A Preliminary Study Using Visual Assessment of Variation in Proximal Ulnar Morphology: Implications for Sex, Age, and Population Estimation

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Abstract: The purpose of this preliminary study was twofold: (1) to examine the morphology of the proximal ulna by way of visual assessment (*i.e.*, morphoscopic analysis) in order to gauge any variability between the sexes, adult ages and populations (African American and European American) and (2) to explore the possibility of utilizing a morphoscopic method in mass grave or mass disaster field settings where quantitative approaches would be prohibitive due to time and equipment constraints. The proximal ulna is an area of interest because it forms the elbow joint along with the proximal radius and distal humerus. And, whereas joints are areas of the skeleton that show sexual dimorphism as well as age-related and or biomechanical changes such as osteoarthritis, it was hypothesized that shape differences exist between females and males, and young, middle and older adult age groups, though perhaps not between populations (*i.e.*, African American and European American), since most population differences are found in the skull and femur. This study was undertaken as well because of the paucity of information on ulnar variation of this nature in the published literature.

In this study, proximal ulnar morphology was largely characterized by a visual evaluation of torsion. A method was developed to assess this torsion, and the morphological data were collected for right and left ulnae from 64 individuals (n=128), aged 22 to 101 years, from the Robert J. Terry Skeletal Collection, Smithsonian Institution, National Museum of Natural History. Gross observations of raw data and results of certain statistical tests indicated that proximal ulnar morphology varied by sex and population; but, no clear distinctions among adult age groups could be determined. Because of small sample sizes, no definitive conclusions were drawn. Further testing on larger sample sizes is recommended. This study contributes novel information about proximal ulnar morphological variation, which, to date, has received little attention in osteological research.

Keywords: Ulna, Ulnar morphological variation, Skeletal variation, Human identification methods, Morphoscopic analysis, Visual assessment.

INTRODUCTION

Obtaining the identity of individuals by examining their skeletal remains relies on the ability to accurately establish the biological profile, which includes determining the sex, age, and population of an individual, from the application of multiple scientifically tested methods. While there are currently many methods available to ascertain the biological profile, it is imperative to explore new techniques to improve upon present methods, especially for areas of the skeleton for which little data have been collected, such as the ulna. Indeed, not all bones or parts of bones may be recovered when unknown human remains are discovered or exhumed [1]. To optimize a positive identification, it is essential to have data and methods for a wide variety of bones and skeletal features.

The ulna, an appendicular bone, is medial in the forearm; its proximal portion is considered the strongest part and may show some age variation due to arthritic changes [2]. Aside from age variation, sexual dimorphism is also common in the proximal and distal portions of appendicular bones, particularly the humerus and femur, among others [3-5]. Therefore, it was hypothesized that the proximal ulna could show differences in both sex and adult age. The question of population differences remained open-ended; most population differences are found in the skull, and to a lesser degree the femur [2, 3, 5]. In this preliminary study, evaluating sex, age, and population variation of the proximal ulna was achieved via a morphoscopic assessment, an examination of morphology, which enabled the collection of qualitative data rather than quantitative data [6].

A visual assessment approach to investigating morphological variation was selected in lieu of a quantitative approach because of the ease and speed with which it could potentially be used in field settings,

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particularly mass graves and mass disaster situations where the commingling of remains is common. Additionally, the volume of skeletal remains collected in these situations is likely to be high. Therefore, it is ideal to have a cost-effective and expeditious method to sort bones by sex and broad adult age (*e.g*., young and old), and to verify population. This study aimed to test such a visual approach-on the proximal ulna-for its ability to show any discerning shape differences that could then be applied in field settings for purposes of aiding the establishment of the biological profile of unknown human skeletal remains.

MATERIALS AND METHODS

Sample

The sample for this study comprised 128 ulnae from 64 individuals aged 22 to 101 years old from the Robert J. Terry Skeletal Collection housed at the Smithsonian Institution's National Museum of Natural History, Washington, DC, USA. The known metadata for the skeletons in the collection were reviewed-the sex, age, and population (*i.e*., European or African American descent) -so that a sample could be selected that reflected a relatively even distribution of these variables. Due to the paucity of females in general and females of European descent in particular, the resulting sample contained 64 individuals: 33 were females and 31 were males. Of the 33 females, 15 were European Americans and 18 were African Americans. Of the 31 males, 14 were European Americans and 17 were African Americans (Table **1**).

Table 1: Sample by Population and Sex

	Female	Male	Total
African American:	18	17	*35*
European American:	15	14	*29*
Total:	*33*	*31*	*64*

Age Clusters

Individuals in the sample were of known age at death *i.e*., ages were known at the time the skeletons were donated to the collection) and ranged in age from 22to 101 years. To study the effect of age, if any, on proximal ulnar variation, the broad age range of the sample was divided into separate age clusters. Age clusters were generated by running statistical tests (K-means clustering) on the entire sample age distribution to determine where the best demarcation points would be to delineate young, middle and older adults. The open source statistical software program, The R Project for Statistical Computing, commonly referred to as "R", created by GNU [7], was used. A code was written to produce"young", "middle", and "older" adult age groups, based on the sample age distribution. The three age groups that were generated were named Cluster 1, Cluster 2, and Cluster 3. Cluster 1 included 27 individuals aged 22 to 41 years. Cluster 2 had 10 individuals, aged 44 to 65 years, and Cluster 3 contained 27 individuals, aged 75 to 101 years. Age Clusters 1, 2, and 3 represented young, middle, and older age groupings, respectively (Table **2**).

Table 2: "R" Derived Age Clusters

Cluster 1:	22-41 years
Cluster 2:	44-65 years
Cluster 3:	75-101 years

Visual (Morphoscopic) Assessment

The morphological variation assessed was essentially an observed amount of curvature or torsion in the proximal portion of the ulna relative to the diaphysis or shaft of the bone. The proximal portion herein is defined as being composed of the olecranon process, semilunar notch, radial notch, and coronoid process (Figure **1**). We identified a separate landmark feature used in the visual assessment, and called this the "ulnar nook", a shallow depression inferior to the coronoid process and lateral to the ulnar tuberosity.The extent to which this proximal portion twisted or deviated from the diaphysis was determined by observing the amount of "wobble" exhibited when the ulnar nook was "compressed" while lying on a flat surface, and then "released". The procedure developed for determining the degree of "wobble" or lack of wobble (*i.e*., stability) of the ulna, involved three steps, explained below and shown in Table **3**.

The first step is to lay the bone in anatomical position (supine), horizontally, on a solid or hard surface, in front of the observer, where the left-side ulna will have its proximal end to the observer's right side. For the right-side ulna, conversely, the proximal end points to the observer's left side. The second step is for the observer to push down on the ulnar nook using the right index finger, and to note what the bone does. For example, if the ulna does not move or "compress", this is coded as 0. If the ulna compresses in one motion, with a singular audible and palpable "click", this is coded as 1. If the ulna compresses and makes two or more audible and palpable "clicks", this is coded as 2. The third and final step in the process is to

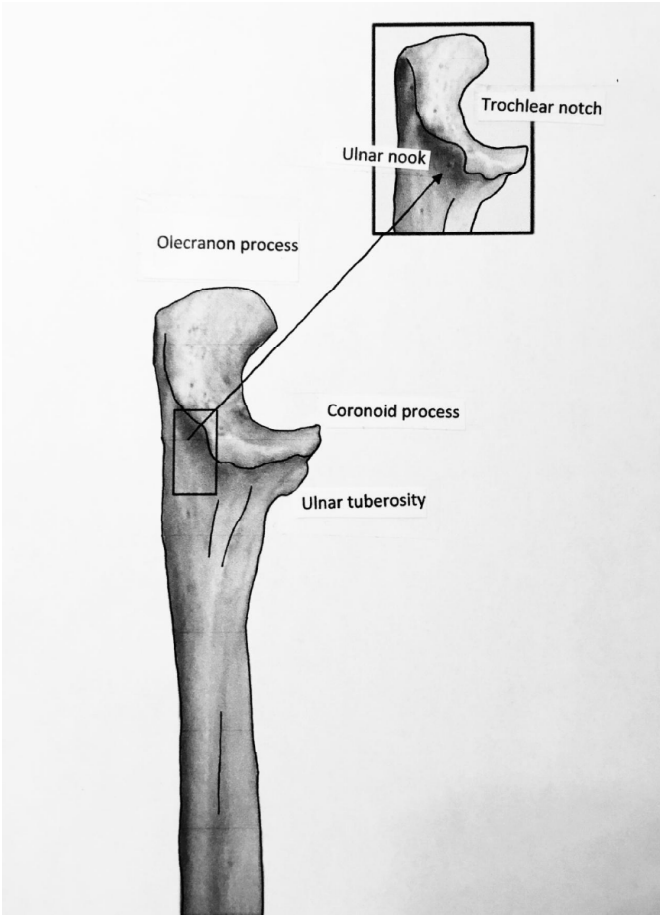

Figure 1: Proximal end of a left ulna. Arrow pointing to the location of the ulnar "nook"; a palpable depression inferior to the coronoid process and lateral to the ulnar tuberosity.

Table 3: Procedural Steps for Determining the Degree of "Wobble"

Steps	Procedure	Occurence	Code
Step 1	Lay the bone in a supine position, horizontal in front of the observer. For a left ulna, the proximal end will be to the observers right. For a right ulna, the proximal end will be to the observers left.		
Step 2 Compression	Push down or compress the ulnar "nook" with the right index finger.	No movement, no compression	0
		Compresses on one "click"	1
		Compresses on ≥ 2 "clicks"	2
Step 3 Release	Lift the right index finger up, to release the bone.	No movement, no release	0
		One "click" to reset	1
		Flips	2

lift the right index finger up after compression-this is known as the "release"-and determine what the bone does. If there is no movement, this is coded as 0. If there is one audible and palpable "click" whereby the bone "resets" back to the original position, this is coded as 1. Finally, if the bone flips, this is coded as 2.

Based on the procedure described above, each ulna (right and left) for each of 64 individuals in the sample had one of seven compression and release pairings: 0-0 no compression and no release, 1-0 one click to compress and no release (no movement), 1-1 one click to compress and one click to release, 1-2 one click to compress and flips over, 2-0 two clicks to compress and it flips over (Table **4**). The data were then analyzed to see if these compression and release pairings followed any pattern according to the sexes (female and male), the different adult age clusters, and populations (African American and European American).

Table 4: Compression and Release Pairings

Pairings	Compression*	Release**
1	*0*	*0*
2	*1*	*0*
3	*1*	*1*
4	*1*	*2*
5	*2*	*0*
6	*2*	*1*
7	*2*	*2*

*Compression: 0= no compression; 1= 1 click to compress; 2= clicks to compress
**Release: 0= stays; 1= 1 click to reset; 2= flips

Analysis

Ulnar compression and release data were entered into Microsoft Excel spreadsheets and analyzed using the statistical software program "R" [7]. Specific codes were written to analyze the data; however, due to limitations with graphically illustrating the findings, the Statistical Packet for the Social Sciences (SPSS v. 24) was employed [8]. Student's t-tests and Chi- Square tests were conducted to identify the effects, if any, of age, sex, and population on variation in ulnar compression and release. As well, analyses of the raw data elucidated characteristics of the ulna that were not sensitive to statistical testing, either due to small sample sizes or idiosyncratic features. Specific findings are presented in the sections that follow.

RESULTS AND DISCUSSION

Data for right and left ulna compression and release variables were subjected to three different types of analyses, where applicable: Students t-tests, Fisher's exact tests, and gross observations of the raw data. Students t-tests were employed to examine the data for any statistically significant sex, age, and population differences. Fisher's exact tests were used for sex and population since those variables constitute nominal level data (*i.e*., they are qualitative). Finally, gross observations of the raw data enabled a visual representation of any patterns in variability to be detected, if they existed, that statistical tests could not identify, if the lack of any significant differences was in fact due to small sample sizes. Findings are explained below, for sex, age, and population, respectively.

Sex

Sex differences were tested by separating the entire sample into two groups: females (n=33) and males (n=31). Results from Students t-tests and Fisher's exact tests, with ages and populations combined, and sexes separated, yielded no statistically significant differences in right ulna compression and release (RUCR), and left ulna compression and release (LUCR).It is unclear if this finding is due to a true lack of a sex difference or a possible effect of small sample sizes.

Gross observations of the raw data followed as a method to remedy, in part, the challenge of small sample sizes. For females and males each, a table was created to determine if any sex differences in right ulna compression and release variables could be visualized (see Table **5**). By viewing the data in the form of a comparison table, it became apparent that females had almost double the right ulna release variables of 0 (n=21) than males (n=12). However, when looked at in comparison to their other release variables, the numerical differences between the two sexes diminished. These gross observation findings seem to suggest a sex difference; therefore, further investigation on a larger sample size could be worthwhile.

Table 5: Release Outcomes: Gross Observations of Sex Differences

Release Outcomes	0	1	2	Total
Number of Females	21	6	6	**33**
Number of Males	12	11	8	**31**

Age

It is generally understood that many bones of the skeleton undergo age-related and or biomechanically induced (stress-related) morphological and arthritic changes such as bony lipping and spur formation at a joint [9, 10] over the course of the lifespan. It was hypothesized that changes of this nature, perhaps even subtle changes not easily visible, could be detected in

the proximal ulna by way of applying the method of compression and release introduced here. The data were first analyzed using the "R" derived age Clusters 1, 2, and 3. Age Clusters 1 and 3 were examined first because they had the greatest separation between "young" and "old" age groupings. Initially the original coding for compression and release was used in the analysis for age (*i.e*., compression 0, 1, 2, separate from release 0, 1, 2). Four Student's t-tests analyzed left ulna compression, left ulna release, right ulna compression, and then right ulna release between age Clusters 1 and 3. Although not statistically significant, left ulna compression for age Clusters 1 and 3 resulted in a p-value of 0.055. None of the other Student's t-tests were significant either. The issue of small sample sizes could not be ruled out as a contributing factor.

In an effort to increase sample size, the data were then classified into two rather than three age clusters. The age clusters represented "young" and "old" individuals, without a "middle" group, and were called Clusters 1 and 3. Clusters 1 and 3 were examined in terms of the compression and release pairings grouped into the seven different possibilities: Pairing 1 represented a 0 compression and 0 release, Pairing2 represented a 0 compression and 1 release, and so on as listed earlier in Table **5** for the seven different combinations of compression and release (*i.e*., pairings). Student's t-tests nonetheless resulted in no significant differences for any of the seven possible compression and release pairings when "young" (age Cluster 1) and "old" (age Cluster 3) individuals were compared. Due to the arthritic changes noted during the analysis of some of the ulnae, and the knowledge that an age effect is identifiable in areas where bones form a joint, the sample age groupings were reconfigured and analyzed again.

Originally there were "R" derived cluster distributions determined statistically based on the ages of the individuals in the sample (see Table **2**). These age clusters were reclassified into more deliberate age groupings based on naturally occurring age changes that statistical analyses are not sensitive to (*i.e*., the development and progression of arthritis). The modified age clusters became a "young" group of individuals spanning an age range of 22-53 years (n=28) and an "old" group spanning an age range of 61-101 years (n=33). Basically, this divided the sample into adults younger than roughly 50 years of age, from those who were around 60 plus years of age. In this scenario, the individuals in their 50s were largely omitted to create a greater age contrast between the two age groups.

A second scenario for grouping the ages into "young" and "old" omitted individuals largely in their 40s, in case that was a decade that would better distinguish any arthritic changes that could affect ulnar morphology. In this second scenario, the "young" group spanned ages 22-41 years (n=22), and the "old" group spanned ages of 53-101 years (n=37). Student's t-tests were then run for both age group scenarios of young and old and none of these resulted in a statistically significant age difference for any of the compression or release variables for either right or left ulnae. It is interesting to note that for the first age grouping scenario, that largely omitted individuals in their 50s, there was a right ulna compression (RUC) p-value of 0.052. Further, for the second scenario, for the age grouping that largely omitted individuals in their 40s, there was a left ulna compression (LUC) p-value of 0.067. Even though these results are not statistically significant, the question arises as to what larger sample sizes could reveal.

Population

Student's t-tests indicated that there were no statistically significant differences between African Americans and European Americans with sexes combined or separated. This finding could reflect that (1) there are no population differences in the morphology of the proximal ulna, or (2) that sample sizes were too small, especially when the sample was divided by both population and sex. It is noteworthy that while Student's t-tests resulted in no statistically significant population differences, a Fisher's exact test seemed to suggest that ulnar morphology varied between African Americans and European Americans. This test revealed a statistically significant population difference in left ulna compression variables only ($p<0.05$), with no differences for left ulna release, or right ulna compression and release variables (Table **6**).

Gross observations of the raw data for population differences were evaluated in table format (Table **7**). The population differences that corroborated the Fisher test findings (refer to Table **6**) were as follows: African Americans had 23 left ulna compressions coded as 1; European Americans had less than half that for the same compression value (n=11). For left ulna release variables, the same pattern is not visible. While it is possible that there is a true population difference in left ulna compression, since there were no apparent differences in the other variables-right ulna compression, and left and right ulna release, with sexes combined and separated, it seems realistic to conclude that, again, small samples sizes are a limiting

Table 6: Crosstabs for Left Ulna Compression and Population, Chi-Square Results

LUlnaCom * Population Crosstabulation					
			Population		Total
			African American	European American	
LUlnaCom	0	Count	0	2	2
		Expected Count	1.1	.9	2.0
		% within LUlnaCom	0.0%	100.0%	100.0%
		% within Population	0.0%	6.9%	3.1%
	1	Count	23	11	34
		Expected Count	18.6	15.4	34.0
		% within LUlnaCom	67.6%	32.4%	100.0%
		% within Population	65.7%	37.9%	53.1%
	2	Count	12	16	28
		Expected Count	15.3	12.7	28.0
		% within LUlnaCom	42.9%	57.1%	100.0%
		% within Population	34.3%	55.2%	43.8%
Total		Count	35	29	64
		Expected Count	35.0	29.0	64.0
		% within LUlnaCom	54.7%	45.3%	100.0%
		% within Population	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.300[a]	2	.043
Likelihood Ratio	7.111	2	.029
Linear-by-Linear Association	1.006	1	.316
N of Valid Cases	64		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is .91.

factor, or that there is very little human variation in ulnar morphology attributed to population (as well as sex and age, as indicated by the previously discussed results).

Table 7: Left ulna Compression (LUC) and Left Ulna Release (LUR) Patterns by Population

LUC Outcomes	0	1	2
African Americans	0	23	12
European Americans	2	11	16
LUR Outcomes	0	1	2
African Americans	19	8	8
European Americans	13	11	5

Asymmetry

Finally, with the overall sample considered-sexes, ages, and populations combined-left and right ulna compression and release variables were analyzed for insights into any possible asymmetry. Asymmetry was examined inasmuch as variations in long bone dimensions within an individual have been found to lead to errors in determining the overall number of individuals in cases where commingling occurs in mass deaths and in mass graves [11].

A Fisher's exact test yielded a highly statistically significant difference between left and right ulna compression variables ($p<0.001$) and a statistically significant difference ($p<0.05$) for left and right ulna

Table 8: Asymmetry Data from Chi-Square Test of Left and Right Ulna Compression

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
LUlnaCom * RUlnaCom	64	100.0%	0	0.0%	64	100.0%

LUlnaCom * RUlnaCom Crosstabulation						
			RUlnaCom			Total
			0	1	2	
LUlnaCom	0	Count	1	1	0	2
		% within LUlnaCom	50.0%	50.0%	0.0%	100.0%
		% within RUlnaCom	50.0%	2.9%	0.0%	3.1%
	1	Count	1	23	10	34
		% within LUlnaCom	2.9%	67.6%	29.4%	100.0%
		% within RUlnaCom	50.0%	67.6%	35.7%	53.1%
	2	Count	0	10	18	28
		% within LUlnaCom	0.0%	35.7%	64.3%	100.0%
		% within RUlnaCom	0.0%	29.4%	64.3%	43.8%
Total		Count	2	34	28	64
		% within LUlnaCom	3.1%	53.1%	43.8%	100.0%
		% within RUlnaCom	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	23.064[a]	4	.000
Likelihood Ratio	14.389	4	.006
Linear-by-Linear Association	11.871	1	.001
N of Valid Cases	64		

a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is .06.

release variables (Tables **8** and **9**). That asymmetry appears to exist may be due to handedness. Given that much of the population is assumed to be right handed [12], it is possible that the greater biomechanical stress to the right arm rather than the left could overshadow any morphological variability due to sex, age, and or population, that might be naturally occurring. Since the left ulna may have experienced less load bearing skeletal changes than the dominant right arm, this may be why left ulna compression and release variables were significantly different from right ulna compression and release variables. While this information is interesting, it is not helpful in ascertaining any aspect of the biological profile (*i.e.*, sex, age, population) when unknown remains are being examined, therefore does not contribute anything meaningful to the aim of this study.

CONCLUSIONS

This study investigated the extent of normal human variation in proximal ulnar morphology by way of physically manipulating the bone via compression and release motions to determine if any shape differences in sex, age, and or population could be discerned in

Table 9: Asymmetry data from chi square test left ulna and right ulna release

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
LUlnaRel * RUlnaRel	64	100.0%	0	0.0%	64	100.0%

LUlnaRel * RUlnaRel Crosstabulation						
			RUlnaRel			Total
			0	1	2	
LUlnaRel	0	Count	21	5	5	31
		% within LUlnaRel	67.7%	16.1%	16.1%	100.0%
		% within RUlnaRel	63.6%	29.4%	35.7%	48.4%
	1	Count	8	9	3	20
		% within LUlnaRel	40.0%	45.0%	15.0%	100.0%
		% within RUlnaRel	24.2%	52.9%	21.4%	31.3%
	2	Count	4	3	6	13
		% within LUlnaRel	30.8%	23.1%	46.2%	100.0%
		% within RUlnaRel	12.1%	17.6%	42.9%	20.3%
Total		Count	33	17	14	64
		% within LUlnaRel	51.6%	26.6%	21.9%	100.0%
		% within RUlnaRel	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.475[a]	4	.022
Likelihood Ratio	10.574	4	.032
Linear-by-Linear Association	6.266	1	.012
N of Valid Cases	64		

a. 3 cells (33.3%) have expected count less than 5. The minimum expected count is 2.84.

this manner. Small sample sizes were a major limiting factor in statistical testing.

The only statistically significant finding was a Fisher's exact test, where a possible population effect was evident in that left ulnar compression variables differed between African Americans and European Americans. Moreover, gross observation of the raw data also indicated a population difference, and suggested some sexually dimorphic differences as well. Although not directly related to estimating aspects of the biological profile (*i.e*., sex, age, and population), Fisher's exact tests were run on right-side versus left-side ulnar variables to explore asymmetry. It was found that right and left ulna compression variables differed highly significantly ($p<0.001$) and right and left ulna release variables differed significantly ($p<0.05$). The meaningfulness of this result, nonetheless, is rather negligible. Table **10** lists the statistical findings.

Even though small sample sizes hindered statistical testing, the morphoscopic method of assessing ulnar shape variation holds promise. Future studies on much larger sample sizes are recommended. A morphoscopic method-being time and task efficient- that can accurately and reliably assist in determinations of sex,

Table 10: Results

	t-test	Fisher	Gross Observation
Sex	♂ / ♀ Right ulna compression (RUC) Right ulna release (RUR) Left ulna compression (LUC) Left ulna release (LUR)	♂ / ♀ RUC, RUR, LUC, LUR	♂ / ♀ RUC, RUR, LUC, LUR The female right ulna stayed "compressed" with no release, more often than males.
Sex Results:	No significance	No significance	♂ = 12 RUC ♀ = 21 RUC Yes, there is a difference
Age	Cluster 1: 22-41 years Cluster 2: 44-65 years Cluster 3: 75-101 years	N/A	22-101 years
Age Results:	No significance	N/A	No difference
Population	RUC, RUR, LUC, LUR African American European American	Left ulna compression (LUC) had a p value of < 0.043	The African American left ulna compression value of 1 (one click to compress) resulted in n=23 European Americans had a compression value of 1, and resultedin n = 11
Population Results:	No significance	P < 0.043	African American: 23 LUC European American: 11 LUC Yes, there is a difference.

age, and or population affinity are a valuable tool in human identification, particularly in situations of mass graves and commingled remains and is worthy of further research, as demonstrated by this preliminary study.

REFERENCES

[1] Rowbotham SK, Blau S, Hislop-Jawbrich J. Recording skeletal completeness: A standardized approach. For Sci Intl 2017; 275: 117-123. https://doi.org/10.1016/j.forsciint.2017.02.036

[2] Bass WM. Human osteology: A laboratory and field manual. 5th Edition. Special publication no. 2 of the Missouri Archaeological Society, 2005.

[3] Burns KR. Forensic anthropology training manual. 3rd Edition. Pearson Education, Inc 2013.

[4] Barrier ILO, L'Abbe EN. Sex determination from the radius and ulna in a modern South African sample. For Sci Intl 2008; 179: 85.e.1-85.e.7.

[5] Byers SN. Introduction to forensic anthropology. 5th Edition. Pearson Education, Inc 2017.

[6] Christensen AM, Passalacqua NV, Bartelink EJ. Forensic Anthropology: current methods and practice. Academic Press 2014; p. 55-89. https://doi.org/10.1016/B978-0-12-418671-2.00003-3

[7] The R Project for Statistical Computing. https://www.r-project.org. Retrieved: October 13th, 2016.

[8] IBM SPSS Software. http://www.ibm.com/analytics/us/en/technology/spss/. Retrieved: October 13th, 2016.

[9] Suzuki S, Sunagawa M, Shindo M, Kimura R, Yamaguchi K, Sato T, *et al*. Degenerative changes in the appendicular joints of ancient human populations from the Japan Islands. Quat Int 2016; 405: 147-59. https://doi.org/10.1016/j.quaint.2015.03.027

[10] Craps DD, Gowland R. The proximal ulna as an additional diagnostic feature of advanced rheumatoid arthritis. Int J Paleopathol 2015; 10: 26-30. https://doi.org/10.1016/j.ijpp.2015.04.002

[11] Kanchan T, Mohan Kumar TS, Pradeep Kumar G, Yoganarasimha K. Skeletal asymmetry. J For Leg Med 2008; 15: 177-179. https://doi.org/10.1016/j.jflm.2007.05.009

[12] Right Left Right Wrong? An Investigation of Handedness. http://www.rightleftrightwrong.com/ statistics.html. Retrieved: November 20th, 2016.

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http://dx.doi.org/10.15379/2410-2806.2017.04.01.03