

SEX ESTIMATION IN FORENSIC ANTHROPOLOGY
USING THE RADIUS, FEMUR, AND SCAPULA

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SEX ESTIMATION IN FORENSIC ANTHROPOLOGY
USING THE RADIUS, FEMUR, AND SCAPULA

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Abstract

One of the most essential aspects of conducting a forensic anthropological analysis is estimating the sex of an unknown individual. This can narrow down missing persons lists by a large margin. Research continues to show that the pelvis is the best indicator of sex due to the morphological differences between males and females. However, the pelvis is not always available. Forensic anthropologists are often left with an incomplete skeleton, leaving other bones to be relied upon to estimate the sex of a person.

According to Spradley and Jantz (2011), the metric use of the postcranial skeleton for estimating sex provides more accurate results than both metric and nonmetric traits of the skull. Further, some postcranial elements prove to be more accurate than others. In their findings, the radius, femur, and scapula were among the highest scoring estimators for sex.

The purpose of this research is to compare the sexing accuracy of the radius, femur, and scapula with the Texas State University Donated Skeletal Collection to those results found among the same postcranial elements in Spradley and Jantz's research. The sample used for Spradley and Jantz was taken from the Forensic Anthropology Data Bank (FDB) which is comprised of donated individuals and forensic cases in the Southeastern United States. This study will serve as validation to ascertain if Spradley and Jantz's results can be used on other skeletal remains from around the country by using the Texas State University Donated Skeletal Collection.

Introduction

According to the American Board of Forensic Anthropology, “forensic anthropologists apply standard scientific techniques developed in physical anthropology to analyze human remains, and to aid in the detection of crime” (ABFA, 2008).

Furthermore, forensic anthropology today is defined as “the scientific discipline that focuses on the life, the death, and the postlife history of a specific individual, as reflected primarily in their skeletal remains and the physical and forensic context in which they are emplaced” (Dirkmaat et al., 47). Forensic anthropologists are responsible for a number of duties including skeletal trauma analysis, forensic taphonomy, and forensic archaeology. It is important to note that forensic anthropologists only work with human remains that are both modern and of forensic significance (Tersigni-Tarrant and Shirley, 2013). For example, a forensic anthropologist would not be interested in working with ancient remains as law enforcement would have no use for them.

Although forensic anthropologists perform many roles of skeletal analysis, perhaps the most important of their duties is to conduct a biological profile for unidentified individuals. A biological profile is essentially the basic biological information of a person: the sex, age, ancestry, stature, and any defining characteristics of an unidentified individual. Recognizing certain aspects of these unidentified individuals can narrow down missing persons lists by a large margin and help to reveal the identity of the person. One of the first steps in conducting a biological profile is estimating the sex, or whether they were male or female. Research continues to show that the pelvis is the best indicator of sex due to the morphological differences between males and females as a result of child bearing ability, such as a wider subpubic angle and flared pelvic blades

in females (Berg, 2013). These differences can be viewed in Figures 1-3 at the end of this section. However, the pelvis is not always available. Forensic anthropologists are more often than not left with incomplete skeletons to work with where the pelvis is missing, fragmented, or damaged.

Although forensic anthropologists are always very careful in retrieving every piece of bone and evidence in a forensic investigation, there are factors that can contribute to the collection of an incomplete skeleton. A couple of these factors include the scattering of a body on the ground surface where animals can scavenge the remains or weather can wash them away or damage them, or inexperienced law enforcement that may not be trained in osteology or proper excavation technique. Because skeletons retrieved from forensic investigations have the possibility of being incomplete, other bones must be relied upon to estimate the sex of a person when the pelvis is missing (DiGangi and Moore, 2013).

According to Spradley and Jantz's (2011) study entitled *Sex Estimation in Forensic Anthropology: Skull versus Postcranial Elements*, the metric use of the postcranial skeleton for estimating sex provides more accurate results than both metric and nonmetric traits of the skull, yet some postcranial elements proved to be more accurate than others. In their findings, the radius, femur, and scapula were among the highest scoring estimators for sex, with classification rates ranging from 94.34% for the radius, 93.54% for the femur, and 93.04% for the scapula (Spradley and Jantz, 2011).

Postcranial bones, meaning any bone below the skull, can be used in sex estimation because of sexual dimorphism. Sexual dimorphism is generally defined as the difference between males and females in shape and size, including the skeleton (Fuentes,

2012). This can also include differences in timing of development between each sex. According to DiGangi and Moore (2013), “the adult female skeleton maintains prepubescent gracility (except in the pelvis), whereas the adult male skeleton shows more robusticity than the female skeleton (especially at muscle insertion sites) in most cranial and postcranial elements” (DiGangi and Moore, 92). Although humans are the least sexually dimorphic compared to other nonhuman primates, the literature shows that modern humans display a significant level of differences in size and shape between sexes.

In a study done in 2014 by Dr. Lia Betti, pelvis size was compared between sexes in twenty populations across the world, including the United States. The results showed that in all populations males appeared to have larger coxal bones than females (Betti, 2014). However, it is important to note that populations may differ in size. This is referred to as inter-population variation. Sexual dimorphism differences between males and females in one population may be great, while in another they may be slight. Intra-population variation refers to sexual dimorphism variations within a single population (SWGANTH, 2010). This can include extrinsic factors such as socio-economic status, activity levels, and nutritional status. Intrinsic factors such as genetics and hormone levels can also affect the level of sexual dimorphism among an individual.

Another study on sexual dimorphism in long bones was performed on a modern population in Greece. Although the results showed that metric features of the radius, ulna, and humerus provided accurate estimates of sex, the skeletal remains were from Greece and thus may not be appropriate for forensic applications within the United States (Charisi et al., 2011).

The purpose of this research was to compare the two intrinsically different samples: the Texas State University Donated Skeletal Collection and the collection used in the Spradley and Jantz study. The sample from the Spradley and Jantz study came from the Forensic Anthropology Data Bank (FDB). The FDB is comprised of donated individuals as well as forensic cases associated with events such as homicide which usually involve younger, more suspicious deaths (fac.utk.edu/databank.html). It also is comprised of mostly individuals from the Southeastern United States. Those that are among donated collections, like in the Texas State Donated Collection, most often died from natural causes and their age-at-death is much higher, with the average age-at-death being 65 as of 2015 (Sophia Mavroudas, personal communication, May 4, 2015). This study was performed to ascertain if Spradley and Jantz's results can be used on other skeletal remains from around the country by using the Texas State University Donated Skeletal Collection and to see if regional variation exists between the two samples.

Another goal of this research was to compare the sexing accuracy of the radius, femur, and scapula with the Texas State University Donated Skeletal Collection to those results found among the same postcranial elements in Spradley and Jantz's research. This will act as a validation study to help contribute to existing research on estimating sex with postcranial bones. The Scientific Working Group for Forensic Anthropology (SWGANTH) stresses the importance of studies done to replicate and verify work done by others. This ensures methods that are performed in forensic cases are accurate and reliable.

The accuracy of sex estimation methods is very important. Sex estimation is often one of the first steps in completing a biological profile. If the sex of an individual

is inaccurately estimated due to invalid studies and methods, the missing person will never be identified. With missing persons lists including categories of either male or female, an incorrect sex estimation can essentially doom all future efforts to identify the unknown individual.

The National Missing and Unidentified Persons System (NamUs) is a website that has options to input missing persons information by anyone with a missing persons report as well as an option for professionals, such as forensic anthropologists, to input data about unidentified persons. Families of missing persons can search for their loved ones on this site by viewing the information put forth by biological profiles and possibly see any personal items the unidentified person may have had with them at the time of their death. Again, if any of the biological profile information is incorrect, particularly the sex, the families of missing persons will never find them.

The sheer number of unidentified and missing people within the United States has been called a silent mass disaster. According to Nancy Ritter's *Missing Persons and Unidentified Remains: The Nation's Silent Mass Disaster*, there are approximately 100,000 missing persons currently in the United States. She writes, "More than 40,000 sets of human remains that cannot be identified through conventional means are held in the evidence rooms of medical examiners throughout the country" (Ritter, 2). Ritter also mentions that because there are so many missing persons, they are often buried in unmarked graves without taking DNA samples. Forensic anthropologists are needed to identify these remains. As the years pass, more people go missing and the people found or identified are not nearly equal to that number. Although a slow process, with validated

methods for sex estimation and other identification practices more people can be identified accurately and at a faster pace.



Above: Students and researchers from Baylor University exhume unidentified migrant remains from a mass grave in South Texas (2014)
Source: dailymail.co.uk

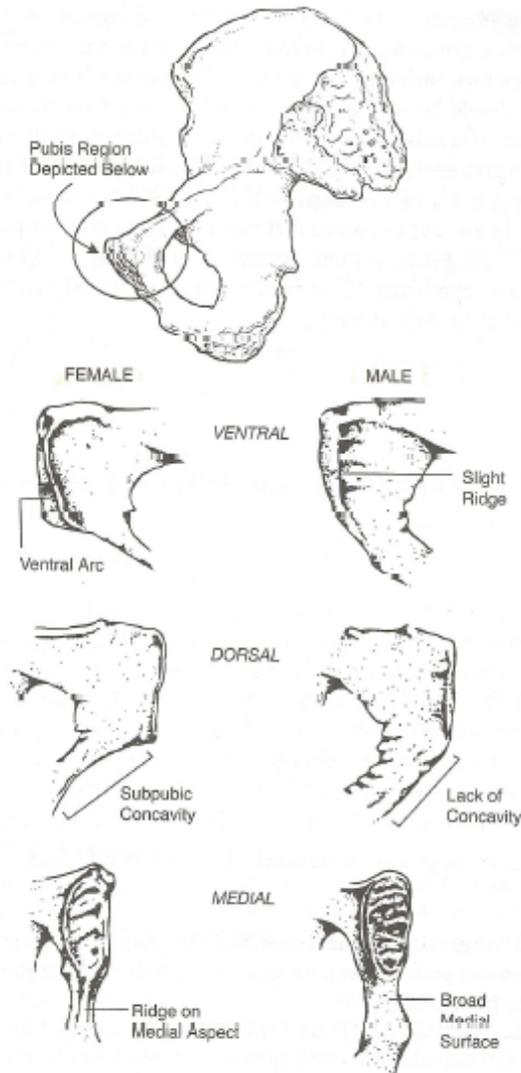


Figure 1: Sex differences in the subpubic region: Phenice's technique for sex determination. Drawing by Zbigniew Jastrzebski (after Buikstra and Mielke 1985; Phenice 1969). Source: Buikstra and Ubelaker 1994

Subpubic region features provided by Buikstra and Ubelaker 1994:

Ventral Arc: The ventral arc (ventral arch ridge) is a slightly elevated ridge of bone across the ventral surface of the pubis (Figure 1: top). To facilitate scoring this feature, the pubis should be oriented with the ventral surface directly facing the observer.

Subpubic Concavity: This feature is found on the ischiopubic ramus lateral to the symphyseal face. In females the inferior border of the ramus is concave, in males it tends to be convex. This observation should be made while viewing the dorsal surface of the bone (Figure 1: middle).

Ischiopubic Ramus Ridge: The medial surface of the ischiopubic ramus immediately below the symphysis forms a narrow, crestlike ridge in females. This structure is broad and flat in males (Figure 1: bottom).

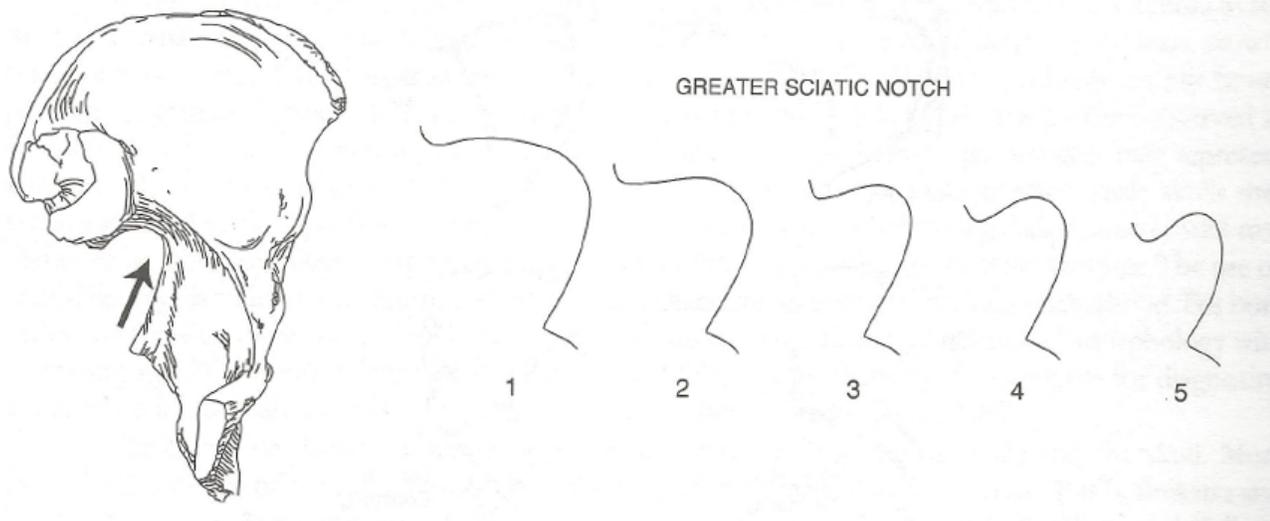


Figure 2: Sex differences in the greater sciatic notch. Drawing by P. Walker.
Source: Buikstra and Ubelaker 1994

From Buikstra and Ubelaker 1994:

The **Greater Sciatic Notch** tends to be broad in females and narrow in males. The shape of the greater sciatic notch is, however, not as reliable an indicator of sex as the conformation of the subpubic region due to a number of factors, including the tendency for the notch to narrow in females suffering from osteomalacia. Figure 2 should be used in recording greater sciatic notch form. The best results will be obtained by holding the os coxae about six inches above the diagram so that the greater sciatic notch has the same orientation as the outlines, aligning the straight anterior portion of the notch that terminates at the ischial spine with the right side of the diagram. While holding the bone in this manner, move it to determine the closest match. Ignore any exostoses that may be present near the preauricular sulcus and the inferior posterior iliac spine. Configurations more extreme than “1” and “5” should be scored as “1” and “5” respectively. The illustration numbered “1” in Figure 2 presents typical female morphology, while the higher numbers show masculine conformations.



From Tersigni-Tarrant and Shirley 2013:
Left: Wide sciatic notch (score = 1; female)
Right: Narrow sciatic notch (score = 5; male)

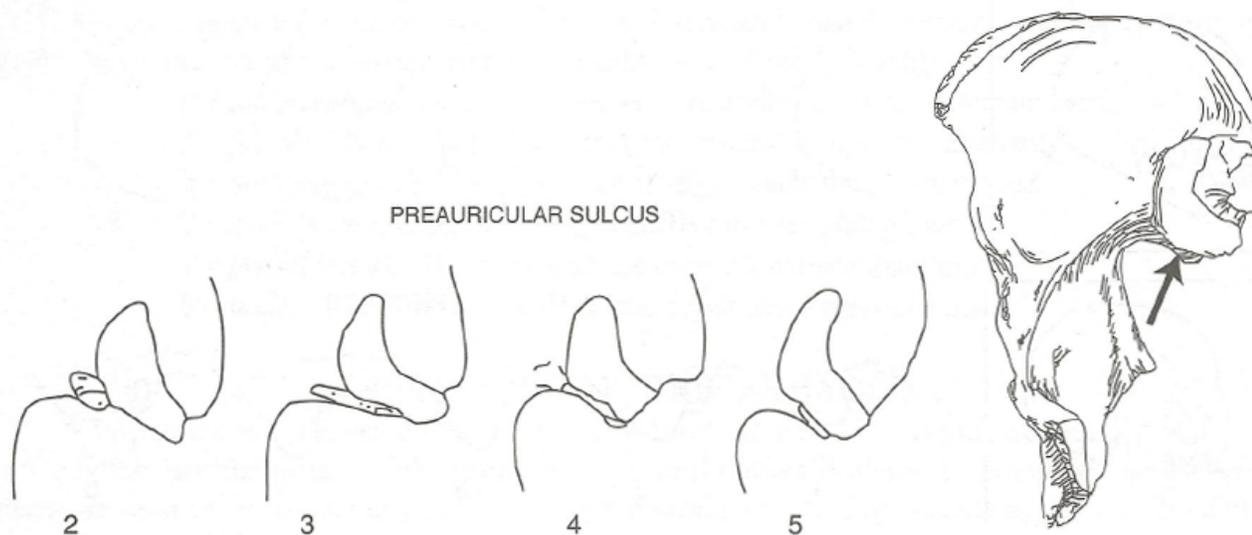


Figure 3: Scoring system for preauricular sulcus. Drawing by P. Walker (after Milner 1992).
Source: Buikstra and Ubelaker 1994

From Buikstra and Ubelaker 1994:

In addition to these features, the *Preauricular Sulcus* is thought to appear more commonly in females than in males. Figure 3 represents variation in preauricular sulcus form. Four positive expressions (2-4 below), as well as absence (1), should be recorded.

0 = (not illustrated) Absence of preauricular sulcus. The surface of the ilium along the inferior edge of the auricular surface and continuing into the greater sciatic notch is generally smooth. In some specimens, this surface may be roughened slightly where ligaments attach during life.

1 = The preauricular sulcus is wide, typically exceeding 0.5 cm, and deep. The walls of the sulcus are transected by bony ridges that make the sulcus appear as if it is composed of a series of lobes. The preauricular sulcus typically extends along the entire length of the inferior auricular surface, often undercutting it.

2 = The preauricular sulcus is wide (usually greater than 0.5 cm) but shallow. The base of the groove is slightly irregular, but bony ridges, if present, are not as marked as in Variant 1. The sulcus usually extends along the entire length of the inferior auricular surface.

3 = The preauricular sulcus is well defined but narrow, less than 0.5 cm deep. Its walls are either undulated or smooth. The sulcus extends along the entire length of the inferior auricular surface. A sharp, narrow bony ridge is typically present on the inferior edge of the preauricular sulcus, and it frequently extends along the entire inferior edge of the groove.

4 = The preauricular sulcus is a narrow (less than 0.5 cm), shallow, and smooth-walled depression. It lies below only the posterior part of the auricular surface. A sharp, bony ridge may be found on the inferior edge of the sulcus; if present, it does not extend the entire length of the sulcus.

Materials

The sample for this research consisted of 56 individuals from the Texas State University Donated Skeletal Collection. A larger sample was not possible as these were the only donations available at the time. As the Texas State University Donated Skeletal Collection is comprised of mostly elderly individuals, anomalies such as severe bone damage, gross pathologies, or bone replacements were present in many skeletons. As these were excluded from the study, it hindered the size of the sample.

The individuals used were of a wide age-at-death range, but no sub-adults were utilized in this study. It is very difficult to estimate the sex of a sub-adult, especially one that has not gone through puberty, and these high error rates could potentially distort the data. All of the donations measured were born in the 20th century, and thus are considered to be modern forensic specimens. This is important because any individuals that are not population-specific to those used in the study (for example, someone born in the 19th century who was much shorter than the modern-day average) would alter the results.

It is important to note that only self-reported white individuals were used in this research due to the limited sample size and the fact that the Texas State University Donated Skeletal Collection receives white donors much more frequently than any other group. Including only white individuals also controlled for any variability due to ancestry.

Out of the 56 persons measured, 21 were female and 35 were male. Measured skeletons were selected at random as to not skew the data. Standard sliding and

spreading calipers were used as well as an osteometric board and metal measuring tape. Pictures of these tools can be viewed on pages 11-14.

Methods

In total, 14 measurements were taken (two for the scapula, three for the radius, and nine for the femur) for each of the 56 individuals. The exact measurements taken can be seen on Table 1 on page 16. The measurement definitions from *Standards for Data Collection from Human Skeletal Remains* (pages 79-83) were used (Buikstra and Ubelaker, 1994). Only the left side of each skeleton was measured to remain consistent for each individual measured. If an anomaly existed that would potentially distort the data, such as metal implants or gross pathological conditions, the right bone was used. Skeletons with anomalies on both sides were excluded from the study. Illustrations and definitions of exact measurements can be seen below on pages 11-14.

Univariate methods of sex estimation were used with sectioning points to establish the classification rate of each individual and estimate if they were male or female. The sectioning points were established for each measurement by taking the means for both males and females, adding them together, and dividing by two. The sectioning points were then used to see which individuals for each measurement fell below that number (for females) or above that number (for males). The number of correctly classified individuals was then taken and divided by the total number of males or females to determine the classification rate for that specific sex. The classification rate is the percentage of males and females that were correctly classified by a specific measurement. To determine the classification rate for both sexes combined, each sex-

specific classification rate was added together and divided by two (Spradley and Jantz, 2011).

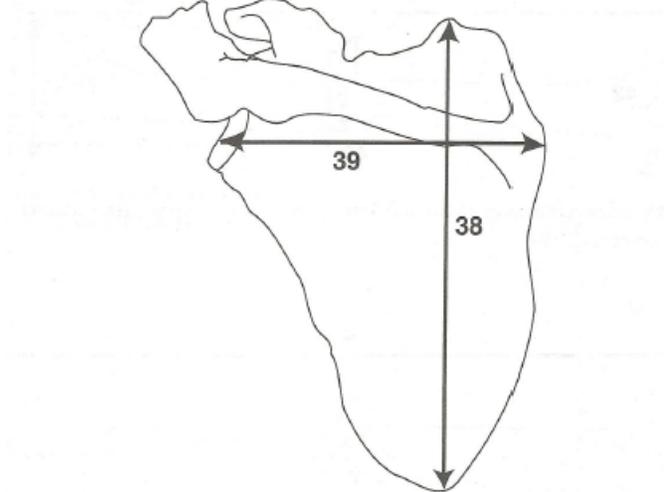


Figure 4: Measurements of the left scapula, dorsal view (after Moore-Jansen et al. 1994).
Source: Buikstra and Ubelaker 1994

From Buikstra and Ubelaker 1994:

38. Scapula: Height (Anatomical Breadth): direct distance from the most superior point of the cranial angle to the most inferior point on the caudal angle.

Instrument: sliding caliper (Figure 4).

39. Scapula: Breadth (Anatomical Length): distance from the midpoint on the dorsal border of the glenoid fossa to midway between the two ridges of the scapular spine on the vertebral border. *Instrument:* spreading caliper. *Comment:* project a line through the obtuse angle of a triangle formed by the vertebral border and the two ridges of the spine, dividing it into two equal halves. The medial measuring point is located where this line intersects the vertebral border (Figure 4).



Above: Scapular height being measured with sliding calipers
Source: Simone Longe 2014

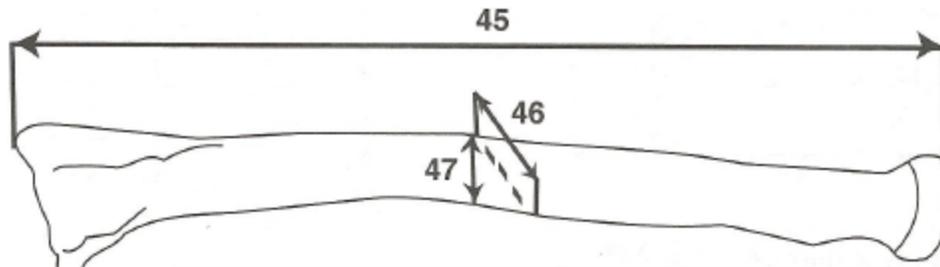


Figure 5: Measurements of the left radius, anterior view (after Moore-Jansen et al. 1994).
Source: Buikstra and Ubelaker 1994

From Buikstra and Ubelaker 1994:

45. Radius: Maximum Length: distance from the most proximally positioned point on the head of radius to the tip of the styloid process without regard for the long axis of the bone. *Instrument:* osteometric board (Figure 5).

46. Radius: Anterior-Posterior (Sagittal) Diameter at Midshaft: distance between anterior and posterior surfaces at midshaft. *Instrument:* sliding caliper. *Comment:* determine the midpoint of the diaphysis on the osteometric board and mark with a pencil. Measure sagittal diameter at that point. This measurement is almost always less than the medial-lateral diameter (Figure 5).

47. Radius: Medial-lateral (Transverse) Diameter at Midshaft: distance between medial and lateral surfaces at midshaft. *Instrument:* sliding caliper. *Comment:* perpendicular to anterior-posterior diameter (Figure 5).



Above: Radius maximum length being measured on an osteometric board
Source: Simone Longe 2014

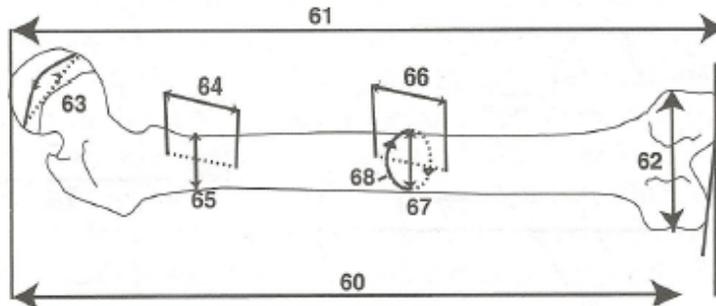


Figure 6: Measurements of the left femur, posterior view (after Moore-Jansen et al. 1994).
Source: Buikstra and Ubelaker 1994

From Buikstra and Ubelaker 1994:

60. Femur: Maximum Length: distance from the most superior point on the head of the femur to the most inferior point on the distal condyles. *Instrument:* osteometric board. *Comment:* Place the medial condyle against the vertical endboard while applying the movable upright to the femoral head (Figure 6).

61. Femur: Bicondylar Length: distance from the most superior point on the head to a plane drawn along the inferior surfaces of the distal condyles. *Instrument:* osteometric board. *Comment:* Place both distal condyles against the vertical endboard while applying the movable upright to the femoral head (Figure 6).

62. Femur: Epicondylar Breadth: distance between the two most laterally projecting points on the epicondyles. *Instrument:* osteometric board (Figure 6).

63. Femur: Maximum Head Diameter: the maximum diameter of the femur head, wherever it occurs. *Instrument:* sliding caliper (Figure 6).

64. Femur: Anterior-Posterior (Sagittal) Subtrochanteric Diameter: distance between anterior and posterior surfaces at the proximal end of the diaphysis, measured perpendicular to the medial-lateral diameter. *Instrument:* sliding caliper. *Comment:* be certain that the two subtrochanteric diameters are recorded perpendicular to one another. Gluteal lines and/or tuberosities should be avoided (Figure 6).

65. Femur: Medial-Lateral (Transverse) Subtrochanteric Diameter: distance between medial and lateral surfaces of the proximal end of the diaphysis at the point of its greatest lateral expansion below the base of the lesser trochanter. *Instrument:* sliding caliper. *Comment:* be certain that the two subtrochanteric diameters are recorded perpendicular to one another (Figure 6).

66. Femur: Anterior-Posterior (Sagittal) Midshaft Diameter: distance between anterior and posterior surfaces measured approximately at the midpoint of the diaphysis, at the highest elevation of linea aspera. *Instrument:* sliding caliper. *Comment:* The sagittal diameter should be measured perpendicular to the anterior bone surface (Figure 6).

67. Femur: Medial-Lateral (Transverse) Midshaft Diameter: distance between the medial and lateral surfaces at midshaft, measured perpendicular to the anterior-posterior diameter (#66). *Instrument:* sliding caliper (Figure 6).

68. Femur: Midshaft Circumference: circumference measured at the level of the midshaft diameters (#66 and 67). If the linea aspera exhibits a strong projection which is not evenly expressed across a large portion of the diaphysis, then this measurement is recorded approximately 10 mm above the midshaft. *Instrument:* metal tape (Figure 6).



Above: Femur maximum length being measured on an osteometric board
Source: Simone Longe 2014



Above: Femur maximum head diameter being measured with sliding calipers
Source: Simone Longe 2014

Results

Overall, the sex estimation results found among the Texas State University Donated Skeletal Collection follow a similar pattern to those found in Spradley and Jantz's research. The smallest difference between Spradley and Jantz's results and the Texas State Donated Collection fell under both the scapular breadth and femur midshaft circumference measurements (1%), while the largest difference fell under the femur transverse subtrochanteric diameter measurement (17%). The most accurate measurement for estimating the sex of an individual turned out to be the scapular height (89%) for Spradley and Jantz and the femur epicondylar breadth (91%) for the Texas State Donated Collection. The least accurate was the femur sagittal subtrochanteric diameter (69%) for Spradley and Jantz and the femur transverse subtrochanteric diameter (54%) for the Texas State Donated Collection. Refer to Figure 7 and Table 1 below for details of these classification rates.

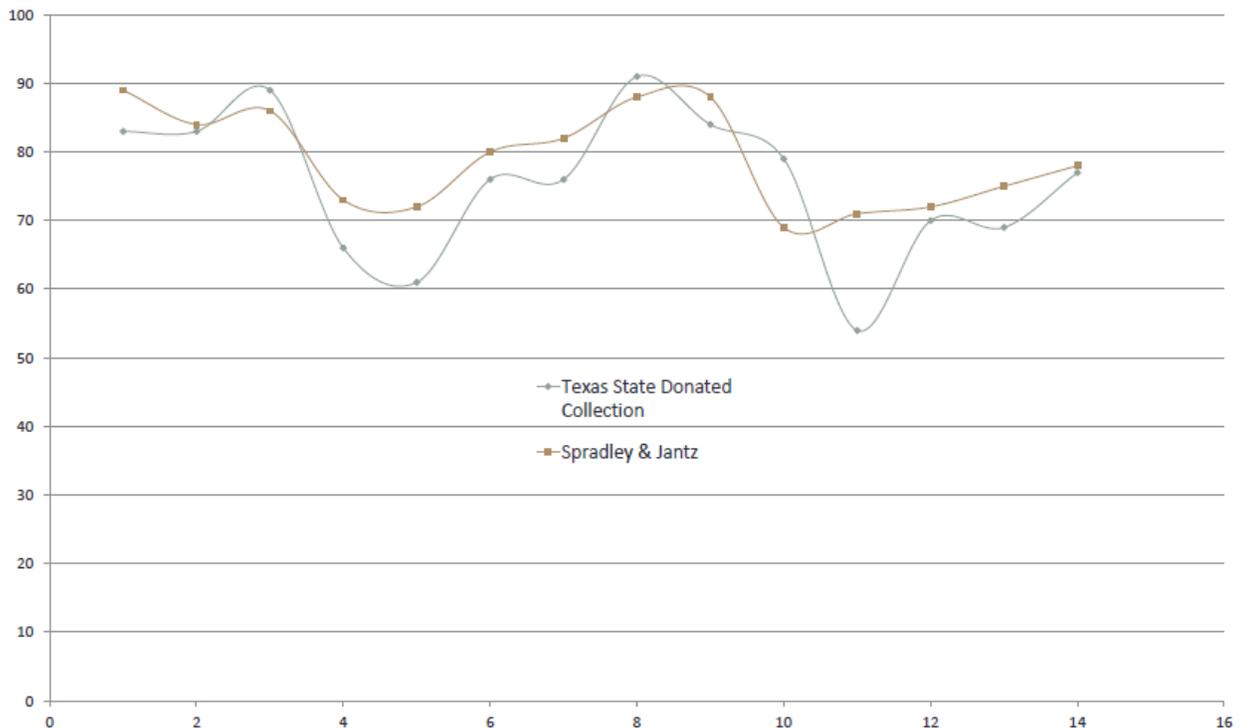


Figure 7 shows the classification rates in scatter plot form with the classification rate percentages on the y-axis and the corresponding measurement number on the x-axis (see Table 1). One can see the overlap, increases, and decreases in measurements for both Spradley & Jantz (brown) and the Texas State University Donated Skeletal Collection (gray).

Table 1

	Measurement	Spradley & Jantz Classification Rates	Texas State Donated Collection Classification Rates
1	Scapular Height	89%	83%
2	Scapular Breadth	84%	83%
3	Radius Maximum Length	86%	89%
4	Radius Sagittal Diameter	73%	66%
5	Radius Transverse Diameter	72%	61%
6	Femur Maximum Length	80%	76%
7	Femur Bicondylar Length	82%	76%
8	Femur Epicondylar Breadth	88%	91%
9	Femur Maximum Head Diameter	88%	84%
10	Femur Sagittal Subtrochanteric Diameter	69%	79%
11	Femur Transverse Subtrochanteric Diameter	71%	54%
12	Femur Sagittal Midshaft Diameter	72%	70%
13	Femur Transverse Midshaft Diameter	75%	69%
14	Femur Midshaft Circumference	78%	77%

Table 1 shows the classification rates for each measurement in Spradley & Jantz’s study versus the research conducted on the Texas State University Donated Skeletal Collection.

Discussion

Although the majority of the classification rates in this study were similar to Spradley and Jantz's research, there were a few that were inconsistent. There are a number of possible reasons for this. The sample used by Spradley and Jantz came from the Forensic Anthropology Data Bank (FDB), which consists of a much larger sample size than the 56 individuals used in this study. Not only was there a large numerical difference in sample size, but the FDB sample is intrinsically different than the Texas State University Donated Skeletal Collection. Forensic cases, such as those in the FDB, are associated with mostly homicides which involve younger, more suspicious deaths. Those who are among a donated collection usually died from natural causes and their age-at-death is much higher, as discussed previously. The Texas State Donated Collection is known to house mostly very old individuals. Because of this, the skeletons in donated collections will oftentimes look much different than those younger persons in the FDB. Bones change as an individual gets older. For example, shaft diameters of long bones get thinner in some individuals and pathologies, such as osteoarthritis or osteoporosis, can form (Roberts and Manchester, 1995). This can ultimately skew the data and produce inaccurate or inconsistent results. It should also be noted that the FDB is comprised of mostly individuals from the Southeastern United States (Spradley and Jantz, 2011). Lastly, Adams and Byrd cite subtrochanteric femur measurements as having a high inter-observer error, which could account for the greatest differences in classification rates of these metrics (Adams and Byrd, 2002). This may be due to the definition for this measurement in *Standards for Data Collection from Human Skeletal Remains* (1994) being vague and unclear. For future studies, it may be a good idea to

avoid using this measurement until it is either excluded completely or defined more clearly.

Some patterns in measurements were observed among the classification rates. There were some height and length trends among the Scapular Height (89%) and Radius Maximum Length (86%) exhibiting that these measurements yielded more accurate results than their counterparts for Spradley and Jantz's results. Scapular Height and Radius Maximum Length are similar in that they measure the length of the bone, which could account for their high classification rates as opposed to Scapular Breadth (84%) and Radius Sagittal Diameter (73%) and Radius Transverse Diameter (72%) measurements. However, although length measurements in the scapula and radius did well, femoral length measurements did not. The Femur Maximum Length came out to only 80% and the Femur Bicondylar Length came out to 82%. Femoral joint surfaces, such as the Femur Epicondylar Breadth (88%) measurement and the Femur Maximum Head Diameter (88%) measurement, performed much better than femoral length. However, the femoral length measurements achieved exceedingly better results than femoral shaft dimensions (femoral shaft dimensions can be seen on Table 1 for measurements 10-14). The Texas State Donated Collection classification rates follow similar patterns, although not exact.

It is always imperative that a population-specific sample be used. The Scientific Working Group for Forensic Anthropology discusses the importance of using current data and methods for population groups that represent real forensic cases. For example, it would be invalid to use data for Hispanic individuals for a study done on White individuals (Spradley et al., 2008). Since the Forensic Anthropology Data Bank and the

Texas State Donated Collection samples used in this study and the Spradley and Jantz study provided similar results, it can be concluded that both samples may be considered population-specific for the United States.

Future research in sex estimation using postcranial elements is needed to fine-tune this area of forensic anthropology. Larger sample sizes and the inclusion of different collections within the same population could improve the accuracy of results. For sex estimation using postcranial elements specifically, more measurements should be taken in order to compare them with the rest of the skeleton to supply a broader conclusion.

Conclusion

This study's purpose was to compare the high accuracy of sex estimation for the radius, femur, and scapula found in Spradley and Jantz's (2011) research with the Texas State Donated Skeletal Collection. This study also sought to see if intrinsically different samples, the FDB and the Texas State Donated Collection, would provide similar results. Since both studies yielded similar results, the formulate put forth by Spradley and Jantz can be used on other skeletal remains from around the United States.

The results show that most of the classification rates for white males and females between the two samples were similar. There were three measurements, however, that showed significant differences. More research should be conducted to help perfect postcranial sex estimation and validate more sex estimation studies. This can include, but is not limited to, validation studies with higher samples sizes or performing validated methods on different samples around the country and the world with population-specific samples and experimenting with nonpopulation-specific samples. Expanding on already

existing research is a key in increasing the number of approved methods forensic anthropologists can use not only for sex estimation, but in many other areas as well.

Postcranial sex estimation is important because forensic anthropologists encounter unidentified individuals with missing pelvises on a regular basis. In order to identify these missing persons, their sex must be estimated through the use of postcranial elements since it has been shown through Spradley and Jantz's research that the skull is much less accurate. With improved methods of determining sex, these unidentified individuals have a higher chance of being crossed off of missing persons lists and returned to their families.

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