

The John A. Williams Documented Human Skeletal Collection

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For the disciplines of bioarchaeology and forensic anthropology, documented human skeletal collections are a unique and valuable resource for innovating research and validation of various methods. While there are multiple large, documented human skeletal collections housed at several institutions in the United States and abroad, many of these large collections date to the 19th century. The demographics of the individuals in these collections, such as body size and shape, are likely subject to secular changes and therefore, no longer comparable to the contemporary population. Unfortunately, because of such secular changes, some of the most frequently consulted skeletal collections may no longer be appropriate for comparison to contemporary human populations, limiting their utility to forensic anthropological research.

This paper will describe the demographic profile of the John A. Williams Documented Human Skeletal Collection (The Williams Collection), as well as its utility for education and research in human skeletal biology including bioarchaeology and forensic anthropology. This collection is a new and growing, contemporary human skeletal collection housed at Western Carolina University (WCU) resulting from a willed-body program associated with WCU's forensic anthropology program and associated human decomposition facility, the Forensic Osteology Research Station (FOREST). The FOREST was established in 2005 and the first donation arrived in 2008. Since 2011, the FOREST has received an average of 12 donors per year, with a total of 102 donors, to date. Of these donors, 69 have been processed through the FOREST and are now housed within the skeletal collection, the remaining individuals are currently at the FOREST in various depositional contexts. The primary use of this collection is for educational purposes, as WCU is a regionally focused teaching institution. However, research using these remains is possible by request through the WCU forensic anthropology program.

Keywords: Forensic anthropology, bioarchaeology, human skeletal collection

Introduction

The need for documented reference samples applies to all specializations within biological anthropology. Reference samples are necessary for hypothesis-based research and the creation and testing of analytical methods (Christensen and Crowder 2009). For the disciplines of bioarchaeology and forensic anthropology, documented reference samples typically take the form of human skeletal collections. Other forms of reference data such as digital repositories of computerized tomography (CT) scans are becoming more common; however, physical collections of documented human skeletons are still the standard (Truesdell 2016).

At present, there are a large number of human skeletal collections curated for research and/or educational purposes throughout the world (Quigley 2001; Stephan and Ross 2018 and referenes therein). Many of these collections are archaeological, having been excavated from various mortuary contexts with dates ranging from prehistoric to historic. The lack of antemortem information means that these undocumented collections hold

relatively little value as reference samples because the demographic parameters (e.g., age, ancestry, sex, stature, etc.) of these individuals can only be estimated at best. Those estimations come from methods developed through the study of documented skeletal collections, like the Williams Collection discussed here.

Documented human skeleton collections available for research or educational purposes are presented in Table 1. Many of the larger documented human skeletal collections were derived from individuals that died in the late 1800s and early 1900s by anthropologists and anatomists (e.g., the Hamann-Todd Collection, the Terry Collection). As such, these collections have been, and continue to be, used as reference or validation samples for the majority of methods used in bioarchaeology and forensic anthropology. However, recent work has demonstrated that even documented reference samples of human skeletal remains can be problematic for method creation and validation.

The bias inherent in archaeologically derived skeletal material has been well documented (Jackes 2011), but it was not until recently that the potential bias

Table 1. Documented Skeletal Collection Comparisons.

Name	Institution	Location	Origin of Remains	Time Period of Collection	Number of Individuals
The Cobb Collection	Howard University	Washington, D.C.	Anatomical cadavers	1931-1965	~700
Hamann-Todd Human Osteological Collection	Cleveland Museum of Natural History	Cleveland, Ohio	Anatomical cadavers and unclaimed bodies from Cuyahoga County Morgue	1912-1938	3000+
John A. Williams Documented Skeletal Collection	Western Carolina University	Cullowhee, NC	Willed body donations	2008-Present	~100+
Maxwell Museum's Documented Skeletal Collection	Maxwell Museum of Anthropology	Albuquerque, NM	Willed body donations	1984- Present	308
The Robert J. Terry Anatomical Skeletal Collection	Smithsonian National Museum of Natural History	Washington D.C.	Anatomical cadavers	1927-1967	1728
William M. Bass Donated Skeletal Collection	University of Tennessee Knoxville	Knoxville, TN	Willed body donations	1981-Present	1800+

in documented skeletal collections was noted. Using the Maxwell Museum Documented Human Skeletal Collection as an example, Komar and Grivas (2008) argue that no documented human skeletal collections accurately reflect either the living or decedent populations from which they were derived. This bias in demographic representation is important to note because it demonstrates the need for validation of methods generated from these reference samples before applying them to unknown individuals. Typically this type of sample bias is expressed as an overabundance of older White males in current documented human skeletal collections. Bias resulting from unbalanced reference samples can have significant effects in method performance. Age mimicry is one such example, where an uneven distribution of reference sample ages produces biased age estimates when applied to other individuals, mimicking the distribution in the original reference sample (Masset 1989; Wood et al. 1992). Secular changes are directional changes in a variable over time and have been observed in a number of human skeletal dimensions in various populations. Examples of how secular change has affected the skeleton in United States populations are: the timing of epiphyseal union (Langley-Shirley and Jantz 2010); adult stature (Klepinger 2001); and cranio-facial dimensions (Jantz and Meadows Jantz 2000).

Secular changes do not eliminate the value or important contributions of the early documented human skeletal collections. Rather, researchers must consider the appropriateness of the context of these collections as reference or validation samples in conjunction with the intended use of their research (Komar and Grivas 2008). It is unclear how appropriate any research is when applied to bioarchaeological specimens

because there is no known identity for the archaeological individuals and therefore, methodological accuracy is unattainable (Hoppa 1996). For contemporary remains, particularly within the context of forensic anthropology, methodological accuracy is observable, and accurate methods are crucial in order to estimate an accurate biological profile to reach an identification from an unknown individual. This means that potential bias in a reference sample, such as those related to secular change, can have significant effects on the generated estimates of biological parameters like sex or age of target individual(s).

Forensic Anthropology at Western Carolina University

The Western Carolina Human Identification Lab (WCHIL) is part of the forensic anthropology program within the Western Carolina University's (WCU) Anthropology and Sociology Department. WCU's forensic anthropology program was created in 2003 with the formal establishment of an undergraduate concentration in forensic anthropology for anthropology majors. The WCHIL was established in 2004 and WCU's human decomposition facility, the Forensic Osteology Research Station (FOREST), followed in 2005. At the time, the FOREST was the second human decomposition facility established in the world and still remains unique for its location in a mountainous, forested, rural area. While pre-donation paperwork started immediately, the first donor to the FOREST did not arrive until 2008. Their remains were allowed to naturally decompose in the FOREST and after decomposition of the soft tissues, the skeletal remains were processed through the WCHIL in 2009, effectively beginning the John A. Williams Human Skeletal

Collection (named for the program founder, Dr. John A. Williams) (Zejdlik, Passalacqua, and Williams, In press).

Today, the primary use of the Williams Collection is to support the forensic anthropology program by providing educational opportunities for forensic anthropology students at the undergraduate level. Students in upper-level forensic anthropology-related classes have access to the collection for projects and training. Students are also involved in all levels of the body donation process from placement and body recovery of the donors at the FOREST as well as processing and curation at the WCHIL (Zejdlik, Passalacqua, and Williams, In press).

The John A. Williams Human Skeletal Collection

The WCHIL and FOREST receive an average of 12 donated bodies per year, and the program accepts both recently deceased individuals as well as cremated remains. As of November 2018, 102 individuals, including 12 cremated individuals, have been donated to WCU's forensic anthropology program. In most cases, donors were placed at the FOREST and remained there until they were

skeletonized. Then they were recovered and brought to the WCHIL for further cleaning and curation.

The geographic distribution of donors to the Williams Collection demonstrates that documented human skeletal collections are typically not representative of the population from which they are derived. The majority of donor remains (~56%) are from the piedmont and mountain regions of North Carolina (Figure 1), with the average distance from WCU's FOREST being ~83 miles. However, remains have been received from as far away as Alaska (Figure 2).

Demographic Profile of the John A. Williams Human Skeletal Collection

The demographic profile of the Williams Collection is slightly biased towards males, who make up 57% of the collection. The majority of individuals in the collection were over 55 years old at their time of death, with an average age of 67 years (Figure 3).

Prior to 2017, demographic information such as ancestry and stature were not routinely collected from donors or next-of-kin.

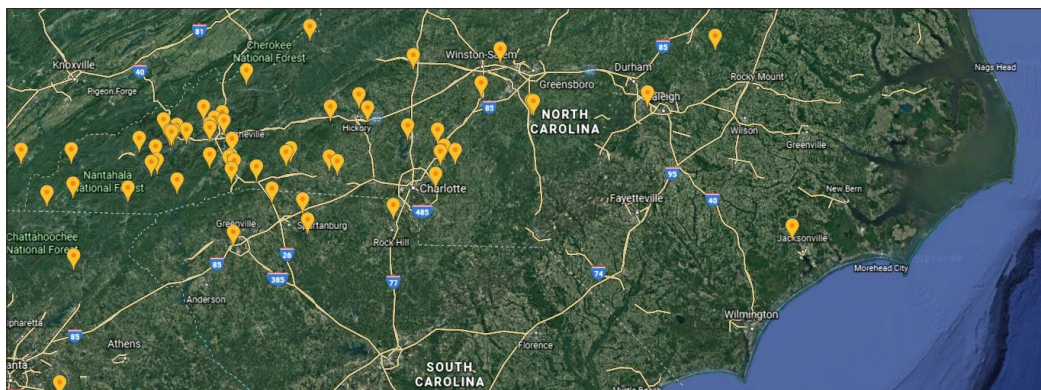


Figure 1. Map of North Carolina indicating locations of donor residence. Google Earth (2018).

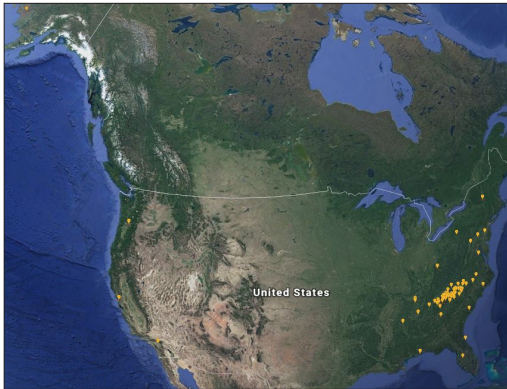


Figure 2. Map of North America indicating locations of donor origin. Google Earth (2018).

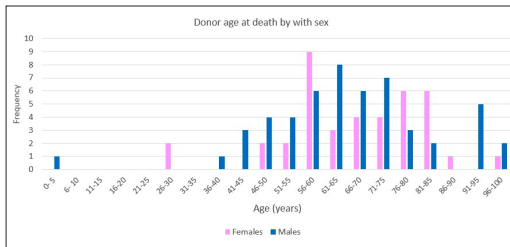


Figure 3. Age at death separated by sex.

The manner of death refers to the circumstances in which a death occurred (Christensen, Passalacqua, and Bartelink 2013). Currently, three different manners of death are represented in the Williams Collection, with natural death being the most common (Table 2). Eight individuals died from various forms of trauma, five of which were ruled as accidents and three as suicide. Cause of death is the specific biological cause of an individual’s death (Christensen, Passalacqua, and Bartelink 2013). The causes of death in the Williams Collection, while variable, were most commonly heart-related (Table 3), which is consistent with the current national leading cause of death in the USA, heart disease (Benjamin et al. 2018).

Table 2. Manners of death of Williams Collection donors.

Manner of death	Frequency
Natural	59
Accidental	5
Suicide	3

Table 3. Most common causes of death of Williams Collection Donors.

Cause of death	Number of donors	Percentage of donors
Heart-related	28	29
Cancer	19	20
Lung-related	10	10
Sepsis	5	5
Brain-related	5	5
Pneumonia	5	5

The Utility of the John A. Williams Documented Skeletal Collection

Every donation to the Williams Collection is unique. Each new donor adds to the potential applications of the collection and increases the amount of human variation observable. At present, the primary use of the collection is as an educational resource supporting WCU’s primary mission as a regionally-focused undergraduate teaching institution. Much of this educational utility is focused on using the collection to examine human skeletal biology, such as pathological conditions and skeletal anomalies for both in class and research purposes. This section will highlight a few individuals from the Williams Collection with particularly interesting skeletal features.

Orthopedic devices

Individual 2004-01

Donor 2004-01 is a 69-year-old Caucasian male. This individual has two interesting skeletal features: (1) a surgical rod on the right lateral femoral neck (Figure 4) and (2) bilateral lower leg amputations (Figure 5). The medical history of this individual is not available, so it is unclear if the orthopedic device in the femur is related to the double amputation.



Figure 4. Oblique anterior view of right femur with surgical rod on the lateral side of the femoral neck.



Figure 5. Anterior view of right tibia with amputation at the midshaft.

Donor 2016-02

Donor 2016-02 is a 66-year-old Caucasian male, also with a medical device. The manner of death was labeled as natural with the cause of death as cardiac arrest. This individual exhibits a total hip replacement on the left side (Figure 6).



Figure 6. Orthopedic replacement of left hip.

Orthopedic devices like those in these donors may provide a great deal of utility in forensic anthropology and skeletal biology. Not only do they provide insight into invasive medical procedures and the remodeling processes associated with their healing, but they may generate leads in missing person's cases, or lead to identifications based on their presence in antemortem medical imaging (i.e., radiographs). Additionally these types of medical devices have serial numbers which can also help provide leads to make a positive identification.

Skeletal pathologies

Donor 2014-02

Donor 2014-02 is an 84-year-old White male. The manner of death was natural with the cause of death as fulminant cardiogenic shock refractory. This individual exhibits vertebral fusion along the anterior spine starting at the 6th thoracic vertebra and ending with the third lumbar vertebra. In addition to the spinal fusion, right ribs 7 through 9 are fully fused with their corresponding vertebrae (Figure 7). Additionally, the 5th lumbar vertebra is fused to the sacrum (Figure 8). These pathological fusions are consistent with diffuse idiopathic skeletal hyperostosis (DISH), which is characterized by bony proliferation at the tendon insertion sites and ligaments of the spine (Cruz, Carilla, and Zejdlik, In Press; Mader et al 2009).



Figure 7. Anterior view of the fusion of right ribs 7 through 9 to thoracic vertebrae 7 through 9.

Donor 2012-04

Donor 12-04 is a 60-year-old Caucasian female. The manner of death was labeled as natural with the cause of death as cardiac arrhythmia. This individual exhibits fusion

in the mid-thoracic and the upper lumbar vertebrae, along with significant lateral curvature of the spine (Figure 9), and osteophyte development on the anterior and lateral regions of many thoracic vertebrae.



Figure 8. Oblique anterior view of sacrum showing fusion of the 5th lumbar vertebra and superior portion of the sacrum.



Figure 9. Mid-thoracic to upper lumbar vertebrae which show signs consistent with scoliosis.

Due to the complexity of this spinal curvature, while it is not definite, it is most likely that this right rib is fused to the mid-thoracic vertebra at approximately the 8th vertebra. (Figure 10). Additionally, ankylosis, or the fusion, of the right sacroiliac joint is present (Figure 11).



Figure 10. Oblique view of fused left rib to thoracic vertebra.



Figure 11. Oblique view of fused right sacroiliac joint.

These morphologies are consistent with ankylosing spondylitis (AS) (Braun et al., 2007). Sacroiliac fusion, when combined with fusion of multiple vertebrae, is a strong indicator of AS on skeletal remains. Clinically, AS is diagnosed via inflammation of the sacroiliac joint and spine, causing a range of pain and

debilitation (Braun et al., 2007). Individual 2012-04 presents with a combination of unusual pathological indicators rarely seen in skeletal collections. These morphologies demonstrate systemic and chronic biological processes likely associated with some degree of disability and dysfunction during life. This is especially important to teach students how different diseases impact the skeleton and the clues given in the skeleton tell us about an individual's health and activity.

Discussion/Conclusions

Research projects using The Williams Collection are encouraged and currently requested via a research application. Potential researchers should complete a research request application, which is available online or directly through contacting WCU's forensic anthropology facilities director or facilities curator. Once applications have been received, they are reviewed by all WCU forensic anthropology faculty for feasibility and scholarly merit.

Documented human skeletal collections are the foundation upon which the majority of research in bioarchaeology and forensic anthropology has been built. Continued advancement of analytical methodologies, comparative exemplars, and an understanding of human variation depends on the curation and expansion of these collections, which is paramount for increasing collection access and usage. The John A. Williams Human Skeletal Collection is currently a small but important addition to the documented human skeletal collections available for education and research, and we expect this collection's size and utility to increase over time.

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