173) macerated human rib bones comprising eighty four (84) third ribs (R₃) [48 right (R₃) and 36 left (L₃) ribs] and eighty nine (89) fourth ribs (R₄) [55 right (R₄) and 34 left (L₄) ribs] of Nigerian origin from nine (9) different Universities in Nigeria were used for this study. The universities and rib bones obtained from their museum included; University of Port Harcourt (22) Madonna University

(15) Niger Delta University (17), Abia State University (18), University of Abuja (26) Lagos State University (12) University of Lagos (11) University of Ibadan (16) and Ladoké Akintola University of Technology Ogbomosho (36). : Three anthropometrical parameters using a digital vernier caliper were measured (Maximum Superior-Inferior Height [MSIH-figure 1], Maximum Anterior-Posterior Width [MAPW-figure 2] and Maximum Pith Depth [MPD-figure 3]).

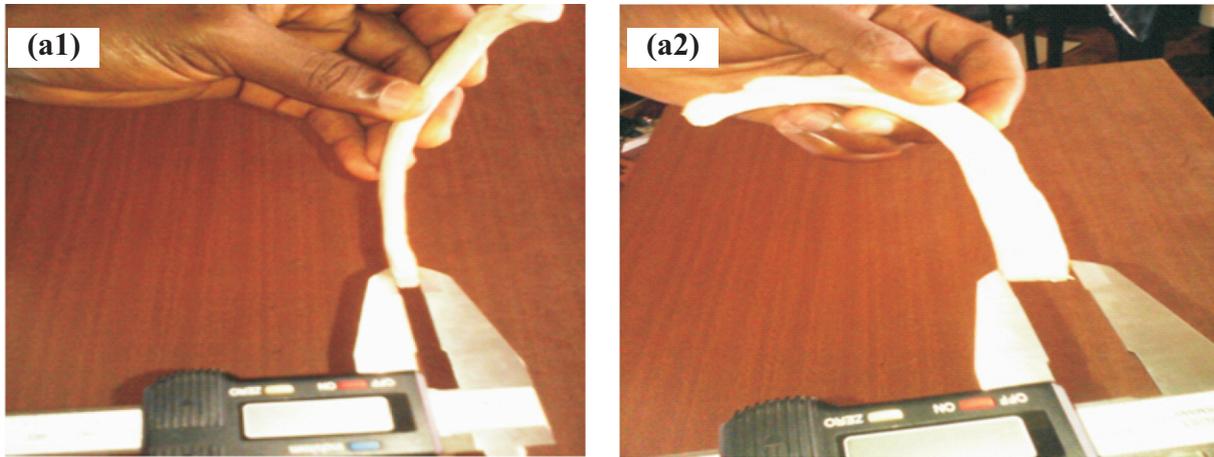


Figure 1: Superior-inferior height (SIH) measurement - (a1) third rib; (a2) fourth rib.

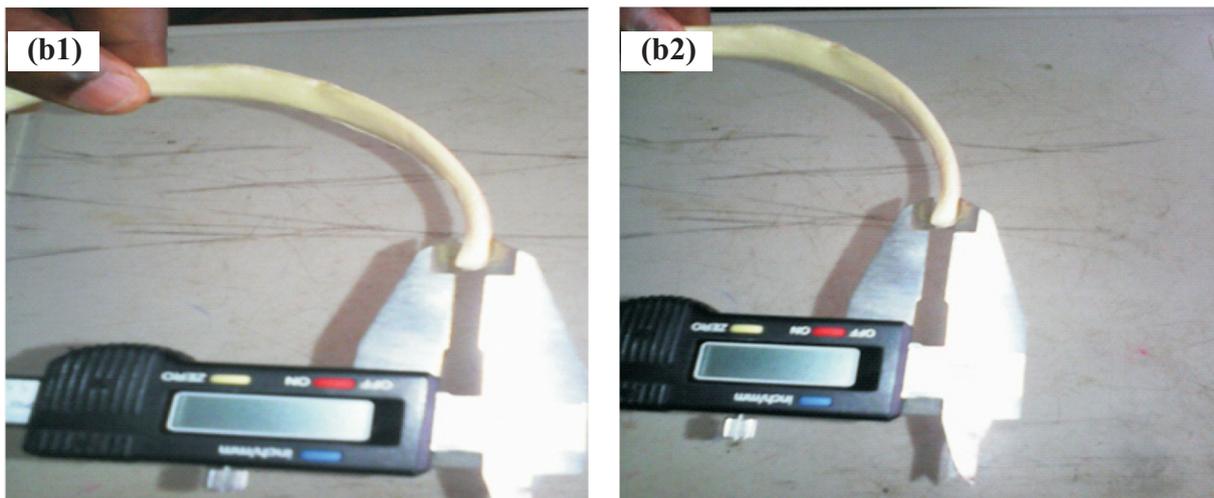


Figure 2: Anterior-posterior width (APW) measurement - (b1) third rib; (b2) fourth rib.

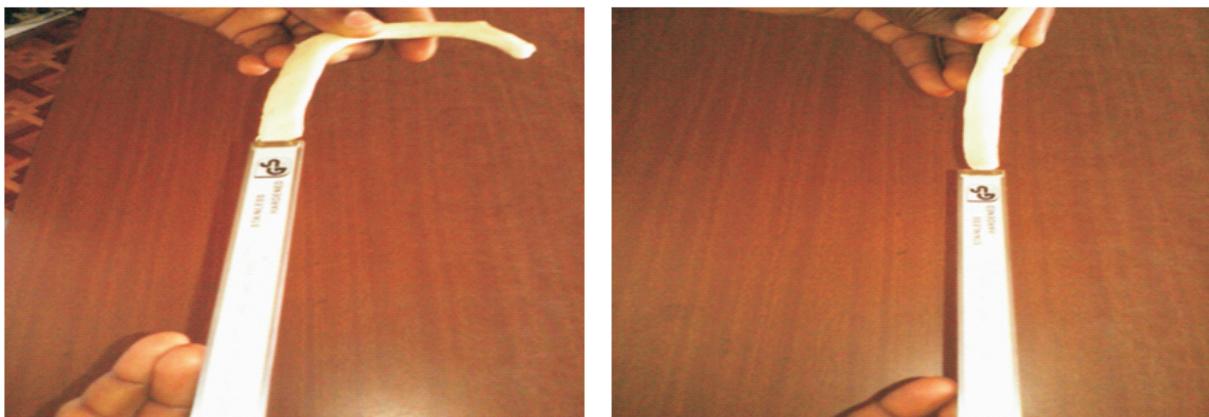


Figure 3: Maximum pith depth (MPD) measurement – (c1) third rib; (c2) fourth rib

1. **Maximum Superior-Inferior Height (MSIH):** The maximum distance between the most superior and inferior points at the end of the rib (Fig. 1). The superior-inferior height was defined as the maximum distance between the most superior and inferior points at the end of the rib. This measurement was taken by holding the rib in anatomical position. The fixed arm of the sliding caliper was held parallel to the inferior side of the sternal end of the rib and the caliper's moving arm was adjusted to meet the most superior point on the sternal end of the rib. It should be noted that the shape and position of the sternal end of the rib is variable, so the calipers will not always lie perfectly across the height of the sternal end. The measurement was always taken at the maximum distance.
2. **Maximum Anterior-Posterior Width (MAPW):** The maximum distance between the most anterior and posterior points at the end of the bone (Fig. 2). The anterior-posterior breadth was defined as the distance between the most anterior and posterior points at the end of the bone. This measurement was taken by holding the rib so that it faced perpendicular to anatomical position. The sliding caliper was held parallel to one edge of the rib and adjusted to meet the maximum breadth point of the sternal end of the rib. As noted for the superior-inferior height, the measurement was always taken at the maximum distance.
3. **Maximum Pit Depth (MPD):** This measurement was taken by holding the rib so that it faced perpendicular to anatomical position (Fig. 3). The sliding caliper was held in other to allow the tail-rod of the caliper to be used to measure the costochondral junction depth of the medial portion of the rib.

RESULTS

Descriptive statistics (min, max, range, median, mean, S.D and SEM) was carried out for each variable as depicted in the Table 1, Table 2, Table 3, Table 4 Table 5, Table 6, Table 7 and Table 8.

All the calculated mean value for the measured parameters for the fourth ribs were higher than those of the third ribs.

The mean±S.D of the measured dimensions for the 3rd right rib (R3) (Tables 1, 2 and 3). R3-MSIH was 11.417±2.533mm (R₃ = 11.171±2.236mm and L₃ = 11.604±2.742mm); R3-MAPW was 5.548±1.492mm (R₃=5.646±1.644mm and L₃=5.420±1.273) and R3-MPD was 2.060±1.176mm (R₃=2.309± 2.008mm and L₃=5.621±1.256mm) with standard error of mean (SEM) for the third right rib R₃-MSIH = 0.396mm, R₃-MAPW = 0.237mm and R₃-MPD = 0.155mm respectively, while those of the corresponding Left rib (L₃) had S.EM of 0.373mm, 0.212mm and 0.222mm respectively.

The mean ±S.D of the measured dimensions for the 4th right rib (R4) (Table 4, 5 and 6). R4-MSIH was 11.843±2.880 mm (R₄=11.618±2.984 and L₄=12.210±2.706), R4-MAPW was 5.753±1.237mm (R₄=5.836± 1.229mm and L₄=5.621±1.256), R4-MPD was 2.258±1.755mm (R₄=2.309± 2.008mm and L₄=2.18±1.267mm) with standard error of mean (SEM) for the fourth right rib R₄-MSIH = 0.402mm, R₄-MAPW = 0.166 and R₄-MPD = 0.271mm; while those of the corresponding Left rib (L₄) were; with S.EM of 0.464mm, 0.215 and 0.217 respectively.

Table 1: Descriptive statistics for third rib (R3)

Variables	Sample size (N)	Min	Max	Median	Mean±S.D	Variance (n-1)	SEM
R3-MSI H (mm)	84	6.00	17.00	11.00	11.417±2.533	6.415	0.276
R3-MAPW (mm)	84	3.00	14.00	5.50	5.548±1.492	2.227	0.163
R3-MPD (mm)	84	1.00	7.00	2.00	2.060±1.176	1.382	0.128

Table 2: Descriptive statistics for third right rib (R₃)

Sample	N	Min	Max	Range	Median	Mean	Variance(n-1)	S.D(n-1)	SEM
R ₃ -MSI H (mm)	48	6.00	17.00	11.00	11.00	11.604	7.521	2.742	0.396
R ₃ -MAPW (mm)	48	3.00	14.00	11.00	5.00	5.646	2.702	1.644	0.237
R ₃ -MPD (mm)	48	1.00	5.00	4.00	2.00	2.042	1.147	1.071	0.155

Table 3: Descriptive statistics for third left rib (L₃)

Sample	N	Min	Max	Range	Median	Mean	Variance(n-1)	S.D(n-1)	SEM
L ₃ -MSIH (mm)	36	6.00	15.00	9.00	11.00	11.17	5.000	2.236	0.373
L ₃ -MAPW (mm)	36	3.00	8.00	5.00	6.00	5.42	1.621	1.273	0.212
L ₃ -MPD (mm)	36	1.00	7.00	6.00	2.00	2.08	1.736	1.317	0.220

Table 4: Descriptive statistics for fourth rib (R₄)

Variables	Sample size (N)	Min	Max	Median	Mean±S.D	Variance (n-1)	SEM
R ₄ -MSIH (mm)	89	5.00	19.00	12.00	11.843±2.880	8.293	0.305
R ₄ -MAPW (mm)	89	3.00	8.00	6.00	5.753±1.237	1.529	0.131
R ₄ -MPD (mm)	89	1.00	14.00	2.00	2.258±1.755	3.080	0.186

Table 5: Descriptive statistics for fourth right rib (R₄)

Sample	N	Min	Max	Range	Median	Mean	Variance(n-1)	S.D(n-1)	SEM
R ₄ -MSIH (mm)	55	5.00	19.00	14.00	12.00	11.618	8.907	2.984	0.402
R ₄ -MAPW (mm)	55	3.00	8.00	5.00	6.00	5.836	1.510	1.229	0.166
R ₄ -MPD (mm)	55	1.00	14.00	13.00	2.00	2.309	4.032	2.008	0.271

Table 6: Descriptive statistics for fourth left rib (L₄)

Sample	N	Min	Max	Range	Median	Mean	Variance(n-1)	S.D(n-1)	SEM
L ₄ -MSIH (mm)	34	8.00	17.00	9.00	12.00	12.21	7.320	2.706	0.464
L ₄ -MAPW (mm)	34	3.00	8.00	5.00	5.50	5.62	1.577	1.256	0.215
L ₄ -MPD (mm)	34	1.00	6.00	5.00	2.00	2.18	1.604	1.267	0.217

Table 7: T-test for mean difference of the right rib and its corresponding left side at 0.05 significant level

Variable	N	Range	Mean ±SEM	S.D	P (obsv.)	P (crit.)	P-value	Inf.
R ₃ -MSIH (mm)	48	11.00	11.604±0.396	2.742	0.782	1.989	0.437	Not Sig
L ₃ -MSIH (mm)	36	9.00	11.167±0.373	2.236				
R ₃ -MAPW (mm)	48	11.00	5.646±0.237	1.644	0.694	1.989	0.489	Not Sig
L ₃ -MAPW (mm)	36	5.00	5.417±0.212	1.273				

R3-MPD (mm)	48	4.00	2.042±0.155	1.071				
L3-MPD (mm)	36	6.00	2.083±0.220	1.317	-0.160	1.989	0.873	<i>Not Sig</i>
R4-MSIH (mm)	55	14.00	11.618±0.402	2.984				
L4-MSIH (mm)	34	9.00	12.206±0.464	2.706	-0.935	1.988	0.352	<i>Not Sig</i>
R4-MAPW (mm)	55	5.00	5.836±0.166	1.229				
L4-MAPW (mm)	34	5.00	5.618±0.215	1.256	0.809	1.988	0.421	<i>Not Sig</i>
R4-MPD (mm)	55	13.00	2.309±0.271	2.008				
L4-MPD (mm)	34	5.00	2.176±0.217	1.267	0.345	1.988	0.731	<i>Not Sig</i>

Table 8: T-test for mean difference between rib 3 (R3) and rib 4 (R4) of at 0.05 significant level

Variable	N	Mean±S.D	SEM	t (Obs)	t (Crit)	P(value)	Inference
R3-MSIH (mm)	84	11.417±2.533	0.276				
R4-MSIH (mm)	89	11.843±2.880	0.305	-1.035	1.960	0.301	<i>Not Sig</i>
R3-MAPW (mm)	84	5.548±1.492	0.163				
R4-MAPW (mm)	89	5.753±1.237	0.131	-0.982	1.960	0.326	<i>Not Sig</i>
R3-MPD (mm)	84	2.060±1.382	0.128				
R4-MPD (mm)	89	2.258±1.755	0.186	-0.880	1.960	0.379	<i>Not Sig</i>

The t-test (Tables 7 and 8) shows no significant difference in mean value of the maximum superior-inferior height (MSIH) of three ribs and four (R3 and R4) ($P>0.05$). Rib three and four have similar mean values for the maximum superior-inferior height. There is no significant difference in mean value of the maximum anterior-posterior width (MAPW) between rib three (R3) and four (R4) ($P>0.05$). Although the mean values of rib four was greater than rib three; the difference was not statistically significant at $P=0.05$. There is no significant difference in mean value of the maximum pit depth (MPD) between all the ribs ($P>0.05$); Although the mean value of rib four was greater than rib two and rib three but the difference was not significant.

DISCUSSION

Proper identification of an individual is important not only for the family or friends of the deceased, but also

necessary for proper completion of a variety of documents and for the purpose of settling insurance claims, estate issues; criminal proceedings, ⁷ origin identification and so on. Means of identifying an individual and the techniques and standards for identification are varied and depend upon the circumstances of each particular case and the nature and condition of the exhibit available.⁷

Few studies have been done on the ribs with most of the studies focusing on the fourth rib and its importance in gender determination.^{12,13} The results from this research is in line with previous studies conducted by ^{11, 16, 18} Additionally, the difference in overall descriptive statistics between the left and right side was negligible.

Observations of sexual dimorphism led to studies more focused on osteometric analysis of the sternal ends of the ribs.^{5, 14, 15, 16, 17} studied sexual dimorphism of the

fourth ribs and obtained correct classification results as high as 85%; this is evident in this study as the mean values of the fourth ribs (R4-MSIH = 11.843±2.880mm; R4-MAPW = 5.753±1.237mm; R4-MPD = 2.258±1.755mm) were higher than those of the third ribs (R3-MSIH = 11.417±2.533mm; R3-MAPW = 5.548±1.492mm; R3-MPD = 2.060±1.176mm); but were not significant. Though these work produced good classification rates, there were limitations which arose because the fourth rib is morphologically similar to other ribs in the human body and is difficult to distinguish when not in articulation. Additionally, it is not uncommon that all elements are usually not found in a recovery site. More often than not, when only a few of the ribs are found, it is difficult to classify the location of the rib.

Gavit¹⁷ focused on the first and second ribs of Americans; she determined the superior inferior height (SIH) and the anterior posterior breadth (APB) of the right ribs of 323 subjects and reported that SIH and APB of the first rib was clearly higher than those of the second right ribs; while this study provided evidence that the anthropometric parameters (MSIH, MAPW and MPD) of the left and right third and fourth ribs are not statistically different. (p>0.05).

Reports on the third and fourth ribs in racial identification are scarce thus comparison using the parameter (MPD) is not suitable for rib differentiation; as Gavit¹⁷ also documented the irrelevance of MPD in gender differentiation. However, this study has successfully documented standard values of MSIH, MAPW and MPD for Nigerians. Possible factors not considered in this study that may affect future and the reliability of the results include age, sex, stature, nutritional status and occupation.

CONCLUSION

This study has successfully documented a range of standard values for MSIH, MAPW and MPD for Nigerians which could be compared with those of other racial groups. The modal range for the 3rd and 4th ribs indicates the reference range for the observed ribs of Nigerian origin which could be useful in comparing rib bones of foreign origin.

It could be concluded from statistical point of view that there is no difference in the left and right third and fourth rib. Based on the measured anthropometrical parameters; rib three and four are similar. Hence in the absence of the fourth rib, the third rib can be used for identification. This could find its use in the field of remodeling and reconstructive anatomy.

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