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Internship Report

The National Museum of Health and Medicine,

Armed Forces Institute of Pathology (NMHM AFIP), Washington, DC

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Mission Statement:

National Museum of Health and Medicine, Armed Forces Institute of Pathology

“The National Museum of Health and Medicine of the Armed Forces Institute of Pathology inspires interest in and promotes the understanding of medicine -- past, present, and future -- with a special emphasis on tri-service American military medicine. As a National Landmark recognized for its ongoing value to the health of the military and to the nation since 1862, the museum identifies, collects, and preserves important and unique resources to support a broad agenda of innovative exhibits, educational programs, and scientific, historical, and medical research.”

Introduction

This summer I interned at the National Museum of Health and Medicine, Armed Forces Institute of Pathology in Washington, D.C. The museum, originally called the Army Medical Museum, was founded “to study and improve medical conditions during the American Civil War” (nmhm website). The museum’s collection includes archival materials, anatomical and pathological specimens, medical instruments and artifacts, and microscope slide-based medical research collections. The museum is officially divided into 5 collections: the anatomical collection, neuroanatomical collection, historical collection, the Human Developmental Anatomy Center (HDAC), and the Otis Historical Archives. Although the largest portion of my internship was spent within the anatomical collection, I was assigned duties in the neuroanatomical collection, the HDAC, and the Otis archives. After introducing the organizational structure, exhibits, and history of the museum, this paper will describe the duties of an intern within each division as well as the special projects I completed during my internship.

MUSEUM LAYOUT

The official name of the institution is the National Museum of Health and Medicine, Armed Forces Institute of Pathology. As the name indicates, the NMHM is affiliated with the military and located on Camp Walter Reed. Walter Reed “provides comprehensive health care for more than 150,000 soldiers, other service members, family members and retirees in the National Capital Area. Its hub is Walter Reed Army Medical Center, the clinical center of gravity of American military medicine” (wramc website). Many soldiers who are injured in Iraq and Afghanistan go to Walter Reed to learn to walk on prosthetics after limb amputations as well

as for treatments to brain injuries and burns. The namesake for the medical center, U.S. Army Major Walter Reed, was curator of the museum from 1893-1902.

The NMHM is an element of the Armed Forces Institute of Pathology. The AFIP is a tri-service (Army, Navy, and Air Force) agency of the Department of Defense (DOD) with missions involving consultation, education, and research. The AFIP serves educational services for both military and civilian pathologists, physicians and other medical professionals as well as research in “fields such as environmental pathology and toxicology, infectious diseases, oncology and forensic science” (afip website). The MNHM receives funding through the Office of Health Affairs within the DOD along with grants, contributions, and donations. The museum is not affiliated with any of the Smithsonian Institutions and, although it is located on the campus of Camp Walter Reed, has no connection to U.S. Army Museum System.

Within the NMHM’s professional staff, there is a director, administrator, and staff assistant. The collections staff consists of a senior curator, anatomical collections assistant curator, an archivist, assistant archivist, archive technician, an historical collections manager and collections specialist, a human developmental anatomy center imaging specialist and imaging technician, and a neuroanatomical collection curator and project technician. There is also a public affairs officer, public affairs specialist, public programs manager, tour program manager, facilities manager, three visitor services representatives and an exhibit specialist (nmhm website).

The NMHM is located within the secured AFIP building. Gaining entry to a secure building within a military base required specific identification and logistical procedures. Because many civilians come to visit wounded soldiers, Camp Walter Reed only requires

identification via a driver's license or passport to gain entry. Although it was not difficult to get onto Walter Reed, I had to get a special badge to get into the museum. Interns at the NMHM are officially Red Cross volunteers. To get my badge for the museum, I had to go through Red Cross orientation, HIPPA training, and medical examination. After learning the history of the Red Cross and verifying that I had my Hepatitis B, Tuberculosis, and Tetanus vaccinations, I received HIPPA training regarding patients' rights to medical information. The last phase of my in-processing involved consultation with the security officer of the AFIP. I was instructed in proper procedures for checking in and out every morning, and the limitations of my access to facilities. For example, my badge gained me access to the museum collections area, but I did not have access to the network on any computers. Once I had completed in-processing and acquired my AFIP identification badge, I was able to enter the museum and its collections area every morning.

HISTORY

The Army Medical Museum was established on May 21, 1862, when U.S. Army Surgeon General William Alexander Hamilton ordered all Union Army medical personnel "to collect, and to forward to the office of the Surgeon General all specimens of morbid anatomy, surgical or medical, which may be regarded as valuable; together with projectiles and foreign bodies removed, and such other matters as may prove of interest in the study of military medicine or surgery." (nmhm website). In addition to the specimens of morbid anatomy, the museum collected photographs documenting the effects of gunshot wounds, amputations, and various surgical procedures. The information was collated into six volumes of *The Medical and Surgical History of the War of the Rebellion*, published between 1870 and 1883 (nmhm website).

After the Civil War, the museum staff conducted medical research focusing on photomicrographic techniques (nmhm website). This research led the museum to study infectious diseases, discovering the cause of yellow fever and vaccinations for tuberculosis. During WWI, the staff engaged in public ad campaigns against sexually transmitted diseases along vaccination and other public health campaigns.

By WWII, research at the museum was centered on its current focus, pathology. In 1946 the Army Medical Museum became a division of the Army Institute of Pathology, which was renamed the Armed Forces Institute of Pathology (AFIP) in 1949. The Army Medical Museum was renamed the Medical Museum of the AFIP in 1949, the Armed Forces Medical Museum in 1974, and received its current name, the National Museum of Health and Medicine, in 1989 (nmhm website).

Currently, the museum is undergoing further reorganization. In 2005, the Base Realignment and Closure Commission (BRAC) voted to close Walter Reed Army Medical Center. The soldiers at Walter Reed Hospital will be moved to the new Walter Reed National Military Medical Center at Bethesda, Md. The museum will remain open during the base relocation and will then move to its new location in Silver Spring, MD.

EXHIBITS

There are three permanent exhibits at the NMHM: [1] To Bind Up the Nation's Wounds: Medicine During the Civil War; [2] Evolution of the Microscope; and [3] Battlefield Surgery 101: From the Civil War to Vietnam. There are also six exhibitions running indefinitely: [1] Abraham Lincoln: The Final Casualty of the War; [2] Trauma Bay II, Balad, Iraq; [3] Resolved: Advances in Forensic Identification of U.S. War Dead; [4] Blood, Sweat and Saline: Combat

Medicine in the Korean Conflict; [5] From a Single Cell; and [6] Visibly Human: Health and Disease in the Human Body. Descriptions of the exhibit come from the NMHM website:

To Bind Up the Nation's Wounds: Medicine During the Civil War. This exhibit examines Civil War medicine from the perspective of battlefield surgeons and includes stories of Union and Confederate sick and wounded.

Evolution of the Microscope. The NMHM houses the world's largest collection of microscopes, spanning the 400 year existence of the scientific tool. The jewel of this exhibit is Robert Hooke's 17th century handcrafted, leather and gold-tooled microscope.

Battlefield Surgery 101: From the Civil War to Vietnam. This exhibit is derived from the museum's historical archives and collections and traces the evolution of military medicine over 140 years. The exhibit is comprised of photographs and artifacts.

Abraham Lincoln: The Final Casualty of the War. The Abraham Lincoln exhibit is probably the most popular exhibit in the museum. It includes anatomical specimens and artifacts related to the assassination of the 16th President. On display are the bullet that killed Lincoln, the probe used to locate the bullet, bone fragments and hair from his skull, and a blood stained shirt cuff from the autopsy. Other items on display include a pencil sketching of the death bed scene and sculpted copies of Lincoln's face and hands. Also associated with the assassination, but not on display are John Wilkes Boothe's cervical vertebrae and portion of his spinal cord that were severed when Boothe was shot. These items are stored in the anatomical collection.

Trauma Bay II, Balad, Iraq. This exhibit is a reconstruction of the former Air Force tent hospital in Iraq. Once a permanent structure was built for the hospital, the old plywood and tent

hospital was sent to the museum. Visitors can see the actual iodine-covered operating room floor and plywood walls complete with written messages from soldiers who had visited the hospital.

Resolved: Advances in Forensic Identification of U.S. War Dead. This exhibit traces the evolution of the forensic sciences that are employed to fulfill the nation's commitment to identifying and bringing home the remains of all U.S. servicemen. The exhibit highlights the six lines of evidence that are crucial to positively identifying deceased servicemen: material evidence, fingerprinting, forensic dentistry, forensic anthropology, forensic pathology, and DNA.

Blood, Sweat and Saline: Combat Medicine in the Korean Conflict. This exhibit is a recreation of a Mobile Army Surgical Hospital used during the Korean Conflict and features surgical instruments and an artificial kidney machine that was used in the field. The exhibit also examines medicine during the conflict through photographs and personal recollections of medics and patients.

From a Single Cell. This exhibit follows human development from embryo to age 5 and includes specimens from the museum's Human Developmental Anatomy Center (HDAC). The NMHM houses the largest collection of fetal material in the United States. Along with the human specimens, the exhibit includes anatomical models and images that relate pre- and post-natal growth patterns and developmental stages.

Visibly Human: Health and Disease in the Human Body. The museum contains over 100 years of anatomical and pathological specimens. This exhibit displays normal anatomical organs alongside pathological specimens. The specimens represent pathologies resulting from injury, disease, and environmental factors.

These exhibits highlight the NMHM's commitment to the military, servicemen, and medicine.

CRANIOLOGY LETTERS

Because of my interest in craniometrics (metric analysis of the size and shape of crania), the staff coordinated a project in which I would be databasing original written communications regarding the museum's role in the history of craniology. The project completed with the Otis Historical Archives was probably my favorite. Letters came from some of the biggest names in the history of anthropology such as Franz Boas, John Wesley Powell, and Jeffries Wyman; and pertained to topics such as craniology, the acquisition of skulls, and contemporary instruments and techniques.

Historically, craniologists were interested in the brain sizes of different population groups. The way to measure brain size from the skeleton was to measure endocranial volume. The measurement was famously performed by mustard seeds. Craniologists would pour mustard seeds into the skull and compare the relative amounts between populations. Endocranial volume was not always measured via mustard seeds. On February 5, 1884, assistant curator of the Peabody museum, Lucien Carr wrote a letter to J.S. Billings discussing a previous method and why mustard seeds were superior:

This is a most important point and I do hope that you will see fit to discard shot and use the mustard seed. Without uniformity in this respect our measurements of capacity are valueless for comparison. The objections to using shot are numerous and weighty to say nothing of the fact that our crania are too fragile to stand the unit packing necessary with so heavy a material.....(Jeffries) Wyman also published a paper on the subject but it does not differ from your practice. He used peas, and we did too until a year or so ago when we adopted mustard seed as being 1. more satisfactory and 2. Bringing us in harmony with the large collection under care of Prof. Flower.

The letter is urging Billings to abandon metal shot as a measure of endocranial volume in favor of mustard seeds because: (1) the shot were damaging the specimens and (2) to bring uniformity in methodology. This was another vital concern of craniologists. Carr notes that without such uniformity, measurements obtained by other researchers would not be comparable. There was much correspondence concerning the standardization of measurements.

Regarding the Frankfort Agreement, Carr wrote to Billings “For this reason I shall not adopt it unless Topinard and Flower should accept it, in which case I would follow suit, not that I think anything would be gained by the change, but because I recognize the importance, I had almost said necessity, of uniformity in our methods if we would arrive at any satisfactory conclusions.” Carr is referring to The Frankfort Craniometric Agreement, a general consensus among Germany anthropologists regarding methods for measuring skulls. The German standards were derived at the 13th General Congress of the German Anthropological Society, held at Frankfort-on-Maine in 1882 (Garson 1885). The museums in America typically adopted French and English standards of measurement. Both Carr and Billings followed the methods of Flower, an Englishman, and Broca and Topinard, both Frenchmen. It goes without saying that Carr did not welcome standardization according to German definitions. In a letter to Billings, Carr stated of the Frankfort Agreement, “if it possesses any advantage over Broca’s and Flower’s methods I have yet to see it.”

By reading and transcribing original correspondence, I gained valuable insight into the first usages of empiricism and the scientific method in anthropology. The letters hearken to an era in which evolutionary theory was taking hold and racial hierarchies

were created to justify the subjugation of African slaves and indigenous American Indians. Anthropology textbooks are filled with accounts of the racist origins of physical anthropology; however, the NMHM letters betrayed the essence of this thinking through original handwriting, lexicon, and style of letter writing. An example of this mindset comes in a letter written by George A. Otis on April 25, 1870, “That judging from the capacity of the cranium, the American Indians must be assigned a lower position in the human scale than has been believed heretofore.” The civil war abolished slavery and freed the African slaves, but races were not equal. Technological advancements such as the railroad, and economic expansion drove the nation west. The occupation of western lands required the displacement of the American Indian inhabitants. Although anthropologists did not advocate the wide-spread extermination of American Indians that characterized the “Indian Wars,” the perspective of biological determinism and racial inferiority justified their mistreatment.

Another interesting letter came from a Texas historical figure, “Adam Paine, Seminole Negro Indian Scout.” Paine’s correspondence shows how the discovery of tucked away and forgotten archives can be useful to contemporary researchers. The letter, dated January 25, 1875, was sent from Fort Concho, TX and addressed to General C.C. Augur, Commanding Department of Texas. In the correspondence, Paine relates that he has in his possession “an Indian scalp taken by me at the Twin Lakes Tex. I was with Gen. MacKenzie’s Command in the engagement which took place at the above named lakes, about the 3rd day of November, 1874.” I further investigated the people and events of the letter in the museum’s historical archives and discovered that Adam Paine was the first Seminole Negro Scout to earn the Medal of Honor.

The Seminole Negroes were descendants of escaped slaves that settled amongst the Seminole Indians of Florida. During the 1830s and 1840s, the Seminoles, along with the Seminole Negroes, were relocated to reservations in what is now Oklahoma. Because of persecution from slave hunters and Creek Indians, one band of Seminoles and a band of Seminole Negroes moved to Mexico. Using skills obtained in the Florida wilderness, the Seminole Negroes became noted frontiersman, known for their riding, hunting, and tracking skills. After the Civil War, the U.S. Army returned to Texas and was called upon to protect citizens from Apache and Comanche Indians, who were being displaced from their homelands. Army leaders needed scouts who were skilled at surviving and fighting in the desert borderlands and recruited Seminole-Negroes. Adam Paine was one of these recruits and served from 1873-1875. He received the Medal of Honor on October 13, 1875, after a Battle at Quitaque Peak, in which he and four other scouts defended themselves against several bands of Comanche and were later able to return and track the Comanche. Adam Paine is buried in Bracketville, TX and is the namesake to the Adam Paine Academy in Sun City, Florida.

The battle referred to in Paine's letter is the battle at Twin Lakes, TX in January of 1875. The letter and accompanying scalp that he had taken were forwarded to the Army Medical Museum. Sometime after, the scalp was sent to the Smithsonian's National Museum of Natural History. As an intern of the NMHM, I got the opportunity to get a behind the scenes tour of the Smithsonian museum. One of the guides on my tour was discussing how she was currently cataloging their collection of scalps. I told her about the Paine letter and she was anxious to see a copy. I photocopied the letter the next day at work and the information contained within helped her match the scalp with its appropriate paperwork at the Smithsonian. By organizing

and sorting the craniology letters, I was able to learn about a little known figure in Texas history and presented with the opportunity to aid researchers at another institution.

INTERNSHIP RESPONSIBILITIES

My overall internship responsibilities included assisting in the organization and preservation of dry skeletonized and wet formalin fixed tissue specimens, aiding in the organization of the osteological collection by digitizing crania and running them through FORDISC 3.0 (Ousley and Jantz 2005), and performing archival research to enhance the collection's research value and update relevant databases and files. My daily responsibility was the organization and preservation of collection specimens, while the digitizing and archival research were projects completed in succession. Each project lasted approximately one working week.

One internship responsibility was to assist in the organization and preservation of dry skeletonized and wet formalin fixed tissue specimens. The NMHM osteological and anatomical collections are housed in storage containers in the collections area. The osteological collection is made up of several small collections. These skeletal specimens came from the Civil War, the Indian Wars, and New York City's Office of the Chief Medical Examiner. In addition to the human skeletal remains, there were numerous animal specimens. Most of the animal specimens were examples of pathologies; however, the museum has the skeleton of one of the original space chimpanzees. The fixed wet tissue specimens were housed in a room of their own because they were contained in formalin filled jars, and these chemicals are considered hazardous. The NMHM collections are accessed daily by museum employees as well as periodically by

researchers from other museums and academic institutions. During my internship, researchers came from George Washington University, the Smithsonian's National Museum of Natural History, and as far away as a university in Holland.

My responsibilities concerned daily use of the osteological and wet tissue specimens of the museum. My duties required daily handling of skeletal material. After obtaining specimens for other researchers or for myself, I was required to close the cabinets housing the specimens once they were removed. Closing the cabinets protects the specimens from mechanical damage from passers-by as well as from damage due to insects. Because space was limited within the collections area, open doors blocked aisles and exposed the specimens to damage as museum employees and researchers passed through. Skeletal materials were individually contained in cardboard boxes to prevent damage during transportation. All crania were additionally secured in Styrofoam beds, formed to the cranium's individual morphology. The foam beds secure the crania against damage from opening and closing cabinets and during transportation. When removed from the foam bed, the crania were always placed on a cushioned "doughnut" to prevent damage during examination.

Formalin-fixed wet tissues, in their glass containers, were always transported on a rolling cart to prevent dropping. A large, sturdy rolling ladder was used to remove specimens that were beyond reach. Formalin is considered a hazardous chemical that can irritate the lungs and eyes. An eyewash station was located at the entrance to the formalin room in case there was ever a spill. Goggles were required whenever refilling the specimen containers.

Another responsibility was to aid in the organization of the osteological collection by digitizing crania and running them through FORDISC 3.0 (Ousley and Jantz 2005) to get a better

understanding of their ancestry. FORDISC is discriminant function analysis software developed by Steve Ousley and Richard Jantz to aid forensic anthropologists in the determination of ancestry and sex of unknown skeletal specimens. Many of the specimens at the museum were obtained in the infancy of osteological collection, when recording standards were not what they are today. The crania that I ran through FORDISC mainly came from a cabinet marked “Peruvian Crania.” Although it was known that some of the crania housed in the cabinet were not Peruvian, the majority were collected from Peru. The FORDISC analysis helped to confirm which were Peruvian and provided additional data on the ones who were not by using statistical analysis to classify each cranium into its ancestral group. For example, one specimen was assigned to the Austrian reference population in FORDISC. I investigated the accession number of the specimen in the collection’s archival files found out that the individual was a white soldier that died during the Mexican-American War.

I also performed archival research to enhance the collection’s research value and update relevant databases and files. Although this goal was primarily accomplished through transcription of the craniology letters, another task was renaming scanned copies of the Kerley slide collection. Ellis Kerley, a founding member of forensic anthropology, worked at the AFIP from 1957-1966. While at the AFIP, Kerley researched “age-related histological bone changes, body constitution and stress fractures, evolutionary patterns of bone, bone type, bone growth and morphology in chimpanzees, nutritional effects on the primate skeleton, skeletal identification, and paleopathology” (Sledzik 2001). Kerley’s best known work at AFIP was his osteon aging technique, often called the Kerley method (Sledzik 2001).

The Kerley method is a means of determining the age-at-death of an individual by microscopically examining cortical bone microstructure (Sledzik 2001). While I was interning,

the museum was undergoing the process of digitizing all of their microscope slides. Once the slides had been digitized, the images on the computer had to be properly named. While the task only involved putting a name on a picture, making sure that it was the correct name required reading a description of the image. As I renamed the slide images, I was able to learn about bone disease at the microscopic level and what normal and pathological bone growth looks like histologically. Diseases such as rickets, scurvy, and osteomyelitis leave their imprint on bone microstructure. After learning how normal cortical and trabecular appear microscopically, I was able to detect the signature markings of each of these diseases.

INDEPENDENT RESEARCH PROJECT

I completed an independent research project as part of my internship at the NMHM. The project was to establish baseline craniometric data from the osteological collection of Civil War soldiers housed at the museum and compare them with individuals born during the Civil War Era. The Civil War Era includes the years the war was fought (1861-1865) through the end of Reconstruction in the South (1878). The objective of the study was to determine whether the widespread hardship endured during the Civil War Era left visible effects on the cranial morphology of children developing during that period.

Many researchers believe that nutritional deficiencies negatively affect bone growth. One such researcher was Larry Angel. Angel (1982) hypothesized that because (1) the base of the skull supports the weight of the head and brain, and (2) malnutrition weakens growing bone during childhood, that (3) individuals who were nutritionally deprived as children will have

shorter, more compressed skull base areas. The idea behind this hypothesis is that malnutrition would lead to weakened cranial bones that were unable to resist gravitational pull, inhibiting vertical growth while exerting force flattening the base. I selected Angel's (1982) hypothesis to test for skeletal indicators of malnutrition during the Civil War Era.

Materials and Methods

Samples

I digitized forty-five crania from the NMHM collection using a Microscribe G2 digitizer that records craniometric landmarks and distances. The individuals in this sample were all white male, American Civil War soldiers, the majority of which (N=26) were Confederate soldiers killed at the battle of the Wilderness, which occurred May 5-7, 1864. Other battles included Second Bull Run and Antietam. The Civil War soldiers were grouped into one cohort and served as the baseline for the population before the war. Cranial growth is almost entirely complete by adolescence; therefore, the soldiers were treated as completely developed adults. Although the birth years for these individuals are not known, adulthood was confirmed by third molar eruption.

The remaining individuals in the study were obtained from published data on the Robert J. Terry and Hamann-Todd osteological collections. The Terry Collection represents individuals from the St. Louis, Missouri area. Most of these individuals were cadavers of unclaimed bodies and donations and ranged in birth years from mid to late 19th century to early 20th century (Hunt and Albanese 2005). The Hamann-Todd Collection is also comprised of unclaimed and donated cadavers from the mid to late 19th century to early 20th century, but representing the Cleveland, Ohio area. These collections contain known birth years for the majority of the individuals. It

was these known birth years that allowed me to isolate those that were born during the Civil War Era.

White males were placed into three cohorts based on birth year: (1) Pre-Civil War, (2) Civil War Era, and (3) Post-Reconstruction. The Pre-Civil War cohort consisted of the Civil War soldiers at NMHM. This cohort served as a baseline for white males before the war. The Civil War Era cohort was the target cohort of the study. Individuals included in this sample came from the Terry and Todd Collections and had birth years ranging from 1851-1877. These individuals were developing during the Civil War Era and would have shorter, more compressed cranial bases than the other two cohorts if Angel's (1982) hypothesis is supported. The Post-Reconstruction cohort included individuals with known birth years from 1878-1899. This cohort documents changes that occurred after Reconstruction ended in the South up until the turn of the 20th century.

Measurements

Four cranial measurements (BAR, BNL, AUB, ASB) were chosen to represent the cranial base. The measurements, as defined below, come from Howells (1973, 1989):

- **Basion radius (BAR):** the distance perpendicular to the transmeatal axis. This measurement essentially measures the distance from the base of the cranium to the sella turcica portion of the sphenoid. This measurement is the equivalent of Angel's (1982) skull base height.
- **Basion nasion length (BNL):** the distance from the anterior border of the foramen magnum, in the midline (basion), to the intersection of the fronto-nasal

suture and the median plane (nasion). This is a measure of horizontal cranial base growth anterior to the foramen magnum.

- **Biauricular breadth (AUB):** the minimum exterior breadth between the roots of the zygomatic processes (auriculare). This is a horizontal measure of the cranial base at the level of the ears.
- **Biasterionic breadth (ASB):** is the direct measurement from the common meeting point of the temporal, parietal, and occipital bones on each side (asterion). This is a horizontal measure of the posterior cranial base.

In addition to the individual measurements, I added a cranial base index. This index (skull base height X 100/ biauricular breadth) is a replication of Angel's (1982) "skull base height index" (Angel 1982: 302). The purpose of this index is to isolate crania base height variation from differences due solely to the size of the individual.

Statistical Analysis

One-way ANOVA were performed on the univariate cranial base measures (BAR, BNL, AUB, ASB) as well as the cranial base index, using SPSS. In addition the ANOVA, post-hoc Tukey analyses were added to each test in order to determine between which cohorts any significant differences lay.

Inter/Intra-observer Error

Measurement error was assessed via independent samples t tests. The only data available for interobserver analysis were the digitized data from the NMHM AFIP collection. Independent t tests were performed on each cranial base measurement (BAR, BNL, AUB, ASB) taken for the

current study. The measurements from the current study were compared to previous measurements taken on the same NMHM specimens by Dr. MK Spradley.

Intraobserver measurement error was assessed by comparison between the digitized cranial base measurements (BAR, BNL, AUB, ASB) and identical measurements taken by calipers. Caliper measurements can be immediately verified and the cranium can be adjusted during measurement unlike with digitized data; therefore, caliper data were treated as more accurate than digitized when there was a discrepancy. Independent sample t tests for each measurement indicated the degree of measurement error present within the digitized data.

Results

Results showed that although cranial base height differed significantly across cohorts (ANOVA: $F(5,518) = 5.808, p < .05$), Tukey post-hoc comparisons revealed no significant differences for the individuals born during the Civil War Era. The Civil War Era cohort ($M = 12.87, 95\% \text{ CI } [11.99, 13.76]$) did not differ significantly from Pre-Civil War ($p = .998$) or from Post-Reconstruction ($p = .897$) cohorts. My analysis did not reveal measurable differences in cranial base height for individuals who supposedly suffered from childhood malnutrition. Inter-observer testing revealed no statistically significant differences between the data collected by Dr. Spradley and my own, and intra-observer testing revealed no statistically significant differences between my digitized data and caliper data. These results do not support Angel's (1982) hypothesis that the cranial base is a good indicator of childhood stress.

Discussion

Although my results did not support Angel's (1982) hypothesis, further studies must be conducted before one can claim that the human cranial base height is resilient to nutritional

deficiencies. One problem with the research design is that nutritional deficiency was inferred according to an individual's birth year coinciding with a historically stressful period. The individuals comprising the Terry and Hamann-Todd collections may or may not have experienced nutritional deficiencies. That fact the individuals included consist of unclaimed cadavers and donations supports the notion that lower SES individuals experience poorer nutritional environments, but these conditions cannot be known for sure. Conducting future research focused on populations with skeletal evidence of nutritional stress (e.g., enamel hypoplasias) may yield additional insight into nutritional effects on cranial base growth.

The results could also demonstrate the cranial base's resiliency to stressful periods during development. Individuals are capable of "catch up growth," as defined by Mosby's Medical Dictionary (2009):

an acceleration of the growth rate following a period of growth retardation caused by a secondary deficiency, such as acute malnutrition or severe illness. The phenomenon, which routinely occurs in premature infants, involves rapid increase in weight, length, and head circumference and continues until the normal individual growth pattern is resumed. The severity, duration, and developmental timing at which the deficiency occurs may result in some growth inadequacy or permanent deficit, especially in such tissue as the brain. (Mosby's Medical Dictionary 2009).

The results of my research project at the NMHM do not reveal any measurable negative effect on cranial base growth for the individuals born during the Civil War Era. However; it is difficult to assess if these results refute Angel's (1982) hypothesis that childhood nutritional deficiencies result in shorter, more compressed cranial bases. Although my results did not

support Angel's (1982) hypothesis, the individuals in the Civil War Era cohort may not have actually experienced nutritional stress or may have had any stress obscured by catch up growth. I plan on conducting future research designed to document the skeletal effects of the Civil War on the subsequent generation.

CONCLUSION

I cannot overemphasize the extent to which my experiences at the National Museum of Health and Medicine have advanced my knowledge and understanding of anthropology. At the museum I examined first-hand accounts from many important periods in anthropological history. I got to see the handwriting of famous anthropologists whom I have studied in the classroom and in textbooks. As the reincarnation of the Army Medical Museum, the NMHM is an institution important to the formation of American anthropology. From the origins of craniology to the understanding of disease, the NMHM and AFIP have been and continue to be hubs visited by anthropologists, pathologists, and students of each. Every day that I worked at the museum, I was shown considerable one-on-one time with the collections staff. Each member was genuinely concerned with the development of my anthropological career, and I can never show them enough gratitude for their mentorship. I encourage any and every student interested to seek out an internship at the National Museum of Health and Medicine, Armed Forces Institute of Pathology.

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Appendix:

The following transcriptions were made directly from original correspondence housed in the Otis Historical Archives of the National Museum of Health and Medicine, Armed Forces Institute of Pathology.

- I. Adam Paine to General Augur.....January 25, 1875
- II. George J. Alden to Spencer Baird.....April 14, 1874
- III. Lucien Carr to J.S. Billings.....February 5, 1884
- IV. Lucien Carr to J.S. Billings.....February 18, 1885
- V. Lucien Carr to George A. Otis.....May 25, 1878
- VI. Lucien Carr to George A. Otis.....February 25, 1880
- VII. Lucien Carr to George A. Otis.....October 9, 1878
- VIII. Romaine J. Curtis to George A. Otis.....May 15, 1877
- IX. John Wesley Powell to George A. Otis.....July 28, 1880
- X. Franz Boas to J.S. Billings.....August 29, 1888
- XI. From George A. Otis.....April 25, 1870

I. Adam Paine to General Augur: January 25, 1875

Fort Concho Texas

January 25th 1875

General C.C. Augur

Comd'g Dep't of Texas

San Antonio, Texas

General,

I have the honor to send you an Indian Scalp taken by me at the Twin Lakes Tex. I was with Gen Mackenzie's Command in the engagement which took place at the above named Lakes, about the 3rd day of November 1874. General I hold myself in readiness for another scout in April, under the flag of the United States.

I have the honor to be

Very Respectfully

Your Obedient Servant

Adam Paine

Seminole Negro Indian Scout

Specimen received May 3, 1875, Ack., and transferred to Smithsonian Institute May 4, 1875.

II. George J. Alden to Spencer Baird: April 14, 1874

Dear Sir,

Since writing you I have received a book entitled "Antiquities of the Southern Indians" C.C. Jones. I also rec. a visit from Dr. Edn? Palmer, had some conversations in reference to the Indian Mounds of Florida by which I was satisfied I had a burial mound on my place. My home being located on a shell mound, the Dr. was in such haste to leave for the St. Johns, leaving on the 12th that he had no time to make any investigations here. Yesterday with four men I made a search and found a burial mound near my house and commenced clearing away the brush, so as to get at the shape and size, which I will send you soon. While this was going on, I commenced the excavation on one side and was quickly rewarded in finding many bones and skulls, but as decomposed as to be of little value, but in the afternoon, I had dug a hole some eight feet deep from which I could easily crumble the earth away with ease and soon collected some fine skulls, one is perfect with the loss of two teeth only, one has lost four, and one with no hair; do you want some or all of these, I shall keep them until I hear from you. I can get the entire skeleton with ease and shall try to do so to-day. These bodies are buried in a sitting posture the first I ever found so buried. No ornaments or implements thus far save an arrowhead, the mound is so large it will take a month or more to make a thorough examination and by the number found in the small excavation, I have no doubt I will get at least fifty perfect skulls. I only regret the lack of means to make a thorough investigation of the mounds in this vicinity. If I am re-instated as Deputy Collector and Inspector of Customs, I will have two men but this is a small force to do

such work. I can hire men for thirty-dollars and their rations which will be ten more. Could I have assistance so as to employ five men for six months? I would work daily until I had all mounds near here examined. If you think them of sufficient interest please write me and I will hold any or all, subject to your order. Do you know any other work on Southern Indians which would be valuable as a book of reference, if so, where can I get it, and the price.

Very truly yours,

George J. Alden

III. Lucien Carr to J.S. Billings: February 5, 1884

Dear Sir,

Mr. Putnam has handed me your letter of 21st. alt (?)

and I write at once to welcome you as a co-laborer and to volunteer any assistance so far as it may be needed. As a rule we follow the system of measurements prescribed by Flower (of the Royal College of Surgeons) in his Osteological Catalogue, London 1879. The chief difference is in taking the length which we measure through the glabella and not through the ophryon. It is almost identical with your practice except that we now use White Mustard seed for measuring the capacity as does Flowers and I believe Topinard too has at last adopted it. This is a most important point and I do hope that you will see fit to discard shot and use the mustard seed.

Without uniformity in this respect our measurements of capacity are valueless for comparison.

The objections to using shot are numerous and weighty to say nothing of the fact that our crania are too fragile to stand the unit packing necessary with so heavy a material. The books necessary in our line are

Flower W.H. Osteological Catalogue of Royal College of Surgeons. Part I. Man.

Broca Instructiones Craniologiques and Craniometriques. Paris 1875. Also published in Revue d'Anthropologie.

Topinard. Anthropologie. Paris 1876. There is English Translation (Lippencott and Co. Phila. 1878)

Wyman also published a paper on the subject but it does not differ from your practice. He used peas, and we did too until a year or so ago when we adopted mustard seed as being 1st more satisfactory and 2. Bringing us in harmony with the large collection under care of Prof. Flower.

This is all for the present tho' there are numerous points we must talk over. In the mean time I can assure you of my sympathy and hearty cooperation in your work. I know your collection and also those in Paris and London and neither of them equals it, especially when supplemented by the one here and in Phila. Wishing you every success in your new departure. I am

Yours Respectfully,

Lucien Carr

IV. Lucien Carr to J.S. Billings: February 18, 1885

Dear Sir,

The Frankfort Agreement as it is called seems to me to be another manifestation of German “___ptiousness”; and if it possesses any advantage over Broca’s and Flower’s methods I have yet to see it. For this reason I shall not adopt it unless Topinard and Flower should accept it, in which case I would follow suit, not that I think anything would be gained by the change, but because I recognize the importance, I had almost said necessity, of uniformity in our methods if we would arrive at any satisfactory conclusions.

Have written to Paris and London on the subject and will let you know the result of my inquiries. If possible you ought to time your visit so as to be in those cities say from May to July- not later, -otherwise you may miss the very people you want most to see as it will then be their “vacation.” If it will be of any service to you, it will afford me pleasure to send you a note of introduction to each of those gentlemen.

Yours

Lucien Carr

V. Lucien Carr to George A. Otis: May 25, 1878

Sr. Geo. A Otis

Washington City

Dear Sir

Will you please let me know whether the Mound crania published on pp 15 ___ of your "Check list for use at Philad" were normal or whether they were flattened posteriorly as in the case with most of them in our collection. It is not necessary to give the facts as to each one- just lump them and let me know abt. how many are so flattened.

Putnam wishes me to say that we are all right at this end of the line. May I ask you to let me have this information as soon as possible as I am using your measurements for comparison.

Have had your lot tabulated, with ___ of breadth and the means ___. Would you like a copy?

Yours Respectfully,

Lucien Carr

VI. Lucien Carr to George A. Otis: February 25, 1880

Dear Sir,

Have you any New England (Indian) crania in your collection?

The Check List only gives the measurements of one a Pegund (?), but it has occurred to me that perhaps others have been received since that publication. I am at work on the skulls of that section and am at present disposed to think that the impression that they belong to the dolichocephalic is not warranted by the facts so far as known. However it is but right to say that upon this point I am open to conviction.

Yours Respectfully,

Lucien Carr

VII. Lucien Carr to George A. Otis: October 9, 1878

Our friend Putnam is in some distress over the sickness of his wife and in order to help him out in his "Wheeler" report I have agreed to write a chapter on the California crania. To do this properly I ought to have access to the collection made by Dr. Yarrow which is now in the Army Med. Museum, and of which the measurements are published in pp of the Check List.

Unfortunately however I cannot at this time visit your city and as the next best thing to it I have to ask that if convenient you will please cause an examination to be made of the crania collected by Dr. Yarrow, Mr. Bowers and party at Santa Barbara, on the mainland, and let me know whether they are flattened, and whether the Inca bone is formed in any of them and how many and also as to the persistence of the frontal suture in the lot. As to the flattening (posterior I mean) I do not expect of course anything like that found in the crania from Tennessee (?), but there is in some of them a slight flattening usually at or above the apex of the occipital, and it is of this and all its various stages that I wish to make a record. If I am asking too much I hope you will not hesitate to say so, but you see how I am situated and I venture to hope that you will help me out of the scrape.

This theory (thing) of craniology requires a good deal of work and sometimes in view of actual results I feel as Sam Willer did about the alphabet "it is not worth while going through so much to learn so little."

Yours Respectfully,

Lucien Carr

VIII. Romaine J. Curtis to George A. Otis: May 15, 1877

Dr. Otis

Surgeon U.S. Army

Sir:

I have been informed by the editor of the Medicinal and Surgical Reporter that the latest and most improved methods of craniometry are those perfected at the Army Medical Museum. I have been hunting information on this subject, for the reason that I am making examinations of criminals at the Illinois State Penitentiary, and want to make use of the best methods of cranioscopy, I therefore beg leave to ask the indulgence of your courtesy, and that you will give me full information regarding your measurements, how they are made, and the instruments required.

I have the honor to be

Very respectfully yours

Romaine J. Curtis

IX. John Wesley Powell to George A. Otis: July 28, 1880

My Dear Sir,

The enclosed letter has just been rec'd by me, and I refer the same to you. I wish very much that you could comply with the suggestions therein by presenting a paper to the American Association for the Advancement of Science on the crania which you have examined.

The society meets this year in Boston in the last week of August and final week of September. As I am to preside over the Anthropological section I shall be the more especially pleased to have you take part in the proceedings of the meeting.

I am, with respect,

Your Obed't Serv't.

J.W. Powell

Dr. Geo. A. Otis,

Medical Museum

X. Franz Boas to J.S. Billings: August 29, 1888

N.D.C. Hodges, Publisher,

47 Lafayette Place.

New York, August 29th 1888.

Dr. John S. Billings.

Washington D.C.

Dear Sir,

A short time ago I returned from my trip to British Columbia. I have collected a considerable number of crania and skeletons – 86 of the former and 14 of the latter, but some parts of that province are not well represented in my collections. I should like to study the material contained in other collections, in order to ascertain the best results. Can you, please, inform me, whether and how much material there is in the Army Medical Museum from Southern Alaska (Tlinkit [sic Tlingit]), Queen Charlotte Islands and the coast of British Columbia, from Puget Sound and the Salish (Flathead) of the interior. I hope to have a chance to visit Washington this winter and trust, you will kindly permit me to examine the material in your possession. I should like to know, how much there is, in order to know, how long it would take, to go over it.

Yours very respectfully,

Dr. Franz Boas

XI. From George A. Otis April 25, 1870

During the past two years over nine hundred crania have been collected at the A.M.M.- 346 were acquired from the Sm.In. (Smithsonian Institute) in exchange for objects of ethnological interest. Others by the surgical collection of the late Prof. Wm. Gibson, and at auction sales in Europe; others by exploration of tumuli (?) in the Mississippi valley, and in Dahkota, by Gen. Swift, U.S.A. and Dr. Comfort, and the remainder from medical officers of the Army stationed at the West.

-434 of these crania have been measured. After considering the methods proposed by Tiedemann, Sir Wm. Hamilton, Prof. Treadwell, the late Saml. Geo. Morton, Dr. J. Barnard Davis, ___ J.S. Phillips, Weleker, J. Attguis Meigs (?), and Prof J. Wyman, I determined to adopt the modes of measurement adopted by the latter anthropologist in his communication to the Boston Soc. Of Nat. Hist. Vol. XI, April 15, 1868, giving the weight in grammes, the capacity in cubic centimeters, the length in millimeters, the indicies of the length, breadth, and height, and of the foramen magnum in 1000ths of the long diameter. The weight has been ascertained by a balance of Becker _____, the lower jaw being detached. The internal capacity by No.8 shot. The diameters by Broca's calipers as made by Charriere (?) The facial angle by a modification of Br___'s goniometer of Tiemann's _____. The circumference and other measurements by a steel tape measure. The general conclusions deduced upon these measurements , are, that the position of the foramen magnum is a more important race characteristic than the facial angle.

That the variations in the dimensions of crania of individuals of the same race and sex were so great that any generalizations of value could only be looked for in the averages obtained by the examination of a large number of skulls. That judging from the capacity of the cranium, the American Indians must be assigned a lower position in the human scale than has been believed heretofore. That the so called prehistoric skulls from California and Illinois, by their pythecoid (?) character suggest views favorable to the doctrine of progressive development.

Attached: and that the examination of a large series of specimens is necessary to determine what osteological peculiarities have real anthropological significance.

That there is a marked difference between the crania found in the northwestern and New England tumuli, and those exhumed in Arkansas, Louisiana, and other Southern states and territories. The former resemble the crania of the Esquimaux, of the Lapps, and other hyperborean (?) races; the latter those of the ancient inhabitants of Mexico and Peru. The distinctive peculiarities of the skulls exhumed from the northern mounds is corroborated by the appearance of the long bones. I have been able to reconstruct the skeletons of these northern mound builders and to measure the femurs and shin bones of some forty one others. The shortness of the lower extremities, the incurvation forwards and lateral compression of the tibia indicate that these remains belong to a people resembling the existing Esquimaux.

I may remark in passing that in almost all cases there were traces of periostitis of the tibia, and that the rude bone awls and stone implements found in the crypts together with their remains, indicated that they were clad in skins, and that their lower limbs were exposed to the inclemencies of the weather. For the delineation of skulls I have employed both photography and the instrument invented by Dr. Lucae. For purposes of measurement the former method is

very faulty since the image may be distorted by the position of the object in the camera; but, with Prof. Lucae's instrument, described in 1861, in his "Morphologie der Rassenschaedel," and adopted by the Anthropological Congress held in Gottingen (?) in that year, and by Von Baer, Vrolich, and the venerable Rudolph Wagner, outlines of the skull may be made, orthnographic projection from which two or three copies on bibulous (?) paper can be taken, and measurements secured almost as accurate as from the specimen itself, and far preferable to those made by perspective drawing