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Body By Colonialism: The Importance of Including Sexual Minorities in Forensic and Medical Lexicons.

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Body By Colonialism: the Importance of Including Sexual Minorities in Forensic and Medical Lexicons

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Body By Colonialism: the Importance of Including Sexual Minorities in Forensic and Medical Lexicons

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ABSTRACT

The purpose of this study is to investigate the implications of excluding the skeletal morphology of sexual minorities such as intersex and trans individuals in forensic and medical context. This study took place over a span of 16 months from 2021-2023.

Anthropologists' reliance on binaries to categorize humans and as a result, the skeletal morphology of sexual minorities is not considered in forensic and medical contexts. Forensic anthropologists rely on sex estimation methodology to identify skeletal remains. Sex estimation methodology as developed with skeletal data from cisgender males and females without considering morphology of sexual minorities such as intersex individuals. In other words the methodology that is relied upon by forensic anthropologists to diagnose sex will not work on all populations.

Sex estimation methodology was developed with skeletal data of known males, the categorical systems that anthropologists rely on today the DEI efforts of universities in response to an overrepresentation of white academics in the field, sexism, homophobia, and white supremacy can still be observed in anthropology today.

Researchers are aware that sexual variation exists in humans, but little has been done to integrate the sexual morphology of sexual minorities into forensic developments, such as biological profiles, which aid in forensic anthropologists in the identification of badly decomposed remains. Anthropologists are currently developing sex estimation. Anthropologists have begun to address the lack of representation of sexual minorities in skeletal collections by developing population specific sex estimation methodology, and investigating cultural norms that could contribute to skeletal variation such as castration.

Individuals housed in the Osteology lab in the Anthropology Department of Western Washington University were measured. The raw data was run through statistical analysis software R to observe statistical differences. A keyword search and meta-analysis was conducted. They keywords pertained to forensic methodology and gender.

The only measurement that was statistically different between male and female individuals was the obturator foramen. The obturator foramen is a skeletal feature not traditionally used in sex estimation. The obturator foramen has been used in conjunctions with other skeletal material, such as irregular bones and teeth, which are also not traditionally used in sex estimation. When used in conjunction with each other, the obturator foramen and irregular bones have yielded a high success rate in sex estimation.

This work advances the field of forensic anthropology by spotlighting the impact of relying on antiquated categorical systems that were created by transphobic, white supremacists as well as making recommendations regarding DEI best practices and queering anthropology.

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CHAPTER ONE: INTRODUCTION

My research focuses on the consequences of disregarding the skeletal morphology of sexual minorities in the development of sex estimation methodology. The exclusion of sexual minorities in forensic anthropology is based on antiquated categorical systems that can be observed in anthropology today. Sex estimation is an important step in learning the identity of decedents in advanced stages of decomposition.

I argue that sexual minorities continue to be overlooked because anthropology still relies on antiquated categorical systems. The intersex population, a demographic that comprises 1.7% of the population, was not taken into consideration when a crucial step of the postmortem identification process was in development. This is especially concerning when considering the systemic violence that the LGBTQ community faces, especially at the hands of law enforcement. Additionally, my research focuses on what actions forensic anthropologists are taking to better serve historically excluded groups such as women, and BIPOC as well as addressing the harm early anthropologists have caused by mishandling the skeletal remains of exploited people.

This thesis has two main goals. The first is to assess variation in post-cranial traits that have historically been used to estimate sex. The second goal is to assess changes in the vocabulary used in forensic anthropology through a detailed meta-analysis of terminology in peer-reviewed literature over the last 100 years.

Chapter Overviews

Chapter One: Introduction

My thesis begins with this introduction. The goal of the introduction is to introduce readers to the overall scope of my thesis project. Additionally, I am to provide readers a roadmap through the thesis with summaries of all chapters.

Chapter Two: Literature Review

Chapter two is a comprehensive literature review of forensic anthropology, methods for sex-estimation, and the historic ignorance of non-binary individuals in social and biological sciences.

Initially, anthropology was a discipline for Europeans to study less civilized societies. While the philosophies of anthropology have shifted, harm is still being caused in the field by way of exclusion and a gross lack of diversity. This section will focus on the exclusion of skeletal data from sexual minorities such as the intersex population, a population that makes up 1.7% of the population, and the implications of not considering the variability of human sexual dimorphism in sex estimation methodology. In addition, this section will explore why white scholars are overrepresented in the field as well what can be done to remedy the lack of diversity in forensic anthropology.

Chapter Three: Materials and Methods

Chapter Three details the materials and methods that I used in this thesis. I describe my protocols in detail and define all measurements that I took. Additionally, I detail the terms that I searched in my meta-analysis, and my overall strategy for completing that analysis.

For this study I collected skeletal measurements from individuals diagnosed as male and female that are housed in the osteology lab in Western Washington University. My goal was to assess variation in post-cranial traits historically used to estimate sex by collected metric data and comparing results statistically between male and female individuals. Measurements that I took are comparable to those that would be gathered for a biological profile, or the set of measurements used to identify decedents. Such measurements include length of the longbones and dimensions of the os coxae.

In addition, I conducted a keyword search to observe trends in published peer-reviewed articles and conducted a meta-analysis. The keywords used in this analysis are: Human/trans, skeletal collections, human biological sex, intersex human, human dimorphism, forensic anthropology, human sexual dimorphism, and Terry collection. The goal was to observe analyzing why some words were featured in peer reviewed articles and reasons why, such as historical events and moments in popular culture.

Chapter Four: Results

The only measurement that was statistically different between the sexes is the breadth of the obturator foramen. The obturator foramen is an opening that is created by the ischium and pubis. It is important to note that the pelvis is highly favored in sex estimation by forensic anthropologists due to dimorphism, or differences between the sexes. The female pelvis has evolved in response to childbirth. My thesis finds that the obturator foramen, unlike other post-cranial traits, may have utility in sex estimation.

The results of my meta-analysis demonstrate that keywords such as "Terry Collection" and "forensic anthropology" are being featured in more peer reviewed journals. Other keywords such as "human dimorphism", "human/trans" and "human/intersex" did increase over time but about half as much as the forensic-based keywords.

Chapter Five: Discussion

My study finds that the breadth of the obturator foramen is the only statistically different measurement between the sexes. This aligns with previous studies demonstrating that the obturator foramen is valuable in estimating sex when measured in conjunction with other skeletal material.

The subset of four forensic keywords: "forensic anthropology", "gender diversity", "assigned sex", and "human transgender studies" did not appear in as many peer-reviewed articles, which may be due to forensic anthropologists relying on archaic views of human sexual variation. "Gender diversity" was published the most out of the forensic keywords most likely due to liberation movements. In this chapter, I also discuss the visibility of forensics in the media as a critical element contributing to changes in vocabulary usage.

Chapter Six: Conclusion

Despite the evidence that sexual variation exists beyond a binary, forensic anthropologists are holding onto outdated philosophies regarding human sexual variation. With that said there are many scholars dedicated to fostering a more inclusive environment in forensic anthropology. This study demonstrates the importance of revisiting sex estimation methodology. For example, taking secular changes into consideration as well as cultural practices that can show up on skeletal material, may improve forensic science. In addition, this study also draws attention to the dangers of continued exclusion from forensic anthropologists.

CHAPTER TWO: LITERATURE REVIEW

Errors in Thinking: The Myth of Objectivity and How Cognitive Biases Inform Ethics in Anthropology

Objectivity is often defined as the lack of bias or favoritism and is often believed to be the core principle of empirical research. Biological anthropology, as a social science, is frequently thought of as an objective science (Winburn et al. 2023). However, the history of anthropology, like many sciences, is actually mired in subjectivity and prejudice. Prior to the development of the four subfields that comprise anthropology today, anthropology was a field that was dedicated to the study of populations that were not white or protestant (e.g., Antón et al. 2018). Early anthropology was consumed with comparing and contrasting white civilizations to populations that white scholars referred to as savage, uncivilized, dirty, ignorant, and ugly to better understand the origins of Europeans (e.g., Antón et al. 2018). I argue, alongside others, that the history of anthropology has a direct influence on the lack of diversity that is seen in anthropology today. This also helps explain why initiatives for Diversity, Equity and Inclusion (DEI) remain ineffective despite efforts of many activists and scholars.

In a systematic literature review, Winburn et al. (2023) found that fewer than twenty peer-reviewed articles have been published regarding the harm that comes with implicit objectivity in the last five decades (1972-2022). In this thesis, I argue that relying on an anthropological methodology that was developed by colonists without acknowledging the harm it has caused is amplified by cognitive bias.

The objectivity that is touted by scholars was founded on the idea that white people are superior and could treat anyone who did not meet their standard of beauty or civility as dispensable. This is significant as forensic anthropologists investigate crimes against the marginalized, they also are currently relying on the methodology that was created by scholars that did not see the worth in people who were not white, heterosexual men (Winburn et al. 2023). Scholars like Winburn et al. (2023) call for mitigated objectivity in anthropology, which considers bias and can be constrained with quality control and best practices.

Early white supremacy is not only the foundation that modern anthropology was built upon, but also demonstrates that early scholars were far from unbiased when they exploited and maimed the people they encountered. By definition, ethics are the principles that guide what one should or should not do in a given scenario (Wright 1947). Arguably, the idea of being ethical and objective is to be fair, to everyone involved in a given scenario. With this in mind, what are the implications that the ethics and objectivity that are being relied upon in forensic anthropology today are based on the supposed objectivity and ethics of sexist, genocidal racists?

For this reason, many are calling for practitioners to revisit the ethics of forensic anthropology and acknowledge the subjectivities of their scientific practices as it is impossible to be completely objective (Winburn et al 2023). Due to forensic anthropologists adhering to sex and gender binaries, I argue that many forensic practitioners believe they are being objective and neutral when not considering identity politics when actually their neutrality is causing harm by not taking lived experiences into account.

Cognitive Bias

Cognitive bias, or errors in thinking, is the processing of information through the lens of personal experiences (Haselton et al. 2015). Causes of cognitive bias include a limited worldview, societal pressure, or individual experiences (Haselton et al. 2015). Triggers of cognitive bias can include ethnicity, gender, sex, weight, name, profession, clothes, among many others (Haselton et al. 2015). Confirmation bias is common and can occur in any circumstance (Haselton et al. 2015). While anyone of any gender, educational status, religion, sex, or ethnicity can be biased, those same people also have the potential to become aware of their biases and how those errors in thinking can impact their views of those around them (Haselton et al. 2015).

What is the role of cognitive bias in forensic anthropology?

Anthropological methodology was pioneered by colonists who believed that people could be placed neatly in categories based on arbitrary criteria to support the idea of racial-based hierarchies (e.g., Marks 2017). Racist hierarchies were used to justify the treatment of people who were not white, male, or able-bodied. Examples include using the principles of craniometry to support the idea that cranium shape could determine ancestry and intelligence (e.g., Gould 1996). This was the basis of eugenics, genocide, colonization, and the use of Black, Indigenous, and other people of color (BIPOC) in cruel medical experiments. I argue that this cruelty was allowed to take place in pursuit of science. After all, their actions were thought to be ethically appropriate because objectively anyone at the bottom of the European hierarchy was not seen as civilized people (Diogo 2018).

While many acknowledge the harm that has been caused by anthropologists, cognitive bias still shows up in how forensic anthropologists categorize decedents when creating biological profiles. Sexual minorities have always been a part of human history and before colonization. Many people historically did not adhere to a gender binary and embraced bodies that did not appear to be exclusively male or female (Prower 2018).

Considering the bodies and experiences of sexual minorities and the gender diverse does impact the integrity of the scientific method (Schaffer 2023). For example, in places that are rife with racism and homophobia, such as Uganda, citizens were historically permitted to dress and behave in the fashion that best represented their gender identity (Prower 2018). Due to settlers violently disposing of anyone who did not conform to protestant views of sex and gender, there is still deep-seated homophobia and transphobia in science and medicine. Willful ignorance of the queer (LGBTQIA) community can be seen in medicine, for example, in the HIV/AIDS epidemic or intersex medical interventions.

Despite making up 1.7% of the population, people who are born intersex are pathologized and subjected to unnecessary surgeries called intersex medical interventions which can lead to a life of physical pain and suffering (Cohen 2023). The goal of intersex medical interventions is to force an infant to fall neatly into the sex and gender binary. This surgery is often unnecessary and arguably very unethical, as infants cannot consent (Cohent 2023; Lund 2023). I argue these surgeries are an example of the deep-seated hatred of the LGBTQIA community in science and medicine, and reinforce that anyone who is not strictly male, or female should be “fixed”.

Sexual minorities such as trans and intersex individuals are thus not considered valid identities due to erasure during colonization. Many researchers have stated that forensic anthropologists should take measures to stop centering cisgenderism (Adams et al. 2023, Martin

2023, Tallman et al. 2021). Tallman et al. (2021) argue that practitioners should become familiar with gender-affirming care and its effects on the skeleton. They also argue for the expansion of forensic categories to include trans feminine, trans masculine, and gender diverse. However, Viera et al. (2023) caution scientists to be aware that some gender-affirming procedures such as filler will not likely not present on skeletal material. The effects of gender-affirming procedures on skeletal anatomy is still matter of investigation.

In the last 10 years, more studies have been conducted to observe how cognitive bias interferes with diagnosing sex in skeletal remains (e.g., Nakhaeizadeh et al. 2014). One such study consisted of 41 participants who held degrees in either osteology, forensic pathology, or physical anthropology and were divided into three groups (Nakhaeizadeh et al. 2014). The three groups assessed the sex of skeletal remains: one group was given no gender-specific information, while the other two were given gender-related information. The study illustrated that the gender-specific contextual information skewed the observations of the professionals who performed the assessment (Nakhaeizadeh et al. 2014). In other words, educated, objective scientists let their sex and gender-related cognitive bias affect their findings.

Schulz (2021) emphasizes that forensic anthropologists should preferably report only on visual assessment, because gender is a construct. Unfortunately, there are no best practices that prevent cognitive bias when diagnosing sex in skeletal remains.

Inclusion in Forensic Anthropology

Academia has an elitist history in which white men with financial resources held power, meaning higher education was not accessible to BIPOC, women, or anyone else who was not white, heterosexual, and Protestant. A lack of diversity in forensic anthropology is the basis of unethical practices of both past and present. To center whiteness, many people, especially non-white people, were dehumanized to the point of simply being seen as fodder for horrific research purposes, which still perpetuates harm today.

This is exemplified through the work of early anthropologist Christoph Meiners, who asserted that those of African origin did not feel pain like white people (Michael 2021). Dr. J. Marion, known as the father of obstetrics, used this racist ideology to perform gynecological surgeries on enslaved Black women without anesthesia or consent (Walls 2006). The longstanding effects of these early practices are still seen in medicine today (e.g., Bailey et al. 2021, Perez-Rodriguez and de la Fuente 2017).

The methodology that forensic anthropologists still commonly use was developed by collecting the remains of the deceased that were not claimed by their surviving relatives, as well as the remains of deceased who became the property of the state (Hunt et al. 2005). So long as the field of anthropology is predominantly white, heterosexual, and male-dominated, exploitation of historically-excluded populations will continue. While many scholars acknowledge anthropology's shortcomings and want to facilitate change, barriers preventing anthropology from becoming more inclusive are still prolific. These barriers can include a lack of retention, the lack of clarity and enforcement of policies that govern the handling and repatriation of remains, and failure of existing DEI efforts to yield the desired results.

Many people in academia are now beginning to understand the value of supporting scholars who come from historically excluded populations (Turner-Byfield 2022). Turner-Byfield (2022) highlights that over the past twenty years universities have made efforts in increasing diversity and inclusion. Likewise, Turner-Byfield (2022) reports that increasing representation of diversity on research teams lowers the rates of confirmation bias.

To increase diversity, universities have been emphasizing recruiting and retaining historically excluded scholars. Likewise, there has been a de-emphasis on standardized testing as it has become better understood how standardized tests are, in essence, products of scientific racism (Kendi 2006, Turner-Byfield 2022). While this is a promising start, Turner-Byfield (2022) also highlights that enrollment data collected by the National Science Foundation indicates that there has only been a 6% increase in the number of minorities who completed a graduate degree in the field of anthropology from 2009-2019. Considering that universities have spent the last two decades increasing DEI initiatives, it begs the question: "Is DEI Doing Enough for Forensic Anthropology" (Turner-Byfield, 2022). The author of "Colonized Knowledge and the WEIRD in forensic anthropology and Beyond", as well as the authors of "On WEIRD Anthropologists and their White skeleton" answer that question with a resounding no (Go et al. 2021).

WEIRD (White, Educated, Industrialized, Rich, Democratic) is an acronym to describe the lack of diversity in the sciences (Go et al. 2021). In a bibliometric study, Go et al. (2021) found that 79% of anthropology articles published were written by white authors. Additionally, 88% percent of articles that focused on ancestry placed Europeans as the control group that was being compared to non-white ancestral populations (Go et al. 2021). The trend of deferring to whiteness as the default is observed in 49% of articles. (Go et al. 2021).

Several methods have been proposed to address the lack of diversity in anthropology. For example, Rosen (2023) suggests using an intersectional framework. Iintersectionality, a phrase coined by Black feminist Kimberle Williams Crenshaw, is the interconnection of social categories and identities such as sex, gender, race, and sexual orientation (Rosen 2023). As Rosen (2023) notes, this framework can be invaluable to anthropology if implemented, because, in a diverse environment, I argue quite a bit less would be overlooked and dismissed such as the misuse of human remains from marginalized communities.

Yuki (2023) further explores the overrepresentation of white scholars as a means to address failed DEI initiatives, addressing this disparity with two additional bibliometric studies. The first review analyzed articles that were published from 2015-2019 (a total of 793 articles) to learn from where the authors of the articles ancestrally originate (Yuki, 2023). The second bibliometric study focused on the ancestral origins of authors from Southeast Asia. Results yielded that in both studies, over 70% of the published authors were of European ancestry (Yuki 2023). Yuki (2023) and Goliath et al. (2023) both argue that, for DEI initiatives to be effective, scholars must examine why white scholars and their findings are over-represented in the field of forensic anthropology.

Adams et al. 2022 leave readers with suggestions on what to address when redefining ethics such as community-building and outreach as a means to start an dialogue between marginalized communities and forensic anthropologists. For example, Saboowala (2023) facilitated a community outreach project by developing an activity for high school aged scholars that challenges their preconceived notions of sex and gender by directly addressing problematic classification system that is still in heavy use today.

Goliath et al. (2023) suggest that, despite college admissions of underrepresented populations having increased from 2000 to 2018, there are barriers in higher education that prevent the field of forensic anthropology from becoming diversified. These barriers include an imbalanced power structure, heteronormative/cis-gender and racial-based methods, as well as the myth of objectivity and impartiality (Goliath et al. 2023). These barriers do nothing to foster environments that welcome underrepresented populations. Without the input of people who have been affected by colonialism, the harm that anthropology has caused will continue.

Delgado et al. (2022) cite that the cost of attendance is another systemic barrier that prevents the field of forensic anthropology from diversifying, thus halting the development of ethical practices that protect vulnerable populations. Taking into consideration the cost of a graduate degree, cost of living, and funding other than loans, the cost of a master's degree is nearly $60,000, with stipends for graduate students maxing out around $35,000 (Delgado et al. 2022). Although not all white people are wealthy, white people are still over-represented in the field. For Delgado et al. (2022), if universities can create more funding opportunities, this can allow underrepresented populations to thrive in the discipline.

Without the input of people affected by colonialism, the harm that anthropology has caused will continue. Diverse voices allow for nuance that cannot be achieved by white, straight, male scholars alone. Despite the last two decades of DEI implementation at the university level, unethical practices surrounding the ownership, handling, and display of human remains that were obtained without consent when the decedent was alive are still observed today. Likewise, there is a general lack of protocol on a federal level to ensure the repatriation of teaching specimens (Bartelink et al. 2022). While it can be empowering for marginalized communites to contribute to DEI initiatives, Pink et al. (2023) warns that DEI implentation should not fall sqaurely on the shoulders of minorities.

The Mishandling of Human Remains and a Lack of Best Practices and Procedures

A byproduct of colonialism in early osteology and forensic anthropology is the mishandling of human remains and the trafficking of osteological material (Bartelink et al. 2022). Skeletal collections such as the Terry Collection have made it possible to develop methodologies that are currently used by forensic anthropologists today, and are an important tool for learning, in forensic and medico-legal training. (Hunt et al. 2005, Bartelink et al. 2022) The Terry Collection is unfortunately made up of deceased individuals who were at one-time property of the state or simply had not been claimed. (Albanese and Hunt 2016, Bartlelink et al. 2022.) It is often more cost-effective for the state to donate unclaimed bodies to science as opposed to burying them (Albanese and Hunt 2016).

Despite the Native American Graves and Repatriation Act (NAGPRA) being passed in November of 1990, the remains of minorities continue to be mishandled (Scott et al. 2023). In a review of recently published articles, Scott et al. (2023) suggest that a review of disciplinary action be undertaken, as disciplinary consequences often do not fit the severity of the offense (Scott et al. 2023). In many cases, archaeologists may have done something severe and may not be reprimanded properly. Scott et al. (2023) highlight that, although archaeologists are reflecting on their problematic past, little action has been taken regarding how bioarchaeologists are curtailing the harm done by early anthropologists.

Scott et al. (2023) specifically focus on an analysis of articles published in *Bioarchaeology International* as a way to assess how archaeologists are approaching the topic of colonialism and the harm it has caused. Their analysis reviewed the process by which archaeologists get permission to study remains, ethics statements, the involvement of the survived communities, DNA and isotopic data or destructive analysis, and if grave sites were disturbed after NAGRA was implemented (Scott et al. 2023). The review revealed that the articles failed to address systemic colonialism, surviving communities were not discussed, there was no mention of obtaining permission, and many of the articles included remains that were disturbed after NAGPRA was enacted and osteological material was destroyed during analysis (Scott et al. 2023).

Beyond NAGPRA, many researchers have also highlighted the need to address the trafficking of anatomical specimens to the colonized West (e.g., Adams et al. 2023). There is a history of human remains being trafficked from historically exploited nations, for example in southeast Asia (Adams et al 2023). These skeletons often end up in University teaching collections.

Many institutions of higher education have their own protocols for retiring and repatriating human remains (Adams et al. 2023, Brow et al. 2023). This can be touted as an example of one of many DEI initiatives not coming to fruition. While forensic anthropologists acknowledge the ethical implications of not retiring human osteology teaching skeletons, ethical concerns are amplified by the lack of guidelines on a federal level that would oversee the repatriation of retired teaching specimens in all universities. In many cases, this lack of guidelines increases the chance that individuals will be sold in antique shows as opposed to being retired properly. (Brow et al 2023. Adams et al 2023.)

While it is unfortunate, many anthropologists believe in prioritizing science over the wishes of the people who are continually exploited, and, eventually, valuable skeletal records may not be available due to repatriation. This presents a possible barrier to creating population-specific methodologies in forensics and other fields. Historically exploited people may rightfully not want those not want to give outsiders access to their dead (Pietrusewsky, 2023; Heathcoate, 2023).

A possible option to curtail this is 3D imaging. Labbe et al. (2023) report that using digitized CT scans allows for sex estimation with a high success rate. Using CT scans could curtail forensic anthropologists from handling human remains directly, but would still allow them to be studied. According to Ujaddugh et al. (2023), using digitized CT scans could also assist forensic anthropologists in becoming familiar with the skeletal morphology of populations they have not recently studied. However, as with the use and misuse of human skeletal remains, there are ethical considerations when displaying these skeletal remains on digital platforms. Digital images of the deceased serve can as a valuable tool for teaching forensic anthropology (Plemmons et al. 2023, Adams et al. 2023). But images of skeletal remains must also be treated with respect.

In addition to a lack of standardization, Fleischman et al. (2023) note that many barriers can prevent governing bodies from developing ethical best practices, including a lack of federally regulated educational standards. The National Institute of Standards and Technology's Organization of Scientific Area Committees are charged with developing best practices regarding forensic science such as the handling and viewing of human remains. The goal is for best practices to be available for public viewing on a registry (Bartelink et al. 2023). These best practices include seeking permission or informed consent to obtain human remains, proper training in the handling of remains, and appropriate use of skeletal data associated with the remains, including those eligible for repatriation (Bartelink et al. 2023). Other organizations involved in developing ethical standards include the Organization of Scientific Area Committees For Forensic Science and Academy Standards Board, two markedly different governing bodies with oscillating membership who are actively working to challenge of writing standards that apply to forensic anthropology.

There is general consensus that standardized methods of care must be developed, and that scholars who handle images of remains should be trained in ethical best practices (Adams et al. 2023, Plemmons et al. 2023). To assess the extent of the problem, Plemmons et al. (2023) used the open-source statistical software, R, to conduct a text analysis of the ethics statements of five organizations: American Academy of Forensic Science, American Association of Biological Anthropology, American Board of Forensic Anthropology, Scientific Working Group for Forensic Anthropology, and the British Association of Biological Anthropology and Osteoarchaeology. The goal of Plemmons et al.'s (2023) study was to understand how ethics is discussed in these statements. Plemmons et al. (2023) found that four out of the five organizations do not mention digital ethics. The organization BABAO redirects readers to a statement on digital ethics. From this work, Plemmons et al. (2023) suggest instituting a cross-cultural ethics board to develop pedagogical curricula and curtail the exploitation of the deceased in the form of images.

We can examine the ABFA as an example of ethics requirements by a professional society. To address misconduct in anthropology, the American Board of Forensic Anthropology's ethics committee determines if a complaint is valid and presents evidence of misconduct to the ABFA board of directors then votes on a solution (Plemmons et al. 2023). Considering that anthropology is white male dominant, there is possible bias when the ABFA board is deciding what constitutes a punishable offense and could be a factor in why so many remains have been mishandled despite the inception of NAGPRA. Without the views of people who have been traditionally underserved, such as the LGBTQIA community, these travesties will continue to go unaddressed.

Passalacqua et al. (2023) also highlight the importance of certification and license because of the lack of national standards to ensure that qualified practitioners are in the field. Currently, there are no national standards to determine the competency of forensic anthropologists, even when competence was evaluated. Passalacqua et al. (2023) assert that core competencies, certification, and licensure are the future of forensic anthropology practice and education.

Queering Science

Forensic anthropologists are in a unique position to advocate for the LGBTQIA community as well as other historically underserved demographics. Many forensic anthropologists recognize that biological sex exists on a continuum and have the tools to help the general public understand that sexual minorities are an important part of human history (Kim et al. 2023). Unfortunately, there is a long history of necroviolence in anthropology (Stewart et al 2023). While necroviolence is traditionally defined as the mistreatment of migrant bodies after death, I argue that necroviolence also applies to trans, intersex, and the gender diverse as well. Forensic anthropologists can help reduce harm by integrating queer theory, re-evaluating language, and amplifying queer voices.

Integrating Queer Theory

The erasure of sexual minorities by colonists is the cause of deep-seated homophobia in science and medicine, despite sexual minorities being a part of human history. Sex and gender spectrums have to stop being conceptualized as a choice and be viewed as a part of the natural order, which can be observed amongst animals such as non-human primates. For example, Kralick (2023) suggests anthropologists study dimorphism in orangutans, as unflanged males' bodies do not exhibit the same stressor in their bodies as flanged males.

Another example is the mosaic hypothesis in animals (Joel 2023). The mosaic hypothesis suggests that the effects on the brain fluctuate and that there is no male or female brain. The recent controversy about the retraction of a sex and gender panel at the American Association of Anthropologist professional conference highlights the ongoing discourse around these definitions and their utility in anthropology (Joel 2023). A better understanding of the mosaic hypothesis may incentivize scholars to conceptualize sex, gender, and gender identity as a spectrum rather than a binary.

Heteronormativity is the idea that heterosexuality is the norm (Wilson 2023). Forensic anthropologist can address heteronormativity in missing persons cases by establishing missing persons data bases that include trans, intersex and other sexual minorities (Flaherty 2023, Wilson 2023). FORDSIC is a software that assists forensic anthropologists in identifying the deceased and despite using FORDISC, a trans woman was misidentified (Flaherty et al. 2023). This misidentification demonstrates the need for forensic anthropologists to develop databases that assist in identifying sexual minorities (Flaherty et al. 2023). Databases such as the National Missing and Unidentified Persons System and the National Center for Missing and Exploited

Children do not have clear guidelines regarding how to report a missing sexual minority (Flaherty et al. 2023). Often these databases feature the dead name, which is a given name that is not longer used and pre-transition photos (Flaherty et al. 2023).

In response to a lack of inclusivity in missing persons databases, the LGBTQ+ Accountability for Missing and Murdered Persons was recently developed (Flaherty et al. 2023). The LGBTQ+ Accountability for Missing and Murdered Persons allows for people to submit cases anonymously and only professionals with the correct credentials can access information submitted to the database (Flaherty et al. 2023) The LGBTQ+ Accountability for Missing and Murdered Persons uses information from nontraditional sources such as Facebook, Reddit and Trans Day of Remembrance websites (Flaherty et al. 2023). Untraditional sources may reduce dead-naming and the use of pre-transition pictures. Many sexual minorities engage in survival sex work, which exposes them to harm, an inclusive database would also help identify missing and murdered sex workers (Gruenthal-Rankin 2023).

Language

The language that is used by forensic anthropologists to describe sexual minorities is detrimental and arguably an aspect of necroviolence and a byproduct of necropolitics. Necropolitics, the use of political power to dictate how someone will possibly live and die, is intimately intertwined with necroviolence (Stewart et al. 2023). There is systemic violence surrounding language, as sexual minorities report being aware they may be misgendered, called by their assigned name (dead-naming), or face some other form of discrimination or harassment and will not seek help from police even in emergencies. Examples of necroviolence include:

misgendering after death, mutilation of a corpse, or displaying the corpse in a distasteful manner. What can be considered necroviolence will varies between cultures.. A recent example of language being used as a tool of violence is the lack of medical vocabulary to properly describe intersex individuals. As a result anyone who is born with a body that is strictly male or female is subjected to mutilation which disregards naturally occurring variation.

Language is also being used to avoid responsibility when discussing anthropology's violent history. When examining how current anthropologists are reconciling with anthropology's past, current anthropologists often state that scholars of the past were simply ignorant. I argue that reducing violent acts of early anthropologists as ignorance invalidates the exploitation that historically excluded populations faced. Anthropologist systematically used violence and intimidation to achieve their goal of surpressing anyone that did not share Eurocentric sentiments.

Examples of necropolitics can include: care not taken regarding the bodies of the deceased that are used in museums, as teaching tools, and even how the dead are spoken of by forensic anthropologists. Stewart et al. (2023) suggests police must also become familiar with the difference between sex and gender, and more inclusive language surrounding the deceased, particularly as they work alongside forensic anthropologists. I look forward to Forensic work to address systemic public health and mortality disparities across forensic contexts and improve the human condition. Osteology methodology was developed by studying the skeletal remains of many marginalized people. The health-related information could be used to study preventable death and improve the lives of the historically excluded.

Review of of Population-Specific Sex Estimation Methodology

Forensic anthropologists are professionals with a specialized skill set that allows them to aid law enforcement in the identification of human remains that are in an advanced stage of decomposition, or are found mutilated (Lundy 1998). The identification process is called a biological profile, which is a set of methodologies that are used to estimate height, age, sex, and ancestry (Lundy 1998). When a sex is diagnosed it brings forensic anthropologists and law enforcement closer to identifying the deceased by 50% (Lundy 1998).

The methodologies that comprise a biological profile were created based on the skeletal dimensions of known male and female descendants (e.g., Hunt and Albanese 2005). Currently, the skeletal collection of the University of Tennessee is the only skeletal collection to be actively collecting anatomical donations to study secular changes. Secular changes are biological changes that occur over the span of decades that are usually caused by environmental influences (Jantz et al. 1999). The methodologies originally developed by anthropologists created racist categorical systems to prop up white supremacy by categorizing anyone who was not white as inferior to justify violence and exploitation of people who did not meet Eurocentric standards of civility (Jahoda 2009). This includes Black, Indigenous, and people of color (BIPOC) and women.

Sexual minorities, such as intersex individuals, make up 1.7% of the population, (Astorino 2023). To be intersex is to be born with a combination of both female and male biological sex traits (Astorino 2023). Of sexual minorities, trans individuals make up 0.3%-0.5% of the population. Being trans means one does not identify with the sex they were assigned at birth (Astorino 2023). Biological sex is comprised of chromosomes, gene expression, hormones, and internal and external sexual organs (Astorino 2023). In contrast, to be cisgender is to identify with the sex one was assigned at birth (Astorino 2023). Astorino (2023) notes that most literature on intersex individuals primarily focuses on intersex medical interventions and that there is very little regarding intersex variation.

Sex is often conflated with gender, which is a culturally constructed set of norms and behaviors that are associated with women, men, girls, boys, and gender-expansive individuals (Astorino 2023). When Europeans colonized the world, they destroyed any semblance of gender diversity to the point that people who are born intersex are seen as a pathology in many contemporary cultures (Prower 2018). Before colonization, people held an expansive view of sex and gender roles and were free to express themselves without fear of violence (Prower 2018).

A current form of medical violence that sexual minorities face is intersex medical interventions (Saraswat et al. 2015). Intersex medical interventions are unnecessary and painful surgeries that intersex infants are subjected to to alter external and internal sex organs to make the individual strictly male or female (Saraswat et al. 2015). Intersex medical interventions lead to lifelong physical and emotional pain as the recipient does not consent to the surgery (Saraswat et al. 2015). Without considering the skeletal data of sexual minorities, a significant and vulnerable portion of the population is likely to be misgendered in death. Considering the violence sexual minorities face, especially at the hands of law enforcement, forensic anthropologists must revisit sex estimation methods (Tallman 2019).

The variability of human skeletal morphology is starting to be revisited as a means to reassess sex estimation methods. According to Langley et al. (2020), the human skeleton has gone through a series of secular changes in the last 150 years. Secular changes are biological changes that have occurred over a vast period. Observed changes to the human skeleton include: early onset skeletal maturation, the cranial base becoming longer, the face narrowed, the cranial vault becoming higher, the cranial base elongated, the pelvis becoming more gracile, and long bones such as the femur becoming more gracile (Langley et al. 2020). These changes are due to environmental factors rather than natural selection (Langley et al. 2020).

Culture can also play a key role in skeletal morphology. For example, there are morphological differences in the men and women of Cecardo de los Santuaurios in Central Columbia. Due to activities associated with gender roles, men and women in this region have different stress markers on their bones (Bourgois et al.2018; Herrera 2019; Rojas-Sepulveda et al., 2023; Wilson, 2023).

Because of politics, the inhabitants of the Dominican and Haiti also have morphologically different morphology despite being in close proximity to each other. Some of these individuals, for example, were castrated during life. Reusch (2023) states that the skeletons of those who have been castrated will appear more intermediate or ambiguous because of a lack of both testosterone and estrogen. This is valuable information regarding sexual minorities and de-emphasizes relying on pure visual assessment.

An additional marginalized group that often gets overlooked by forensic anthropologists is immigrants. Methodology that has been developed for some immigrants will not work for all. It is also difficult to create methodology because immigrants rightfully may not want to reveal their immigration status (Dwyer et al. 2023;Lieurance et al. 2023, Lopez et al. 2023).

The pelvis, long bones, and cranium can all be used to make a biological profile, and if the secular changes they underwent are not taken into consideration during sex estimation, people may be misidentified. Forensic anthropologists have been working to mitigate the problem of methodology by incorporating bones other than the pelvis into sex estimation.

The pelvis is traditionally favored by forensic anthropologists because of its dimorphism resulting from selection on childbirth. However, a growing body of evidence suggests that it is important to include bones other than the pelvis in sex estimation due to the number of factors that can impact skeletal morphology, including geographic location, socioeconomic factors like poor nutrition or lack of medical care, and the medical disposition of being intersex (Hunt et al. 2009, Smith et al. 2022, Spradley et al. 2019, Teruel et al. 2022). Arguably, scientists focus on the pelvis not just because it is the most dimorphic bone in the body, but also because they rely on antiquated categorical systems created by anthropologists who had a limited perspective on human variation, human experiences, and expression.

Quantifying sexual dimorphism of the bony labyrinth and biological sex distribution in Lagoa Santa, Brazil

The pelvis is the most sexually dimorphic bone of the skeleton due to a long history of natural selection on childbirth in females. However, other bones can also be used in sex estimation. Bones that have been successfully used in place of the pelvis are the bony labyrinth, nonmetric features of the crania, the obturator foramen, the crown, and the cervical metrics of the teeth (Teruet al. 2023). The incorporation of other bones in biological profiles to estimate sex could expand current methodologies even more. And the addition of more methodology could arguably curtail misidentifying descendants and assist forensic anthropologists in assessing the remains of populations with which they are not familiar.

Studies in which the same-sex estimation methodologies are used on populations from different geographic locations yield different results (Teruet al. 2023). In other words, a methodology with high success rates for one demographic did not always perform well when used for a different population (e.g., Smith et al. 2022, Spradley et al. 2019, Tallman 2019, Teruel et al. 2022). Some of the following are studies that illustrate the importance of revisiting sex estimation methods and considering secular changes.

A study by Teruel et al. (2022) examined the osteological record of people living in Lagoa Santa, Brazil between the Holocene to the post-colonial period. This is a vast period that offers a large dataset to illustrate extensive secular changes in skeletal morphology. In this study, Teruel et al. (2022) applied a discriminant function that was developed from the bony labyrinth of people Indigenous to North America and applied it to the inhabitants of Lagoa Santa, and it yielded an 85% success rate in sex estimation. Then they applied a different discriminate function developed from another demographic group to the Lagoa Santa inhabitants, yielding just a 33% "success" rate (Teruel et al. 2022). These results are significant because a methodology that is successful with one population is not necessarily successful in another.

Evaluation of the Obturator Foramen as a Sex Assessment Trait

Similarly, Rennie et al. 2023 report that using the obturator foramen to diagnose sex yielded a 30% success rate when applying the methodology to South African populations. However when they applied the same method to Canadian populations, a 93% rate of success was achieved (Rennie et al. 2023). This is another demonstration that sex estimation methodologies can not apply universally to all populations.

In some populations, variation in successful application of the method can derive from a reduction in sexual dimorphism. This is the case in Asian populations and South African

Holocene San and Khoekhoe populations (Malek 2022, Smith et al. 2022, Spradley et al. 2016, Tallman 2019). Tallman (2019) states that using crania, which is arguably the second most dimorphic osteological material other than the pelvis, is viable, but the methodology will not apply to every Asian population. Tallman (2019) also reports that the methodology that diagnoses the sex of those of Filipino ancestry may be used on other Asian populations of Southeast Asia. However, the same methodology yielded a low success rate of sex estimation in people of Japanese and Thai ancestry (Tallman, 2019).

Another case in which populations developed reduced sexual dimorphism is the Holocene San and Khoekhoe populations in South Africa (Malek et al. 2022). Malek et al. (2022) note that before their study there was no reliable sex estimation methodology to diagnose sex in South African Holocene and Khoekhoe populations. Sex estimation relies heavily on visual assessment (Tallman, 2019) which can complicate the creation of a biological profile (Malek et al. 2023). Similar to those who are of Asian descent, in African Holocene San and Khoekhoe populations, male individuals are often misdiagnosed as female (Malek et al. 2022). This has broad implications for people who fall out of the sex and gender binary, as well as for people from particular populations.

People who originate from populations with reduced dimorphism can be misidentified by a forensic anthropologist who is not familiar with a given population morphology (Tallman, 2019; Malek et al. 2023). Refusing to revisit sex estimation methodology has the potential to impede forensic anthropologists from doing their job. This is problematic because forensic anthropologists not only aid law enforcement in the identification of the deceased, but are also tasked with aiding in the recovery and identification of people who died in political conflicts, such as the attacks on September 11th or victims of the Guatemalan Civil War (Rosen, 2023).

Irregular Bones and Teeth

Two sets of skeletal materials that are overlooked but could prove invaluable to expand sex estimation methodology are teeth and irregular bones. Human dentition displays sexual dimorphism using measurements of the crown, however, there are very few examples that incorporate the cervix of the tooth (Smith et al. 2022). Using a discriminant function with 5 variables, a success rate of 81%. Subjects included populations from the United States and South Africa (Smith et al. 2022).

Measurements and morphology of permanent teeth, as well as morphology of metacarpals, metatarsals, the patella, and the clavicles have potential to be used in sex estimation (Broeht et al. 2023, Panageas et al. 2023, Smith et al. 2022, Ujaddughe et al. 2023). Irregular bones such as the metacarpal, metatarsal, patella, and clavicle may not be useful for sex estimation individually, but used in conjunction with other irregular bones yield a high success rate in sex diagnostics. Using these bones in combination, a small amount of population-specific methodology can still yield a high accuracy score for sex estimation (Smith et al. 2022). However, future research in this area needs to include non-binary individuals.

The current study

I am conducting this study to better quantify sexual dimorphism in small samples of human skeletons. This important because sex estimation methodology needs to be revisited to account for secular changes as well as develop methodologies that include sexual minorities such as intersex individuals. My methods include gathering skeletal measurements from seven individuals of different ages. I used calipers and an osteometric board to collect data, with the textbook by Black et al. (2017) as a guide. I also conducted a meta-analysis of terminology used in forensic anthropology, from 1900 to present.

The literature review presented here summarizes the current state of what has been done to address the pitfalls of sex methodology. This literature review also recounts how forensic anthropologists are addressing barriers such as such as cognitive bias and a lack of diversity.

The next chapter will detail the materials and methods for my study. I give a detailed account of the measurements I took, the tools I used, and my procedures for this study.

CHAPTER THREE: METHODS AND PROCEDURES

My goals for this project were to evaluate error in sex estimation protocols and to assess changing terminology around sex estimation in forensics. I had two main objectives: 1) to take measurements of traits used in forensic sex estimation for all the human skeletons in the Osteology collections in the Department of Anthropology at Western Washington University (n=9), and 2) to perform a meta-analysis of how terminology used in forensic estimation has changed over the last century. To meet these objectives, I tested two main hypotheses:

Objective 1:

Null Hypothesis (H0): There are no significant differences in skeletal measurements between male and female individuals.

Hypothesis (H1): Measurements of traits used in sex estimation are significantly different between males and females.

Objective 2:

Null Hypothesis (H0): The frequency of publications using terminology specific to sex estimation of non-binary individuals has not changed over the last 100 years.

Hypothesis (H1): There has been a significant increase in the frequency of publications using terminology specific to sex estimation of non-binary individuals over the last 100 years.

Skeletal Measurements

For the Objective 1, I completed all data collection onsite in the Osteology Lab (Arntzen Hall 314) on Western Washington University campus. I collected 18 measurements from n=8 human skeletons held in the Osteology collections. These skeletons are part of a historical teaching collection. There are n=3 identified females in the collection, and n=5 identified males.

Ten of the measurements were taken from both left and right sides to compare, for a total of 28 measurements. All skeletons are associated with known sex and are adult (third molars erupted). The measurements were chosen due to their common use in forensic sex estimation. I used Human Osteology Black et al. (2017) to choose the relevant measurements. All skeletal data collection was completed over a period of 16 months. My data collection procedures are summarized in detail below.

Data Collection

Day 1: I arrived at campus at noon on Saturday. I planned to stay 8-12 hours with a break every two hours. Using my textbook as a guide, I wrote out every measurement and dimension I would measure by hand in my composition notebook. I decided to begin by laying out one individual at a time. I began by collecting measurements from the skeleton belonging to the postpartum female. In eight hours, I only collected data from one skeleton. This was due to me spending an unnecessary amount of time writing out measurements and dimensions.

After reflecting on my eight hours in the lab, I reflected on how I could best utilize my time. To use my time more wisely, I created an Excel spreadsheet for data collection. I included the measurements I would take, which bones I would collect from, and the dimensions of each bone I would be evaluating. I dedicated an Excel page for the long bones of the upper body, a page for the long bones of the lower body as well as the bones of the pelvis. My measurements were in both millimeters and centimeters. I was advised to choose one unit. I chose millimeters. After speaking to my advisor, we decided I would take three sets of data per individual.

Day 2: For my second day of data collection, I started by laying out all the individuals on tables. After the individuals were prepared for evaluation, I proceeded to gather my tools. I used my iPad to record my measurements and sticky notes, to make notes of any questions or observations that I wanted to discuss or share with my advisor. For this second set of data, I collected three sets of data per individual over eight to ten hours. I rounded my numbers to the nearest whole number.

After submitting my next set of numbers, I was informed that I should use decimals so that when said data is presented in the form of a graph, the range of the data would be illustrated. In preparation for my third day of data collection I was advised to collect data over three days as opposed to three times in a single sitting; I watched several videos to ensure I used the tools correctly. Several of the bones presented challenges in data collection as some materials are oddly shaped. For example, I decided on calipers for areas of the bones that were challenging to measure, such as the obturator foramen of the os coxae.

Day 3: Before collecting my last data set, I was introspective and honest with myself. I have a short attention span. I also struggle with decision fatigue; in other words, I can only make so many decisions before I feel completely drained. I considered what triggered me to become distracted. I am distracted by deciding what background noises I want while I work. Looking for music while I work has the potential to distract me for thirty minutes. The night before my third data collection session, I created a playlist of songs I knew I would not skip through. I also compiled a list of movies and television shows I could play in the background. I decided on the horror franchise *Saw* to listen to while I gathered data. I have seen the franchise several times and knew I would not be distracted by attempting to follow a plot. As I write this, I am watching *Hostel*.

When I was satisfied with the best practices I created, I started my next three days of data collection. For the following three days, I made sure to work in 45-minute increments and took breaks for 15-20 minutes to allow my mind to roam without slowing my progress. My three days of data collection took place in the Osteology Lab (AH 314). I worked in the evening so I would not be bothered or distracted by other students.

As opposed to laying out all individuals, I removed one at a time. It was less overwhelming when done in that manner. After my advisor approved my work, we ran my data through software *R*. The goal of running my data through software was to conduct some basic descriptive statistics. I made my data look presentable by ensuring that no cells were empty and that the names of my measurements were abbreviated.

Tools: osteometric board, sliding calipers, cloth taper measurer, calculator, sticky notes, colorful pens, composition notebook, iPad, Microsoft Excel, Microsoft Word, skeletal individuals housed in the osteology lab at Western Washington University.

Software: Microsoft Word, Microsoft Excel, and R.

Skeletal Measurements

I took a total of 28 measurements on each skeleton. These measurements span eight bones of the postcrania. The definition of each measurement is presented by bone below.

Definitions of Skeletal Measurements

Humerus

1. **Maximum Humeral Length:** Using an osteometric board, find the length between the top of the humeral head to the distal humerus. (Martin,1928: 1010, Buikstra and Ubelaker, 1994: 80, #40)
2. **Biomechanical Length:** Using an osteometric board, measure the interspace between the top of the humeral head and the distal, lateral lip of the trachea. (Trinkaus, et al., 1999: 756).
3. **Humeral Bicondylar Breadth**: Using sliding calipers; measure the interspace between the medial and lateral epicondyles, making sure to keep the jaws of the caliper parallel to the humeral shaft. (Martin, 1928; Buikstra and Ubelaker, 1994).
4. **Humeral Midshaft Circumference:** Locate the middle of the shaft. Use a soft tape measure to determine the minimum circumference of the humeral shaft. (Martin, 1928).
5. **Vertical Head Diameter**: Using sliding calipers; measure the greatest interspace between the perimeter of the vertical head in the ventral and dorsal planes. (Martin 1928; Buikstra and Ubelaker, 1994).

6. **Maximum Midshaft Diameter**: Find the center of the shaft. Use sliding calipers to ascertain the largest cross-section of the humeral shaft. (Martin, 1928; Buikstra and Ubelaker, 1994).
7. **Minimum Midshaft Diameter**: Using sliding calipers, measure the smallest cross-section at the center humeral shaft. (Martin, 1928; Buikstra and Ubelaker, 1994).

Radius

1. **Maximum Radial Length:** (Martin, 1928: 1014, #1; Buikstra and Ubelaker, 1994: 80, #45) Using an osteometric board, measure the distance of the radial head to the tip of the styloid process.
2. **Radial biomechanical length**: Using a sliding caliper; determine the distance between the center of the radial head and the deepest point of the articular surface. (Trinkhaus et al., 1999, pp. 756-757).
3. **Radial Head Anteroposterior Diameter:** Using sliding calipers; Measure the largest diameter of the radial head (Martin, 1928).
4. **Radial Midshaft Circumference:** Using a flexible measuring tape to determine the smallest circumference of the radial midshaft (Martin, 1928).
5. **Radial Anteroposterior Midshaft Diameter:** After locating the middle shaft, use sliding calipers to measure the anteroposterior diameter (Martin, 1928; Buikstra and Ubelaker).
6. **Radial Mediolateral midshaft diameter:** After determining the midshaft of the radius; use a soft measuring tape and measure the mediolateral diameter. (Martin, 1928; Buikstra and Ubelaker).

Ulna

1. **Maximum Ulnar Length:** Using an osteometric board measure the maximum interspace from the olecranon to the distal-most of the styloid (Martin 1928; Buikstra and Ubelaker, 1994).
2. **Ulnar Biomechanical Length:** Using an osteometric board or spreading calipers; measure the interspace between the trochlear notch's proximodistal midpoint and the distal-most point middle point of the ulnar head (Trinkaus et al., 1999, p. 756).
3. **Ulnar Physiological Length:** Using sliding calipers; place one end in the deepest center point of the trochlear notch, measure to the deepest point on the ulnar head (Martin, 1928; Buikstra and Ubelaker, 1994).
4. **Maximum Anteroposterior Diameter:** Locate the point on the shaft where the interosseous crest is the most prominent. Using sliding calipers, determine the anteroposterior diameter (Martin, 1928; Buikstra and Ubelaker, 1994).
5. **Maximum Mediolateral Diameter:** Using sliding calipers; determine where the interosseous crest is most prominent. Measure the mediolateral diameter (Martin, 1928; Buikstra and Ubelaker, 1994).
6. **Ulnar Minimum Circumference:** Using a soft measuring tape measure the circumference of the diaphysis. This is located near the proximal ulnar end (Martin, 1992: Buikstra and Ubelaker, 1994).

Sacrum

1. **Maximum Anterior Height:** Using slider calipers or an osteometric board; measure from the ventral midline of the sacral promontory to the anteroventral midline point of the last sacral vertebral body (Martin, 1928).
2. **Maximum Anterior Breadth:** Using sliding calipers measure the greatest breadth of the first sacral vertebrae (Martin, 1928; Flanders, 1978).
3. **Ventral Height Arc:** Using a soft tape measure; Measure the surface area of the superior ventral midline point of S-1 to the inferior most point of the ventral midline (Martin, 1928).
4. **Dorsal Height:** Using sliding calipers or an osteometric board; measure the interspace from the super dorsal midline point of the sacrum the inferior dorsal midline point (Martin, 1928; Buikstra and Ubelaker, 1994).
5. **Anterosuperior Superior Breadth:** Using sliding calipers measure the transverse distance between the inferior most points of the auricular surface (Martin, 1928; Buikstra Ubelaker, 1994).
6. **Middle Breadth:** Using sliding calipers to measure the distance between the inferior most points of the auricular surface (Martin, 1928).
7. **Auricular Surface Height:** Using sliding calipers, Measure the maximum craniocaudal landmark of the auricular surface (Martin, 1928).
8. **Auricular surface Breadth:** Using sliding calipers measure the largest dorsoventral landmark of the auricular surface (Martin, 1928).
9. **Sacral Index:** Divide the maximum anterior breadth by the maximum anterior height. Multiply the quotient by 100 (Hrdlicka, 1939).

Coxal Measurements

1. **Os Coxae Height:** (Buikstra and Ubelaker, 1994: 82, #56) Using an osteometric board; measure the interspace between the iliac crest and the ischiopubic ramus.
2. **Superior Iliac Breadth:** (Martin, 1928: 1033, #12; Buikstra and Ubelaker, 1994: 82, #57) Using an osteometric board or large sliding calipers determine the largest interspace between the anterior and posterior superior iliac spines.
3. **Iliac Height:** Using sliding calipers; measure from the acetabular notch closest to the iliac crest (Martin, 1928).
4. **Pubic Length:** Using sliding calipers; measure from the point along the superior margin of the acetabular notch closest to the center of the triradiate suture **(**Martin, 1928; Buikstra and Ubelaker, 1994).
5. **Acetabular Symphyseal Length:** Using sliding calipers measure from the lunate surface closest to the superior point on the pubic symphysis (McCown & Keith, 1939).
6. **Ischial Length:** Using sliding calipers measure from the superior margin of the acetabular notch closest to the middle of the triradiate suture (Martin, 1928; Buikstra and Ubelaker, 1994).
7. **Acetabular Height:** With sliding calipers, measure from the lunate surface beneath the anterior inferior iliac spine (Martin, 1928).
8. **Acetabular Depth** (Trinkaus, 2003: 4): Using calipers placed in the same points used for height; ascertain the maximum depth of the acetabular fossa.
9. **Obturator Foramen Length** (Martin, 1928: 1033, #20): Using sliding calipers; measure from the center of the obturator groove to the distant inferior margin of the obturator foramen.

10. **Obturator Foramen Breadth:** With sliding calipers, ascertain the largest breadth of the obturator foramen perpendicular to the length of the obturator foramen (Martin, 1928).

Femur

1. **Maximum Femoral Length:** Using an osteometric board; ascertain the maximum interspace between the femoral head and the bottom of the condyle. (Buikstra, Martin and Ubelaker, 1928, 1994).
2. **Femoral Biomechanical Length:** From the superior femoral neck, use sliding calipers to measure the distances to the medial condyle; and the distalmost point of the lateral condyle. The average of the two measurements yields the biomechanical length. (Trinkaus et al, 1999).
3. **Femoral Bicondylar Length:** Using an osteometric board; keep the femur parallel to the length of the board, from the condyles, proceed to measure to the furthest point on the femoral head (Buikstra, 1928; Martin and Ubelaker, 1994).
4. **Femoral Midshaft Circumference:** Find the femoral midshaft. Using a flexible cloth tape to determine the minimum circumference at that location. (Buikstra, 1928; Martin and Ubelaker, 1994).
5. **Femoral Epicondylar Breadth:** With sliding calipers or an osteometric board, measure the distance between the medial most and lateral most points on the epicondyles. (Buikstra, 1928; Martin et al, 1994).
6. **Femoral Anteroposterior (or Sagittal) Midshaft Diameter:** Utilizing sliding calipers to determine the anteroposterior dimension of the femoral midshaft. (Buikstra, 1928; Martin et al., 1994).

7. **Femoral Mediolateral (or Transverse) Midshaft Diameter:** At the exact midshaft location as above tto determine the mediolateral dimension. Tools: sliding calipers. (Buikstra, 1928; Martin et al., 1994).
8. **Platymeric Index** Divide anteroposterior midshaft diameter by mediolateral midshaft diameter. Multiply the quotient by 100. (Martin, 1928).

Tibia

1. **Maximum Tibial Length:** Measure between the top of the intercondylar eminence and the bottom of the medial malleolus using an osteometric board. (Buikstra, 1928; Martin et al.,1994).
2. **Tibial Biomechanical Length:** From the center point of the talar articular surface and use an osteometric board to measure the distances to 1) the center point of the medial condyle; and 2) the center point of the lateral condyle. Find the average. (Trinkaus et al, 1999).
3. **Tibial Maximum Proximal Epiphyseal Breadth:** Using an osteometric board or sliding calipers, measure the greatest interspace between the centermost and lateral most points of the plateau. (Buikstra et al., 1994)
4. **Tibial Maximum Distal Epiphyseal Breadth:** Using an osteometric board or sliding calipers, measure the greatest interspace between the medial point on the medial malleolus and the lateral most point on the distal epiphysis (Buikstra et al., 1994).
5. **Tibial Midshaft Circumference:** Determine the center of the tibial midshaft. Use a soft tape measure to measure the circumference. (Martin, 1928).

6. **Tibial Circumference at Nutrient Foramen:** Using a soft measuring tape, ascertain the smallest circumference at the nutrient foramen. (Martin, 1928; Buikstra et al., 1994).
7. **Tibial Anteroposterior Midshaft Diameter:** Locate the center of the tibial shaft. Using a sliding caliper to determine the anteroposterior diameter. (Martin, 1928).
8. **Tibial Mediolateral (or Transverse) Midshaft Diameter:** Locate the center of the tibial shaft. Using a sliding caliper to determine the mediolateral diameter. (Martin, 1928).
9. **Tibial Maximum Shaft Diameter at Nutrient Foramen:** Using sliding calipers, measure the greatest distance from the anterior border to the posterior surface at the level of the nutrient foramen. (Martin, 1928: Buikstra et al.,1994).
10. **Tibial Mediolateral (or Transverse) Shaft Diameter at Nutrient Foramen:** Using calipers, measure the maximum mediolateral dimension of the shaft at the level of the nutrient foramen. (Martin, 1928; Buikstra et al., 1994).
11. **Platycnemic Index:** Divide mediolateral shaft diameter at nutrient foramen by maximum shaft diameter at nutrient foramen. Multiply the quotient by 100. (Martin, 1928).

Fibula

1. **Maximum Fibular Length:** Using an osteometric board; measure the interspace between the top of the styloid process and the bottom of the lateral malleolus. (Martin, 1928; Buikstra et al., 1994).
2. **Maximum Fibular Midshaft Diameter**: After locating the middle of the fibular shaft, use sliding calipers to determine the diameter of the midshaft (Martin, 1928; Buikstra et al., 1994).

3. **Fibular Midshaft Circumference:** In the same location where the fibular diameter was ascertained, use a flexible cloth tape to determine the smallest circumference of that location (Martin, 1928).

Keyword Search and Meta-Analysis

To meet the second main objective of my study, I performed a keyword search and meta-analysis. The search spanned 100 years of published literature. In Google Scholar, I searched the number of articles that have been published per decade that featured each keyword. The time frame I focused on was from 1923-2023. I collected 10 sets of data per keyword. The goal of my keyword search was to observe how often peer-reviewed articles are published that pertain to topics regarding the eight keywords, while noting what if any historical or popular culture events may have had an impact on an increase or decrease in publication.

Keywords

I chose eight keywords based on my literature review and knowledge of forensic protocols. The keywords that I chose were:

1. Human/trans
2. Skeletal collections
3. Human biological sex
4. Intersex human

5. Human dimorphism
6. Forensic anthropology
7. Human sexual dimorphism
8. Terry collection

After creating a list of relevant keywords relating to my project, I wrote a list of the keywords in my composition notebook. From there I searched each keyword and counted how many articles mentioned said keywords. My advisor quickly re-directed me as my method was not feasible or time effective. Instead, I created an Excel spreadsheet for the keywords. Ten rows are dedicated to every decade for the last one hundred years. After gathering data, I synthesized my findings in a line graph to illustrate the change in the use of keywords for one hundred years. The quantitative goal of my keyword search was to learn how often the keywords appeared in peer reviewed journals per decade.

Overcoming Possible Obstacles

I assessed eight individuals, three of which originated from Southeast Asia. I used methods that were developed using skeletal morphology of Black, white and Indigenous populations. Population specific skeletal assessment methods specific to Asia are currently in development.

Rennie et al. (2023) and Tallman et al. (2023) have demonstrated the importance of studying skeletal morphology from a variety of geographically diverse populations because sex estimation methodology developed from inhabitants of a geographic location may not be applicable to inhabitants of other locations. As forensic anthropologists continue to develop population specific methodology for Asian demographics, there will be opportunities to re-assess the three South East Asian individuals in my data set. Reassessing the Southeast Asian individuals using population specific methodology would allow for me to compare two different sets of methodology on the same set of individuals.

It is important to recognize that not all articles are available to the public due to not being digitized. As such, my study likely underestimates the number of times these words have been used. However, with my extensive search, I feel confident that I captured a range of variation in journal, article type, time-period, discipline, and authors.

Prior to my keyword search, I realized that it was acceptable in the past to use language that is now widely considered derogatory to describe sexual minorities. I did not include these words in my meta-analysis, there may be a number of peer-reviewed articles that were not included in my search results.

CHAPTER FOUR: RESULTS

For this project, I tested two primary hypotheses, related to the two main goals of my study.

Objective 1: Assess variation in skeletal measurements used in forensic sex estimation.

Hypothesis 1: Measurements used to estimate sex are significantly different between males and females.

Objective 2: Conduct a meta-analysis of sex estimation terminology used in forensics over the last 100 years.

Hypothesis 2: Terminology used in sex estimation, and particularly terms associated with non-binary individuals, have become significantly more frequent in the literature over the last 100 years.

The results of data gathered to address each objective and hypothesis are presented below.

Skeletal Results

To meet this objective, I took 18 measurements per individual. Ten of those measurements were taken from both left and right sides to compare, for a total of 28 measurements (Appendix 1).

The average results of each measurement are presented separately by bone in Tables 1-6 below.

Table 1. Average measurements of the sacrum and os coxa

Individual	Post-Menopausal Female (M1)	Final Indian Male 8	Final Indian Male 7	Chuckanut Man 1	Final Older Indian Male 6	Final Younger Indian Female 5	Final Female India 9	Final Skel 3
Assigned Sex	F	M	M	M	M	F	F	M
MX Anterior Height	12.3	10.2	11.2	NA	12.3	9.6	11.3	14.2
MX Ant Breadth	10.9	8.3	10.8	NA	11.2	9.5	11.2	11.3
VentralHeight Arc	12.4	8.3	8.7	NA	12.0	9.9	10.6	14.6
Dorsal height	11.3	9.5	12.1	NA	12.2	9.8	11.1	12.8
Anterosuperior Breadth	9.2	7.4	9.5	NA	10.6	9.5	7.1	10.8
Middle Btreadth	9.0	8.9	7.2	NA	8.0	7.0	7.4	9.4
Auricular Surface height	7.0	5.0	9.4	NA	4.8	4.9	3.9	8.5
Auricular surface breadth	3.8	3.4	6.3	NA	4.9	4.1	3.8	5.5
Sacral Index	NA	NA	NA	NA	NA	NA	NA	NA
Os Coxae Height (L)	20.8	17.5	17.6	23.1	20.3	17.0	20.0	21.4
Os Coxae Height(R)	20.4	17.5	17.5	22.7	19.6	16.9	17.7	21.4
Superior Illiac Breadth(R)	17.1	13.0	12.7	15.8	15.5	13.6	14.7	16.1

Superior Illiac Breadth(L)	17.2	13.0	12.7	15.9	10.2	13.5	9.6	16.1
Illiac length(R)	12.3	10.3	12.9	13.1	10.5	10.5	6.8	12.1
Illiac length(L)	12.2	10.2	12.8	13.0	5.9	10.4	6.8	12.2
Pubic length(R)	6.4	5.5	6.3	6.9	6.0	6.8	5.9	5.6
Pubic length(L)	6.4	5.4	6.4	7.0	6.0	6.9	5.9	5.5
Acetabubsymphyseal length(R)	4.9	5.1	5.7	6.5	5.7	6.1	6.2	5.9
Acetabubsymphyseal length(L)	4.8	5.1	5.7	13.1	5.1	6.1	8.9	5.9
Ischial length(R)	10.0	8.5	9.5	13.1	5.0	8.7	4.1	8.7
Ischial length(L)	10.1	8.5	9.5	4.8	8.5	3.8	4.1	8.7
Acetabular height(R)	4.9	4.9	4.4	4.9	4.4	3.8	4.1	4.8
Acetabular height(L)	4.9	4.8	4.4	4.8	4.5	3.7	4.9	4.9
Acetabular depth(R)	4.0	15.5	3.8	4.9	4.6	3.5	3.5	4.4
Acetabular depth(L)	4.0	3.9	3.9	4.9	5.1	3.5	3.5	4.5
Obturator foramen (R)	4.5	4.2	2.8	5.6	5.2	2.9	5.1	4.9
Obturator foramen(L)	4.5	4.1	2.7	5.5	5.2	2.9	5.1	4.8
Obturator foramen breadth(R)	3.1	3.9	5.1	3.5	3.2	3.1	3.0	3.1

Obturator foramen breadth(L)	3.1	3.9	5.0	3.5	3.2	3.1	3.0	3.1

Table 2. Average measurements of the ulna

Individual	Post-Menopausal Female (M1)	Final Indian Male 8	Final Indian Male 7	Chuckanut Man 1	Final Older Indian Male 6	Final Younger Indian Female 5	Final Female India 9	Final Skel 3
Assigned Sex	F	M	M	M	M	F	F	M
Maximum Ulnar Length (R)	23.9	25.4	25.3	27.3	24.5	24.5	25.1	25.6
Maximum Ulnar Length (L)	23.9	25.4	25.4	27.2	24.5	24.5	25.1	25.6
Ulnar Biomechanical Length (R)	23.5	25.1	N/A	20.5	24.6	24.9	22.5	25.4
Ulnar Biomechanical Length (L)	23.5	25.1	N/A	20.5	24.6	24.9	22.5	25.4
Ulnar Physiological Length (R)	22.5	24.7	N/A	24.7	21.1	24.1	22.1	23.2
Ulnar Physiological Length (L)	22.5	24.7	N/A	24.7	21.1	24.1	22.1	23.2
Maximum Anteroposterior Diameter (R)	1.1	1.6	N/A	1.9	0.9	0.9	1.1	1.5
Maximum Anteroposterior Diameter (L)	1.1	1.6	N/A	1.9	0.9	0.9	1.1	1.5
Maximum Mediolateral Diameter (R)	1.5	1.3	N/A	1.8	1.6	0.6	1.2	1.3

Maximum Mediolateral Diameter (L)	1.5	1.3	N/A	1.8	1.6	0.6	1.2	1.3
Ulnar Minimum Circumference (R)	1	4.2	N/A	3	2	1	1.9	3.6
Ulnar Minimum Circumference (L)	1	4.2	N/A	3	2	1	1.9	3.6

Table 3. Average measurements of the humerus

Individual	Post-Menopausal Female (M1)	Final Indian Male 8	Final Indian Male 7	Chuckanut Man 1	Final Older Indian Male 6	Final Younger Indian Female 5	Final Female India 9	Final Skel 3
Assigned Sex	F	M	M	M	M	F	F	M
Maximum Humeral Length (R)	30.3	28.6	29.1	33.9	30.2	28.4	28.1	31.4
Maximum Humeral Length (L)	30	28.7	29	33.8	29.1	28.3	28	31.1
Biomechanical Length (R)	29.5	28.4	21.9	6	6.1	29.7	27.1	31.1
Biomechanical Length (L)	29	28.4	21.9	5.3	6	29.8	27	31
Humeral Bicondylar Breadth (R)	8.4	5.6	5.9	7.5	4	6.9	5.5	5.9
Humeral Bicondylar Breadth (L)	8.3	5.6	5.9	6	3.9	6.9	5.4	5.9
Humeral Midshaft Circumference(R)	8.4	5.5	4.1	5.3	4	3.1	2.2	4.8
Humeral Midshaft Circumference (L)	8.3	5.5	4.4	5.3	4	3.1	2.1	4.8
Vertical Head Diameter (R)	6.5	6.8	3.9	7.5	6.9	5.5	3.8	4.1

Vertical Head Diameter (L)	6.5	6.8	3.9	7.5	6.8	5.4	3.8	4
Maximum Midshaft Diameter (R)	4.9	1.8	2.5	2.1	1.9	1.5	2.2	1.8
Maximum Midshaft Diameter (L)	4.9	1.8	2.5	2	1.9	1.4	2.2	1.8
Minimum Midshaft Diameter (R)	4.3	1.9	2.3	1.9	2.1	1	1.8	1.9
Minimum Midshaft Diameter (L)	4.4	1.9	2.3	1.9	2	1	1.8	1.9

Table 4. Average measurements of the radius

Individual	Post-Menopausal Female (M1)	Final Indian Male 8	Final Indian Male 7	Chuckanut Man 1	Final Older Indian Male 6	Final Younger Indian Female 5	Final Female India 9	Final Skel 3
Assigned Sex	F	M	M	M	M	F	F	M
MX Radial Length (R)	21.7	22.5	24.9	24.5	23.9	23.9	22.5	24.6
MX Radial Length (L)	21.5	22.3	24.9	24.4	23.9	23.9	22.5	24.6
Radial Biomechanical Length (R)	21.1	24.1	24	23	23.7	23.7	21.9	22.1
Radial Biomechanical Length (L)	21.1	24.1	24.1	23	23.7	23.7	21.9	21.1
Radial Head Anteroposterior Diameter. (R)	1.9	1.9	1.9	2	23.7	1.2	1.9	2.2
Radial Head Anteroposterior Diameter. (L)	1.9	1.8	1.9	2	1.2	1.2	1.9	2.2
Radial Midshaft Circumference. (R)	4.4	3.5	3	2.8	3	3	2.1	3.2
Radial Midshaft Circumference. (L)	4.4	3.4	3	2.8	3	3	2.1	3.2
Radial Anteroposterior Midshaft Diameter (R)	4.4	0.9	1.3	1.2	0.9	0.9	0.8	1.1

Radial Anteroposterior Midshaft Diameter (L)	4.4	0.9	1.3	1.2	0.9	0.9	0.8	1.1
Radial Mediolateral Midshaft Diameter. (R)	0.9	1.1	1.9	1.9	1.3	0.8	1.1	1.2
Radial Mediolateral Midshaft Diameter. (L)	1	1.1	1.9	1.9	1.3	0.8	1.1	1.2

Table 5. Average measurements of the femur

Individuals	**Post-Menopausal Female (M1)**	**Final Indian Male 8**	**Final Indian Male 7**	**Chuckanut Man 1**	**Final Older Indian Male 6**	**Final Younger Indian Female 5**	**Final Female India 9**	**Final Skel 3**
Assigned Sex.	F	M	M	M	M	F	F	M
Maximum Femoral Length (R)	41.7	38	41.5	47.5	42	40	42	42.1
Maximum Femoral Length (L)	41.7	38	41.2	47.5	41	40	42	41.8
Femoral Biomechanical Length (R)	41.1	33.2	43.4	44.3	39.1	31	42.7	39.1
Femoral Biomechanical Length (L)	41.2	33.1	43.1	44.2	39.1	31	42.6	39
Femoral Bicondylar Length (R)	41.6	39.9	41.5	47.6	41.9	39.9	42.1	42.2
Femoral Bicondylar Length (L)	41.6	40	41.5	47.6	41.9	39.9	42.1	42.2
Femoral Midshaft Circumference (R)	9	7.5	7.1	10.5	8.5	5.5	4.5	7.4
Femoral Midshaft Circumference (L)	9	7.5	7.1	10.5	8.5	5.6	4.5	7.4
Femoral Epicondylar Breadth (R)	73	9.7	7.3	8.9	9.9	8.4	7.1	16.8
Femoral Epicondylar Breadth (L)	73	9.8	7.2	8.9	9.9	8.4	7.1	16.8
Femoral Anteroposterior (or Sagittal) Midshaft Diameter (R)	5.4	2.1	4.8	5.9	5.1	2	2.2	3.8
Femoral Anteroposterior (or Sagittal) Midshaft Diameter (L)	5.5	2.1	4.8	5.8	5.1	2	2.1	3.7

Femoral Mediolateral (or Transverse) Midshaft Diameter (R)	5.6	2	4.7	8.5	4.9	2.3	2.3	4.1
Femoral Mediolateral (or Transverse) Midshaft Diameter (L)	5.7	2	4.8	8.4	4.9	2.3	2.2	4.1
Platymeric Index (R)	96.4	100	102.2	69.4	N/A	100	N/A	92
Platymeric Index (L)	98.2	100	102.2	69.4	N/A	100	N/A	98.2

Table 6. Average measurements of the fibula

Individuals	**Post-Menopausal Female (M1)**	**Final Indian Male 8**	**Final Indian Male 7**	**Chuckanut Man 1**	**Final Older Indian Male 6**	**Final Younger Indian Female 5**	**Final Female India 9**	**Final Skel 3**
Assigned Sex	F	M	M	M	M	F	F	M
Maximum Fibular Length (R)	33.8	30.9	35.7	38	34	33.6	34	34.9
Maximum Fibular Length (L)	33.8	30.9	35.7	38	34	33.6	34	34.9
Maximum Fibular Midshaft Diameter (R)	1	1	1.1	1.8	1	1.9	2.5	1.3
Maximum Fibular Midshaft Diameter (L)	1	1	1.1	1.8	1	1.9	2.5	1.3
Fibular Midshaft Circumference (R)	4.5	3.3	4	3.3	3	3.3	2.3	2.4
Fibular Midshaft Circumference (L)	4.5	3.3	4	3.3	3	3.3	2.3	2.4

Only one measurement is statistically different between males and females in this sample: the obturator foramen breadth (Table 7). All other measurements are not significantly different across the sexes.

Table 7. Statistical differences between males and females for each trait

TRAIT	P-Value
MX.Anterior.Height	0.593
MX.Ant.Breadth	0.858
VentralHeight.Arc	0.724
Dorsal.height	0.289
Anterosuperior.Breadth	0.212
Middle.Btreadth	0.480
Auricular.Surface.height	0.289
Auricular.surface.breadth	0.285
Os.Coxae.Height..L.	0.456
Os.Coxae.Height.R.	0.453
Superior.Illiac.Breadth.R.	0.655
Superior.Illiac.Breadth.L.	0.882
Illiac.length.R.	0.368
Illiac.length.L.	0.549
Pubic.length.R.	0.456
Pubic.length.L.	0.549
Acetabubsymphyseal.length.R.	0.881
Acetabubsymphyseal.length.L.	0.881
Ischial.length.R.	0.764
Ischial.length.L.	0.453
Acetabular.height.R.	0.282
Acetabular.height.L.	0.645
Acetabular.depth.R.	0.051
Acetabular.depth.L.	0.097

Obturator.foramen..R.	0.655
Obturator.foramen.L.	0.655
Obturator.foramen.breadth.R.	**0.047**
Obturator.foramen.breadth.L.	**0.047**

Meta-Analysis of Keywords

The following section is a meta-analysis of the keywords Human/trans, skeletal collections, human biological sex, intersex human, human dimorphism, forensic anthropology, human sexual dimorphism and terry collection. This section illustrates how the use of the keywords has changed over the past 100 years.

The frequency of published keywords is presented by decade in Tables 10-11.

Table 8. Frequency of keywords from 1923-2023 (subset).

Decade	Human/Trans	Human Biological Sex	Human Sexual Dimorphism	Skeletal Collections	Intersex, Human	Terry Collection	Human Dimorphism	Biological Profile
1923-1933	12	16500	200	6040	86	1560	200	17200
1933-1943	16	16200	186	6120	151	1440	186	16400
1943-1953	25	16500	256	7240	175	1910	256	16900
1953-1963	28	16700	716	14200	705	3870	716	16900
1963-1973	87	18100	2100	16800	1200	11600	2110	18500
1973-1983	186	53900	6090	17300	1660	16600	6090	17900
1983-1993	439	18900	13600	17700	2640	25300	13600	18600
1993-2003	8400	18400	20100	18400	7280	93800	13600	18200
2003-2013	31000	39400	23300	18400	17200	108000	23300	17900
2013-2023	55700	27400	18200	47200	17800	130000	18200	33200

Table 9. Frequency of keywords from 1923-2023 (subset part 2).

Decade	Forensic Anthropology	Gender Diversity	Assigned Sex	Human Transgender Studies
1923-1933	16600	491	16500	7
1933-1943	23200	396	16300	11
1943-1953	28900	590	16100	38
1953-1963	38300	1060	16100	62
1963-1973	28900	3310	21300	124
1973-1983	27400	15500	63800	190
1983-1993	38500	59100	20100	370
1993-2003	49600	39100	35000	6340
2003-2013	74200	69000	47400	26300
2013-2023	57400	22700	97400	55200

The graphs illustrate the number of articles per decade per keyword (Figures 1-2). A key goal is to understand why some keywords may have fluctuated, or remained static, over the past 100 years.

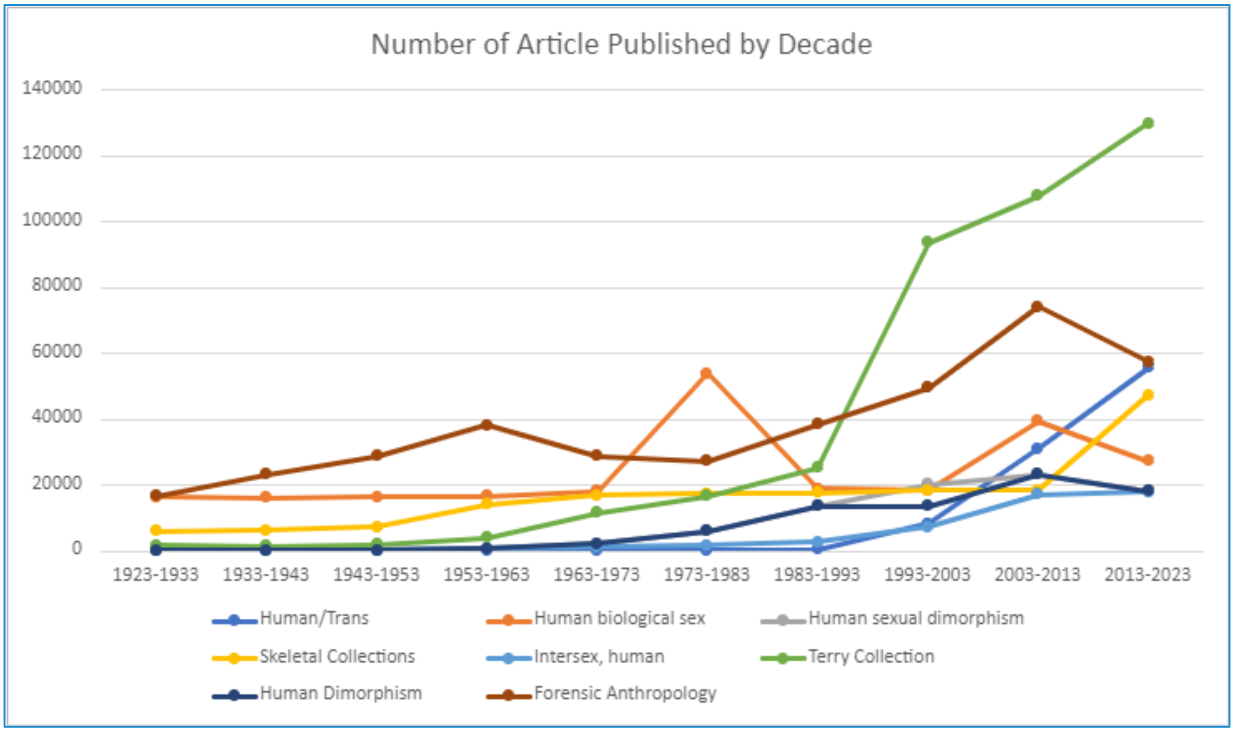

Figure 1. Number of articles published by decade: skeletal keywords. A subset of eight keywords. The oldest publications are on the left (1923-1933) and the more recent publications are on the right (2013-2023). Each keyword has a distinct color. The legend is at the bottom of the figure.

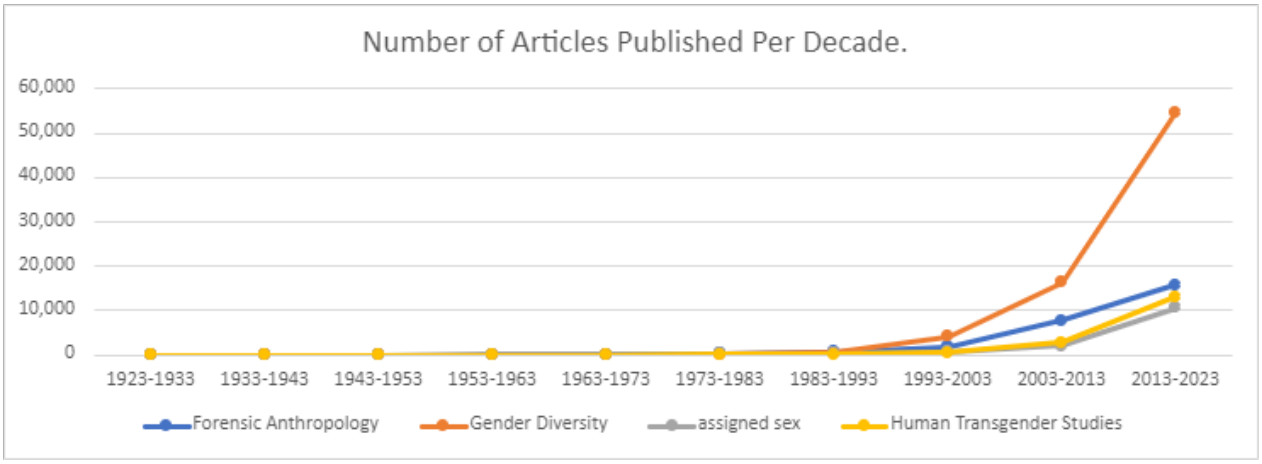

Figure 2. Number of articles published by decade: forensic keywords. A subset of four keywords. The oldest publications are on the left (1923-1933) and the more recent publications are on the right (2013-2023). Each keyword has a distinct color. The legend is at the bottom of the figure.

Only three keywords have been published more than 50,000 times in the last decade: Forensic Anthropology, Gender Diversity, and Terry Collection. Some keywords increased in frequency rapidly and are in prolific use now (e.g., gender diversity, forensic anthropology, human transgender studies).

CHAPTER FIVE: DISCUSSION

Forensic anthropologists are distancing themselves from the discourse that challenges the notion that biological sex is exclusively expressed as XX and XY and that gender is determined based exclusively on chromosomal expression. My thesis finds two key results:

1) Almost all post-cranial traits historically used to estimate sex are not significantly different between males and females in this sample. The exception is obturator foramen breadth.

2) Scientific papers used terms related to gender diversity have increased through time.

Obturator Foramen Breadth

The traits that I measured for this project did not vary significantly between males and females, except for the breadth of the obturator foramen. The obturator foramen is a large opening created by the pubis and ischium bones of the pelvis. Blood vessels and nerves pass through the foramen.

One reason why the obturator foramen can vary is because of the potential for birth. A female pelvis is shorter and rounder. A male pelvis is taller in length. Females are estimated to possess a triangular obturator foramen and males have an oval-shaped obturator foramen.

Other factors that may impact skeletal morphology are height, weight, geographic location, hormones, and lifestyle and secular changes such as the pelvis becoming more gracile over the last 150 years (Spradley et al. 2016). According to Rennie et al. (2022), the obturator foramen may be a useful tool in sex estimation if used in conjunction with other methods. My results support this hypothesis.

Rennie et al. (2022) developed a multivariate five-point system to evaluate the accuracy of using the obturator foramen amongst four skeletal collections. Rennie et al. (2022) also cite Rogers et al. (2022) for creating a methodology that yields a 95% rate of accuracy by combining methodology for the obturator foramen and ventral arc. Having the ability to use a statistical analysis for sex estimation that does not rely on pure visual assessment is integral for developing sex estimation methodology that is applicable to a diverse range of skeletal morphology (Byrnes et al. 2023). In summary, the obturator foramen is a trait that should be investigated in greater detail to assess its utility in sex estimation. Other post-cranial traits appear to have limited utility for estimating sex and may contribute to ongoing biases in understanding sex, gender, and human variation.

Gender Diversity and Scientific Terminology

Based on my meta-analysis, the key words gender diversity and human transgender studies are on the rise due to paradigm shifts surrounding sex and gender. I credit this to Third Wave Feminism.

Third Wave Feminism was a movement started in the early nineties, and is defined by the inception of intersectionality, sex positivity, and post-modern feminism (Snyder, 2008). I argue that the rise in the keyword gender studies is due to gender-related injustices being brough to the forefront. Examples of gender-related injustices include gender-based violence, gender wage gap, violence towards the LGBTQ+ community, victim blaming, and lack of gender diversity in the workplace and academic institutions is another reason why keywords pertaining to gender and sex are on the rise.

The rise of terminology associated with forensic science likely has other origins. I observed that popular culture has influenced the rise in the popularity of forensic science. For example, from 1993 to 2003 there was a rise in peer-reviewed journals regarding forensic anthropology. This increase in the interest of forensic anthropology coincides with the premiere of the television show *Bones,* a show about a forensic anthropologist. Interest in forensic anthropology has continued to rise as the discipline gets more representation. Forensic anthropologists are thus in the position to use the growing interest of the field as an opportunity to educate the public on the nuances of biological sex and gender.

Certain keywords (biological sex, human trans, and human dimorphism) may not be increasing in peer-reviewed journals due to forensic anthropologists continuing to rely on outdated beliefs of sex and gender. For example, the concept of biological sex is framed as a binary, meaning biological sex consists of male and female. Despite evidence that supports biological sex being an intersectional product of hormones, chromosomes, and genetics, forensic anthropologist hold on to their supposed objectivity and willingly look past the harm that is upheld by an outdated binary. Forensic anthropologist framing biological sex as a binary disregards intersex individuals, a demographic that makes up 1.7% of the population. Considering the violence that sexual minorities face from medical professionals, law enforcement and other community members, continuing to disregard intersex individuals would be irresponsible on the part of forensic anthropologists.

Gender Affirming Care and De-Transitioning

A possible obstacle to queering the field of forensic anthropology is the misconception surrounding gender-affirming care and de-transitioning. Gender-affirming care is a form of healthcare designed to affirm an individual's gender (Turban et al. 2021). Gender-affirming care can range from therapy to surgery. Examples of therapy are speech therapy, mental health therapy, and hormone therapy (Turban et al. 2021).

Other ways in which trans and gender-diverse individuals affirm their identity are pronouns, gender-affirming haircuts/hairstyles, clothes, and engaging in activities despite traditional gender roles (Turban et al. 2021). Gender-affirming surgeries can include but are not limited to, top surgeries, hysterectomies, and facial reconstruction (Turban et al. 2021).

The general public is greatly misinformed regarding gender-affirming surgeries and believe people who undergo gender-affirming surgeries will eventually regret permanently altering their bodies, especially if the individual is under the age of 18. This 'regret' is termed de-transitioning.

De-transitioning is halting or reversing gender affirming care (Turban et al. 2021). Turban et al, (2021) conducted a study to understand why de-transitioning occurs. In their study, n=27,715 individuals were asked if they had ever de-transitioned and why. Turban et al. (2021) report that 13.1% of the participants, n=2,242 individuals, de-transitioned. Of those, 82.5% of individuals who de-transitioned did so because of external factors such as societal stigma (Turban et al. 2021). Turban et al. (2021) note that more research is necessary to understand what factors contribute to de-transitioning as well as how to best support individuals while they navigate the nuances of gender identity.

Those who oppose gender-affirming care should consider why they are complicit regarding intersex medical interventions but are opposed to gender-affirming surgeries. The difference between intersex medical interventions and gender-affirming surgeries is consent. Infants cannot consent to surgical medical interventions that force their bodies into the sex binary. Intersex medical interventions are often unnecessary and can leave the individual with physical and emotional distress, while gender affirming surgeries are associated with a reduce in psychological distress (Almazan et al. 2021).

Summary

In summation, my results found that the only trait that was statistically different than the others was the obturator foramen, which supports studies that suggest re-evaluating sex estimation methodologies due to human sexual dimorphism, as well as studies that not the importance of the obturator foramen when used in conjunction with other skeletal material. Despite these compelling studies it is apparent that many forensic anthropologists need to be incentivized to stop disregarding evidence that supports human sexual dimorphism is variable. The stagnancy of some of the keywords demonstrates the need for intersectionality in academics. A key goal for this work is to make recommendations to forensic anthropologists who are building biological profiles and estimating sex. Those recommendations are presented in the next chapter.

CHAPTER SIX: CONCLUSION

Human skeletal morphology and sexual variation is expansive and cannot be contained in something as one dimensional as a binary. Cultural practices such as castration, adaptation to geographic locations and secular changes, such as long bones and the pelvis becoming more gracile, leaves human skeletal morphology to exist on a continuum. The existence of intersex individuals or individuals who possess both male and female characteristics, serve as a reminder of the importance to re-evaluate their deep-seated dependence on archaic systems of categorization, especially when those archaic systems ignore the complexities of biological sex and its variability, because sex estimation methods are not applicable to all bodies. The job of forensic anthropologists depends on having the ability to successfully diagnose sex, to identify decedents, as well as investigate crimes against humanity.

My study demonstrates that even within a small data set of males and females, variability in skeletal morphology exists. This is in direct alignment of studies that have successfully used the obturator foramen in conjunction with other skeletal material to successfully diagnose sex. In addition, this study illustrates that current anthropologists are aware of the detriment that a lack of diversity in the field has caused and are strategizing to create an environment of equity inclusion.

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APPENDIX A

Table A1. Measurements of the sacrum

Individual	MAH	MAB	VHA	DH	AB	MB	ASH	ASB	SI
4	12.9	10.9	12.4	11.9	9.3	9.1	7.1	3.8	53.5
	12.0	11.0	12.4	11.9	9.1	8.9	6.9	3.9	56.5
	11.9	10.9	12.3	10.1	9.3	9.0	7.0	3.8	54.2
	12.2	10.9	12.3	11.3	9.2	9.0	7.0	3.8	54.7
8	12.9	8.3	8.3	9.5	7.5	8.9	5.1	3.4	66.6
	12.0	8.2	8.4	9.5	7.5	8.8	5.0	3.3	66.0
	11.9	8.3	8.3	9.4	7.3	8.9	5.0	3.4	68.0
	12.2	8.3	8.3	9.4	7.4	8.8	5.0	3.3	66.8
7	11.3	10.8	8.8	12.2	9.5	7.0	9.5	6.3	66.3
	11.1	10.7	8.7	12.0	9.6	7.2	9.3	6.4	68.8
	11.2	10.9	8.7	12.1	9.5	7.3	9.4	6.2	65.0
	11.2	10.8	8.7	12.1	9.5	7.1	9.4	6.3	66.7
4	23.1	23.2	16.1	16.0	13.1	12.9	6.9	7.0	6.5
	22.9	22.0	16.1	15.9	13.2	13.2	7.0	6.9	6.4
	23.2	23.0	15.1	15.8	12.9	12.8	6.9	7.0	6.5
	13.1	4.7	4.9	4.8	4.9	4.9	5.5	5.4	3.4
6	12.3	11.2	12.1	12.2	10.6	8.1	4.8	4.9	102.0
	12.3	11.2	12.1	12.1	10.6	7.9	4.7	4.8	102.1
	12.2	11.1	11.9	12.2	10.5	8.1	4.8	4.9	102.0
	12.2	11.1	12.0	12.1	10.5	8.0	4.7	4.8	102.0
5	9.6	9.5	9.9	9.7	9.5	7.1	5.0	4.0	80.0
	9.7	9.4	9.9	9.8	9.4	6.9	4.8	4.1	85.4
	9.6	9.5	9.9	9.9	9.5	7.1	5.0	4.1	82.0
	9.6	9.4	9.9	9.8	9.4	7.0	4.9	4.0	82.4
9	11.3	11.2	10.7	11.1	10.1	7.3	3.9	3.9	100.0

11.2	11.2	10.5	11.2	10.1	7.4	3.9	3.8	97.4
11.3	11.1	10.7	11.1	1.2	7.5	3.9	3.7	94.8
11.2	11.1	10.6	11.1	7.1	7.4	3.9	3.8	97.4

Key: I=Individual, MAH-Maximum Anterior Height, MAB=Maximum Anterior Breadth., VHA=Ventral Height Arc., DH=Dorsal Height, ASB=Anterosuperior Superior Breadth., MB=Middle Breadth. ASH=Auricular Surface Breadth

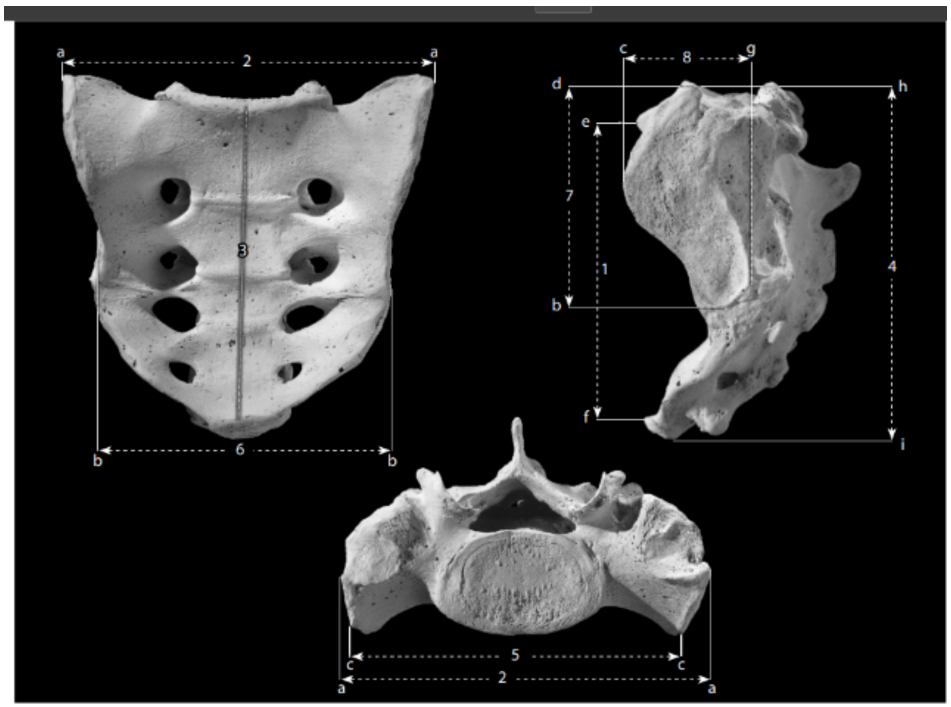

Figure A1. Sacrum Measurement Guide. (White et al. 2011).

Table A2. Measurements of the os coxa

Individual	OH	OH	SIB	SIB	ILL	ILL	PL	PL	ACE	ACE	AH	AH	AD	AD	OBF	OBF	OBFB
4	21.1	21.1	20.1	17.2	17.2	12.3	12.2	6.4	6.3	4.9	10.3	4.9	4.9	4.1	4.1	4.5	3.1
	20.1	20.1	20.1	17.1	17.1	12.2	12.1	6.3	6.4	4.9	9.9	4.8	4.9	3.9	3.9	4.5	3.1
	21.1	21.1	21.1	17.1	17.2	12.3	12.2	6.4	6.4	4.8	10.1	4.9	4.8	4.0	4.1	4.5	3.0
	20.7	20.7	20.4	17.1	17.1	12.2	12.1	6.3	6.3	4.8	10.1	4.8	4.8	4.0	4.0	4.5	3.0
8	17.6	17.6	17.5	13.1	13.0	10.3	10.1	5.5	5.4	5.1	8.5	4.9	4.8	39.0	3.9	4.5	3.9
	17.5	17.5	17.5	12.9	12.9	10.2	10.2	5.4	5.5	5.1	8.6	4.8	4.9	3.7	4.0	4.5	3.9
	17.5	17.5	17.6	17.2	13.1	10.3	10.3	5.5	5.4	5.0	8.5	4.9	4.7	3.7	3.9	4.5	4.0
	17.5	17.5	17.5	17.1	13.0	10.2	10.2	5.4	5.4	5.0	8.5	4.8	4.8	15.4	3.9	4.5	3.9
7	17.6	17.6	17.5	17.1	12.7	12.8	12.7	6.3	6.4	5.7	9.4	4.4	4.3	3.8	3.9	4.5	5.1
	17.7	17.7	17.5	17.1	12.6	12.9	12.8	6.4	6.5	5.6	9.5	4.4	4.4	3.9	4.0	4.5	5.1
	17.6	17.6	17.6	13.0	12.7	12.9	12.9	6.3	6.3	5.8	9.5	4.5	4.4	3.8	3.9	4.5	5.1
	16.6	16.6	17.5	13.0	12.6	12.8	12.8	6.3	6.4	5.7	9.4	4.4	4.3	3.8	3.9	4.5	5.1
1	6.5	6.5	13.2	12.7	4.9	4.9	4.8	4.9	4.9	5.6	3.4	3.3	4.3	4.4	3.3	4.4	5.0
	22.9	22.9	22.0	12.6	15.9	13.2	13.2	7.0	6.9	6.4	4.7	4.8	4.9	5.0	5.0	5.5	3.4
	23.2	23.2	23.0	12.8	15.8	12.9	12.8	6.9	7.0	6.5	4.7	4.9	4.8	4.9	4.9	5.6	3.5
	17.5	17.5	19.4	12.7	12.2	10.3	10.2	6.2	6.2	6.1	4.2	4.9	4.9	5.0	5.0	5.5	3.5
6	19.9	19.9	19.0	13.1	10.5	10.5	5.9	6.1	6.0	6.1	8.6	4.4	4.5	4.6	5.1	5.2	3.3
	20.0	20.0	19.9	16.1	10.0	10.4	5.9	6.1	5.9	5.0	8.6	4.5	4.4	4.6	5.2	5.2	3.1
	21.0	21.0	20.0	15.1	10.2	10.5	6.0	5.9	6.0	6.0	8.4	4.4	4.5	4.5	5.0	5.2	3.3
	20.3	20.3	19.6	14.7	10.2	10.4	5.9	6.0	5.9	5.7	8.5	4.4	4.4	4.5	5.1	5.2	3.2
5	17.1	17.1	16.9	15.6	13.5	10.5	10.5	6.8	6.9	6.1	3.7	3.8	3.7	3.5	3.5	2.9	3.1
	16.9	16.9	16.8	15.5	13.5	10.5	10.3	6.9	6.8	6.1	3.8	3.9	3.7	3.5	3.5	2.8	3.1
	16.9	16.9	17.0	15.4	13.6	10.4	10.4	6.8	6.9	6.2	3.9	3.8	3.8	3.6	3.4	2.9	3.0
	16.9	16.9	16.9	15.5	13.5	10.4	10.4	6.8	6.8	6.1	3.8	3.8	3.7	3.5	3.4	2.8	3.0
9	19.0	19.0	17.0	13.6	9.9	6.9	6.9	5.9	5.9	6.2	4.1	4.2	4.9	3.5	3.4	5.1	3.0

20.0	20.0	18.0	13.5	9.0	6.7	6.8	5.8	5.8	6.1	4.0	4.1	4.8	3.5	3.5	5.1	3.1
21.0	21.0	17.6	13.6	9.8	6.9	6.7	5.9	5.9	6.3	4.1	4.0	4.9	3.4	3.5	5.0	3.0
20.0	20.0	21.5	13.5	9.5	6.8	6.8	5.8	6.3	6.2	4.0	4.1	4.8	3.4	3.4	5.0	3.0

Key:I=Individual, OH=Os Coxae Height, SIB=Superior Illiac Breadth, ILL-Illiac Length, PL=Pubic Length, ACE=Acetabubsymphyseal Length, AH=Acetabular Height, AD=Acetabular Depth, OBF=Obturator Foramen, OBFB=Obturator Foramen Breadth. *R=Right, *L=Left.

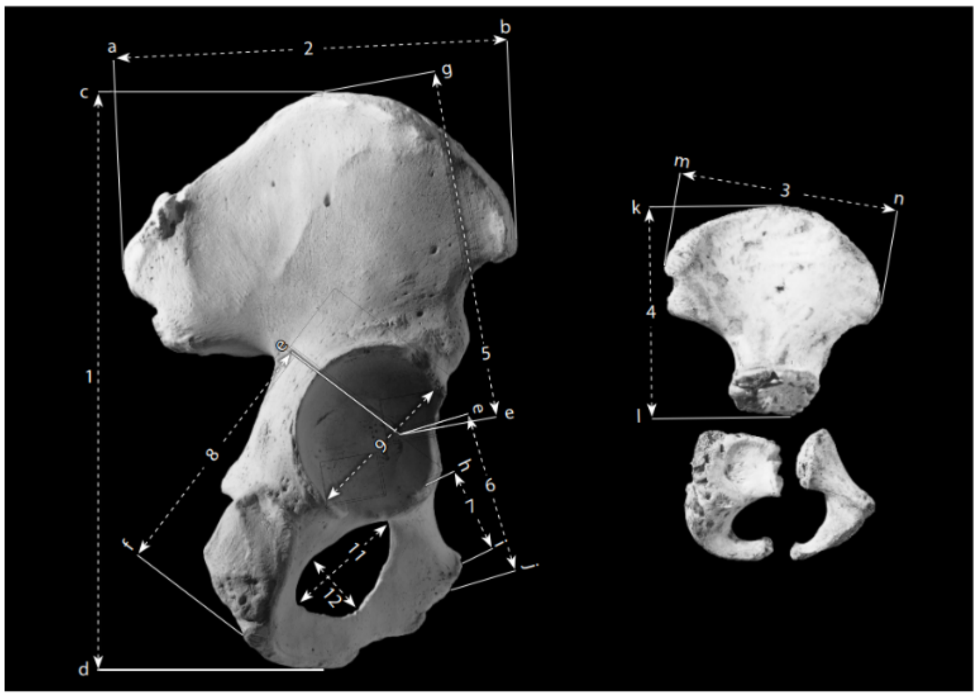

Figure 1A. Os Coxae Measurement Guide (White et al. 2011).

Table A3. Measurements of the humerus

Individual	MHL	BL	HBL	HBL	HBB	HBB	HMC	HMC	VHD	VHD	MMD	MMD	MMD	MMD
4	30.3	30.3	29.5	29.5	8.4	8.3	8.4	8.3	6.5	6.5	4.8	4.8	4.4	4.3
	30.1	30.0	29.0	29.5	8.4	8.3	8.4	8.3	6.6	6.5	4.8	4.8	4.4	4.4
	30.3	30.0	29.5	29.0	8.4	8.3	8.4	8.3	6.5	6.5	4.9	4.9	4.3	4.4
8	28.7	28.7	28.4	28.4	5.6	5.5	5.5	5.5	6.8	6.8	1.8	1.8	1.9	1.9
	28.7	28.7	28.5	28.5	5.6	5.6	5.4	5.4	6.7	6.8	1.7	1.8	1.8	1.9
	28.6	28.7	28.4	28.4	5.6	5.6	5.5	5.4	6.8	6.8	1.8	1.8	1.9	1.8
7	29.1	29.0	21.9	21.9	5.9	5.9	4.1	4.4	3.9	3.9	2.5	2.5	2.3	2.3
	29.1	29.0	21.9	21.9	5.8	5.8	4.1	4.3	3.9	3.8	2.5	2.4	2.2	2.3
	29.1	29.1	21.9	21.9	5.8	5.9	4.0	4.4	3.9	3.9	2.4	2.5	2.3	2.3
1	33.9	33.9	33.8	33.8	6.0	6.0	5.3	5.3	7.5	7.5	2.1	2.1	1.9	1.9
	33.9	33.8	33.8	33.8	6.0	6.0	5.3	5.3	7.5	7.5	2.1	2.1	1.9	1.9
	33.9	33.9	33.8	33.8	6.0	6.0	5.3	5.2	7.5	7.5	2.1	2.0	1.9	1.9
6	30.2	30.2	29.1	29.1	6.1	6.1	4.0	4.0	6.9	6.9	1.9	1.9	2.1	2.1
	30.2	30.2	29.0	29.1	6.1	6.0	4.0	4.0	6.9	6.8	1.9	1.9	2.1	2.1
	30.0	30.0	29.1	29.0	6.0	6.0	4.0	4.0	6.9	6.8	1.9	1.9	2.1	2.1
5	28.4	28.4	29.7	29.7	6.9	6.9	3.1	3.1	5.5	5.4	1.0	1.0	1.5	1.5
	28.3	28.4	29.7	29.7	6.9	6.9	3.0	3.1	5.5	5.5	1.0	1.0	1.5	1.5
	28.0	28.3	29.7	29.7	6.8	6.9	3.1	3.0	5.5	5.5	1.0	1.0	1.4	1.4
9	28.1	28.0	27.0	27.0	5.5	5.4	2.2	2.2	3.8	3.8	2.2	2.2	1.8	1.8
	28.0	29.0	28.0	27.0	5.5	5.4	2.2	2.1	3.8	3.8	2.2	2.1	1.7	1.7
	28.0	28.0	29.0	28.0	5.4	5.4	2.1	2.2	3.7	3.7	2.1	2.1	1.8	1.8
4	30.3	30.3	29.5	29.5	8.4	8.3	8.4	8.3	6.5	6.5	4.8	4.8	4.4	4.3
	30.1	30.0	29.0	29.5	8.4	8.3	8.4	8.3	6.6	6.5	4.8	4.8	4.4	4.4
	30.3	30.0	29.5	29.0	8.4	8.3	8.4	8.3	6.5	6.5	4.9	4.9	4.3	4.4
8	28.7	28.7	28.4	28.4	5.6	5.5	5.5	5.5	6.8	6.8	1.8	1.8	1.9	1.9

	28.7	28.7	28.5	28.5	5.6	5.6	5.4	5.4	6.7	6.8	1.7	1.8	1.8	1.9
	28.60	28.70	28.40	28.40	5.60	5.60	5.50	5.40	6.80	6.80	1.80	1.80	1.90	1.80

Key: I=individual, MHL=Maximum Humeral Length, BL=Biomechanical Length, HBB=Humeral Bicondylar Breadth, HMC=Humeral Midshaft Circumference, VHD=Vertical Head Diameter, MMD=Maximum Midshaft Diameter, MD=Minimum Midshaft Diameter.

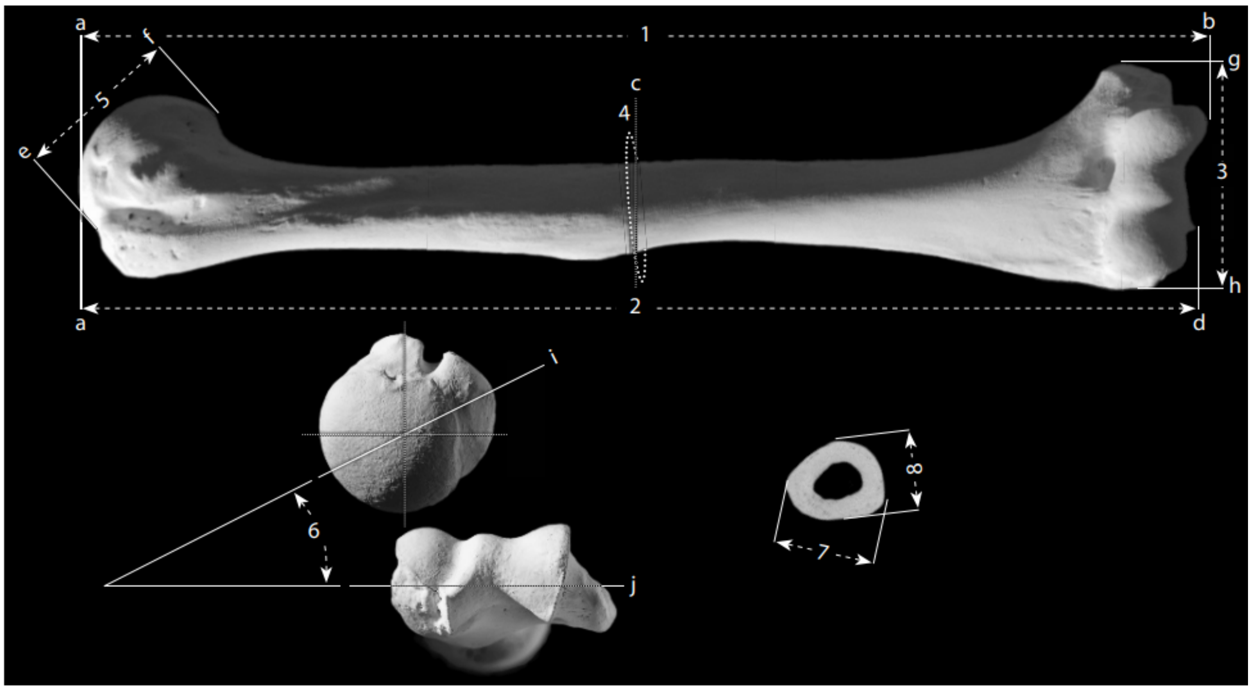

Figure 2A. Humerus Measurement Guide (White et al. 2011).

Table 4A. Measurements of the radius

Individual	MRL	MRL	RBL	RBL	RHAD	RHAD	RMC	RMC	RAD	RAD	RM	RM
4	21.7	21.0	21.1	21.0	1.9	1.9	4.4	4.4	0.9	0.9	1.7	1.7
	21.0	21.1	21.0	21.0	1.8	1.8	4.3	4.3	0.9	0.9	1.7	1.7
	21.1	21.0	22.0	21.0	1.8	1.8	4.4	4.4	0.9	0.9	1.7	1.7
8	22.5	22.1	24.1	24.0	1.9	1.8	3.5	3.5	0.9	0.9	1.1	1.1
	22.5	22.0	24.1	24.0	1.8	1.8	3.4	3.4	0.9	0.9	1.1	1.1
	22.0	22.0	24.1	24.0	1.9	1.8	3.5	3.5	0.9	0.9	1.0	1.0
	22.2		24.1	24.1	1.9	1.9	3.4	3.4	0.9	0.9	1.0	1.0
7	24.9	24.0	24.0	24.0	1.9	1.9	3.0	3.0	1.3	1.3	1.9	1.9
	24.9	24.9	24.0	24.0	1.8	1.8	3.0	3.0	1.2	1.2	1.9	1.9
	24.0	24.0	24.0	24.0	1.8	1.8	3.0	3.0	1.3	1.3	1.9	1.9
	24.0	24.0	24.0	24.0	1.8	1.8	3.0	3.0	1.3	1.3	1.9	1.9
1	24.5	24.0	23.0	23.0	1.8	1.8	2.8	2.8	1.2	1.2	1.9	1.9
	24.5	24.1	23.0	23.0	1.9	1.9	2.8	2.8	1.2	1.2	1.8	1.8
	24.0	23.1	23.0	23.0	1.8	1.8	2.8	2.8	1.2	1.2	1.9	1.9
	24.3	23.7	23.1	23.1	1.8	1.8	2.8	2.8	1.2	1.2	1.9	1.9
6	22.5	22.2	22.2	22.2	1.9	1.9	4.0	4.0	1.9	1.9	1.3	1.3
	22.5	22.0	22.1	22.1	1.9	1.8	4.1	4.1	1.8	1.8	1.3	1.3
	22.5	22.5	22.2	22.2	1.9	1.9	4.0	4.0	1.9	1.9	1.3	1.3
	22.5	22.2	22.1	22.1	1.9	1.8	3.9	3.9	1.9	1.9	1.2	1.2
	NA	NA	NA	NA	1.9	1.9	4.0	4.0	NA	NA	NA	NA
5	23.9	23.9	23.7	23.7	1.2	1.2	3.0	3.0	0.9	0.9	0.8	0.8
	23.9	23.9	23.7	23.7	1.1	1.1	3.0	3.0	0.9	0.9	0.8	0.8
	23.9	23.9	23.6	23.6	1.1	1.1	3.0	3.0	0.9	0.9	0.7	0.8
	23.9	23.9	23.7	23.7	NA	NA	NA	NA	NA	NA	0.7	2.4
9	22.5	22.0	21.9	21.9	1.9	1.9	2.1	2.1	0.8	0.8	1.1	1.1

22.5	22.0	21.0	21.0	1.8	1.8	2.0	2.0	0.8	0.8	1.1	1.1
22.0	22.1	21.9	21.9	1.9	1.9	2.1	2.1	0.8	0.8	1.1	1.1
22.3	22.0	21.0	21.0	1.9	1.9	2.1	2.1	0.8	0.8	1.1	1.1

Key-:I=Individual, MRL=Max. Radial length, RBL=Radial Biomechanical Length, RHAD=Radial Head Anteroposterior Diameter, RMC=Radial Midshaft Circumference, RAD=Radial Anteroposterior, RM=Radial Mediolateral

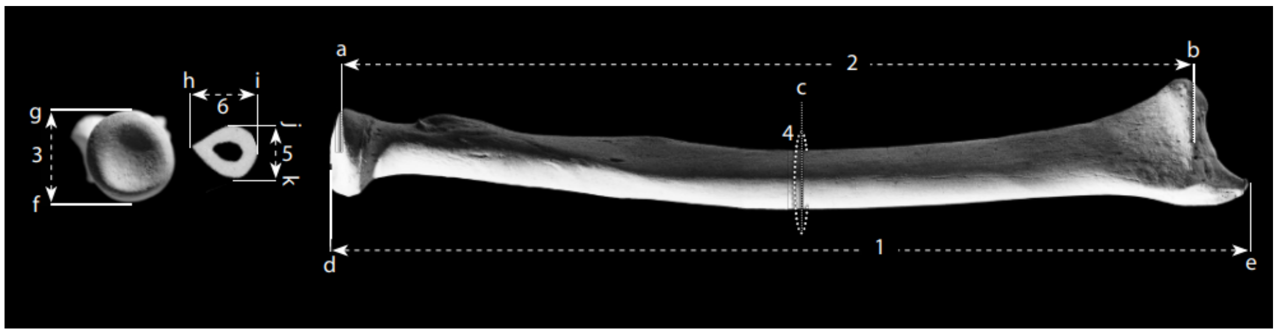

Figure 3A. Radius Measurement Guide (White et al. 2011).

Table 5A. Measurements of the ulna

Individual	MUL	MUL	UBL	UBL	UPL	UPL	MAD	MAD	MED	MED	UMC	UMC
4	23.9	23.9	23.5	23.5	22.5	22.5	1.1	1.1	1.0	1.0	1.5	2.0
	23.9	23.9	23.5	23.5	22.5	22.5	1.1	1.1	1.0	1.0	1.5	2.0
	23.9	23.9	23.5	23.5	22.5	22.5	1.1	1.1	1.0	1.0	1.5	2.0
	23.9	23.9	23.5	23.5	22.5	22.5	1.1	1.1	1.0	1.0	1.5	2.0
8	25.4	25.4	25.1	25.1	24.7	24.7	1.6	1.6	1.3	1.3	4.2	4.2
	25.4	25.4	25.1	25.1	24.7	24.7	1.6	1.6	1.3	1.3	4.2	4.2
	25.4	25.4	25.1	25.1	24.7	24.7	1.6	1.6	1.3	1.3	4.2	4.2
	25.4	25.4	25.1	25.1	24.7	24.7	1.6	1.6	1.3	1.3	4.2	4.2
7	25.3	25.3	25.4	25.4	24.0	24.0	1.7	1.8	1.7	1.8	2.0	2.0
	25.3	25.3	25.4	25.4	24.0	24.0	1.7	1.8	1.7	1.8	2.0	2.0
	25.3	25.3	25.4	25.4	24.0	24.0	1.7	1.8	1.7	1.8	2.0	2.0
	25.3	25.3	25.4	25.4	24.0	24.0	1.7	1.8	1.7	1.8	2.0	2.0
1	27.3	27.3	27.2	27.2	20.5	20.5	1.9	1.9	1.8	1.8	3.0	3.0
	27.3	27.3	27.2	27.2	20.5	20.5	1.9	1.9	1.8	1.8	3.0	3.0
	27.3	27.3	27.2	27.2	20.5	20.5	1.9	1.9	1.8	1.8	3.0	3.0
	27.3	27.3	27.2	27.2	20.5	20.5	1.9	1.9	1.8	1.8	3.0	3.0
6	24.5	24.5	24.6	24.6	21.1	21.1	0.9	0.9	1.6	1.6	2.0	2.0
	24.5	24.5	24.6	24.6	21.1	21.1	0.9	0.9	1.6	1.6	2.0	2.0
	24.5	24.5	24.6	24.6	21.1	21.1	0.9	0.9	1.6	1.6	2.0	2.0
	24.5	24.5	24.6	24.6	21.1	21.1	0.9	0.9	1.6	1.6	2.0	2.0
5	24.5	24.5	24.9	24.9	24.1	24.1	0.9	0.9	0.6	0.6	1.0	1.0
	24.5	24.5	24.9	24.9	24.1	24.1	0.9	0.9	0.6	0.6	1.0	1.0
	24.5	24.5	24.9	24.9	24.1	24.1	0.9	0.9	0.6	0.6	1.0	1.0
	24.5	24.5	24.9	24.9	24.1	24.1	0.9	0.9	0.6	0.6	1.0	1.0
9	25.1	25.1	22.5	22.5	22.1	22.1	1.1	1.1	1.2	1.2	1.9	1.9
	25.1	25.1	22.5	22.5	22.1	22.1	1.1	1.1	1.2	1.2	1.9	1.8

25.1	25.1	22.5	22.5	22.1	22.1	1.1	1.1	1.2	1.2	1.9	1.8
25.1	25.1	22.5	22.5	22.1	22.1	1.1	1.1	1.2	1.2	1.9	1.8

Key-I-Individual, MUL=Maximum Ulnar Length, UBL=Ulnar Biomechanical Length, UPL=Ulnar Physiological Length, MAD=Maximum Anteroposterior Diameter, MED=Mediolateral Diamer, UMC=Ulnar Minimum Circumference.

Figure 4A. Ulna Measurement Guide (White et al. 2011).

Table 6A. Measurements of the femur

Individual	MFL	MFL	FBL	FBL	FBL	FBL	FMC	FMC	FEB	FEB	FAM	FML	FML		PI
	41.7	41.7	41.1	41.2	41.6	41.6	9.0	9.0	73.0	73.0	5.4	5.5	5.6	5.7	96.5
	41.7	41.7	41.1	41.2	41.6	41.6	9.0	9.0	73.0	73.0	5.4	5.5	5.6	5.7	96.4
	41.7	41.7	41.1	41.2	41.6	41.6	9.0	9.0	73.0	73.0	5.4	5.5	5.6	5.7	96.4
	41.7	41.7	41.1	41.2	41.6	41.6	9.0	9.0	9.7	9.7	5.4	5.5	5.6	5.7	96.4
8	38.0	38.0	33.3	33.1	39.9	40.0	7.5	7.5	9.7	9.7	2.1	2.1	2.0	2.0	100.0
	38.1	38.1	33.3	33.2	40.0	40.0	7.5	7.5	9.8	9.8	2.1	2.1	2.0	2.0	NA
	38.0	38.0	33.1	33.0	39.9	41.0	7.6	7.6	9.7	9.7	2.2	2.1	2.0	2.0	NA
	38.0	38.0	33.2	33.1	39.9	40.3	7.5	7.5	7.3	7.3	2.1	2.1	2.0	2.0	100.0
7	41.5	41.2	43.4	43.1	41.5	41.5	7.1	7.1	7.3	7.3	4.8	4.8	4.7	4.8	102.2
	41.5	41.2	43.4	43.1	41.5	41.5	7.1	7.1	7.3	7.3	4.8	4.8	4.7	4.8	102.2
	41.5	41.2	43.4	43.1	41.5	41.5	7.1	7.1	7.3	7.3	4.8	4.8	4.7	4.8	102.2
	41.5	41.2	43.4	43.1	41.5	41.5	7.1	7.1	8.9	8.9	4.8	4.8	4.7	4.8	102.2
1	47.5	47.5	44.3	44.2	47.6	47.6	10.5	10.5	8.9	8.9	5.9	5.8	8.5	8.4	69.4
	47.5	47.5	44.3	44.2	47.6	47.6	10.5	10.5	8.9	8.9	5.9	5.8	8.5	8.4	69.4
	47.5	47.5	44.3	44.2	47.6	47.6	10.5	10.5	8.9	8.9	5.9	5.8	8.5	8.4	69.4
	47.5	47.5	44.3	44.2	47.6	47.6	10.5	10.5	9.9	9.9	5.9	5.8	8.5	8.4	69.4
6	42.0	41.0	39.1	39.1	41.9	41.9	8.5	8.5	9.9	9.9	5.1	5.1	4.9	4.9	NA
	42.0	41.0	39.1	39.1	41.9	41.9	8.5	8.5	9.9	9.9	5.1	5.1	4.9	4.9	NA
	42.0	41.0	39.1	39.1	41.9	41.9	8.5	8.5	9.9	9.9	5.1	5.1	4.9	4.9	NA
	42.0	41.0	39.1	39.1	41.9	41.9	8.5	8.5	8.4	8.4	5.1	5.1	4.9	4.9	NA
5	40.0	40.0	31.0	31.0	39.9	39.9	5.5	5.5	8.4	8.4	2.0	2.0	2.3	2.3	100.0
	40.0	40.0	31.0	31.0	39.9	39.9	5.5	5.5	8.4	8.4	2.0	2.0	2.3	2.3	100.0
	40.0	40.0	31.0	31.0	39.9	39.9	5.5	5.5	8.4	8.4	2.0	2.0	2.3	2.3	100.0
	40.0	40.0	31.0	31.0	39.9	39.9	5.5	5.5	7.1	7.1	2.0	2.0	2.3	2.3	100.0
9	42.0	42.0	42.7	42.6	42.1	42.1	4.5	4.5	7.1	7.1	2.2	2.1	2.3	2.2	NA
	42.0	42.0	42.7	42.6	42.1	42.1	4.5	4.5	7.1	7.1	2.2	2.1	2.3	2.2	NA

42.0	42.0	42.7	42.6	42.1	42.1	4.5	4.5	7.1	7.1	2.2	2.1	2.3	2.2	NA
42.0	42.0	42.7	42.6	42.1	42.1	4.5	4.5	73.0	73.0	2.2	2.1	2.3	2.2	NA

Table 6. Key-:I=Individual, MFL=Maximum Femoral Length, FBL=Femoral Biomechanical Length, FBL=Femoral Bicondylar, FMC=Femoral Midshaft Circumference, FEB=Femoral Epicondylar Breadth, FAMD=Femoral Anteroposterior Midshaft Diameter, PI= Platymeric Index

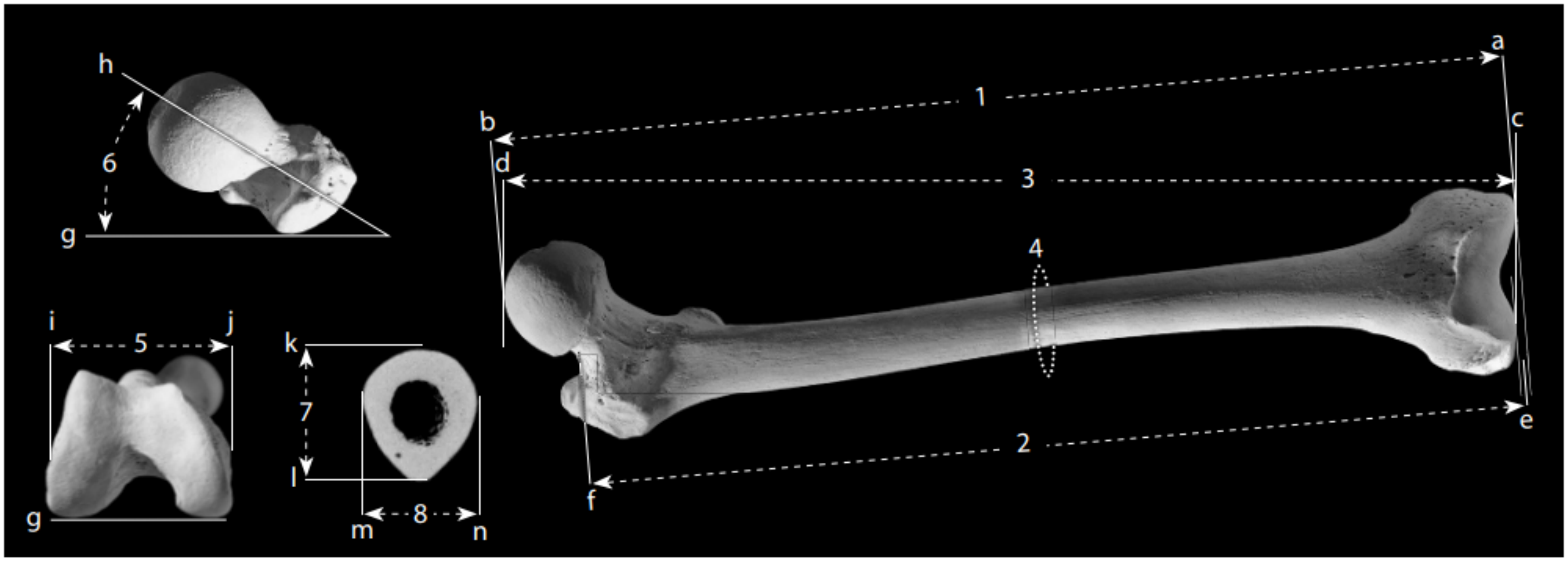

Figure 5A. Femur Measurement Guide (White et al. 2011).

Table 7A. Measurements of the tibia

Individual	MTL	MTL	TBL	TBL	PEB	PEB	TC	TC	MB	MB	DB	MC	MC	AF	AF	MM	MM	MF	MF
4	35.5	35.5	35.5	35.0	6.1	6.1	7.4	7.4	4.6	4.6	4.6	8.0	8.0	8.8	8.8	5.0	5.0	6.2	6.2
	35.4	35.4	35.5	35.0	6.1	6.1	7.4	7.4	4.6	4.6	4.6	8.0	8.0	8.8	8.8	5.0	5.0	6.2	6.2
	35.5	35.5	35.5	35.0	6.1	6.1	7.4	7.4	4.6	4.6	4.6	8.0	8.0	8.8	8.8	5.0	5.0	6.2	6.2
	35.4	35.4	35.5	35.0	6.1	6.1	7.4	7.4	4.6	4.6	4.6	8.0	8.0	8.8	8.8	5.0	5.0	6.2	6.2
8	38.0	38.0	39.0	28.9	8.7	8.8	5.0	5.0	7.8	7.9	8.0	1.9	1.9	2.1	2.1	1.9	1.9	2.6	6.2
	37.0	37.0	38.0	28.9	8.7	8.7	5.0	5.0	7.9	7.9	8.0	1.9	1.9	2.1	2.1	1.9	1.9	2.5	2.6
	38.0	38.0	38.0	28.9	8.8	8.8	4.0	4.8	7.8	7.9	8.0	1.9	1.9	2.1	2.1	1.9	1.9	2.6	2.5
	37.6	37.6	38.3	28.9	8.7	8.7	4.6	4.9	7.8	7.9	8.0	1.9	1.9	2.1	2.1	1.9	1.9	2.5	2.6
7	36.5	36.5	36.5	36.2	65.2	65.2	6.0	6.0	6.6	6.5	6.5	6.5	6.5	7.5	7.5	5.4	5.4	2.8	2.5
	36.5	36.5	36.5	36.2	65.2	65.2	6.0	6.0	6.6	6.5	6.5	6.5	6.5	7.5	7.5	5.4	5.4	2.8	2.8
	36.5	36.5	36.5	36.2	65.2	65.2	6.0	6.0	6.6	6.5	6.5	6.5	6.5	7.5	7.5	5.4	5.4	2.8	2.8
	36.5	36.5	36.5	36.2	65.2	65.2	6.0	6.0	6.6	6.5	6.5	6.5	6.5	7.5	7.5	5.4	5.4	2.8	2.8
1	39.0	39.0	39.0	37.0	8.0	7.9	9.1	9.2	7.7	7.8	7.9	7.9	7.9	3.9	3.9	3.8	3.8	2.8	2.8
	39.0	39.0	39.0	37.0	8.0	7.9	9.1	9.2	7.7	7.8	7.9	7.9	7.9	3.9	3.9	3.8	3.8	6.2	NA
	39.0	39.0	39.0	37.0	8.0	7.9	9.1	9.2	7.7	7.8	7.9	7.9	7.9	3.9	3.9	3.8	3.8	6.2	NA
	39.0	39.0	39.0	37.0	8.0	7.9	9.1	9.2	7.7	7.8	7.9	7.9	7.9	3.9	3.9	3.8	3.8	6.2	NA
6	34.1	34.1	34.2	33.9	7.1	7.2	7.5	7.4	2.6	2.6	2.6	6.8	6.8	8.7	2.8	2.4	2.4	6.2	NA
	34.1	34.1	34.2	33.9	7.1	7.2	7.5	7.4	2.6	2.6	2.6	6.8	6.8	8.7	2.8	2.4	2.4	2.6	3.8
	34.1	34.1	34.2	33.9	7.1	7.2	7.5	7.4	2.6	2.6	2.6	6.8	6.8	8.7	2.8	2.4	2.4	2.5	3.8
	34.1	34.1	34.2	33.9	7.1	7.2	7.5	7.4	2.6	2.6	2.6	6.8	6.8	8.7	2.8	2.4	2.4	2.6	3.8
5	34.2	34.2	34.1	3.3	8.1	8.1	3.1	3.1	5.8	5.5	5.4	5.1	5.1	2.1	2.1	16.4	16.4	2.5	3.8
	34.2	34.2	34.1	3.3	8.1	8.1	3.1	3.1	5.8	5.5	5.4	5.1	5.1	2.1	2.1	16.4	16.4	2.8	1.9
	34.2	34.2	34.1	3.3	8.1	8.1	3.1	3.1	5.8	5.5	5.4	5.1	5.1	2.1	2.1	16.4	16.4	2.8	1.9
	34.2	34.2	34.1	3.3	8.1	8.1	3.1	3.1	5.8	5.5	5.4	5.1	5.1	2.1	2.1	16.4	16.4	2.8	1.9
9	36.2	36.2	33.1	33.1	3.9	3.9	17.9	17.9	3.9	4.1	4.1	5.1	5.1	1.9	29.2	NA	NA	2.8	1.9
	36.2	36.2	NA	33.1	3.9	3.9	17.9	17.9	3.9	4.1	4.1	5.1	5.1	1.9	29.2	NA	NA	NA	NA

36.2	36.2	NA	33.1	3.9	3.9	17.9	17.9	3.9	4.1	4.1	5.1	5.1	1.9	29.2	NA	NA	6.2	NA
36.2	36.2	NA	33.1	3.9	3.9	17.9	17.9	3.9	4.1	4.1	5.1	5.1	1.9	29.2	NA	NA	6.2	NA

Key: I=Individual MTL Maximum Tibial Length, TBL=Tibia Biomechanical Length, PEB=Maximum Proximal Epiphyseal Breadth, TC=Tibial Circumference at Nutrient Foramen, TMC=Tibial Midshaft Circumference, TCNM=Tibial Circumference at Nutrient Foramen, TAMD=Tibial Anteroposterior Midshaft Diameter, TMD=Transverse Midshaft Diameter.

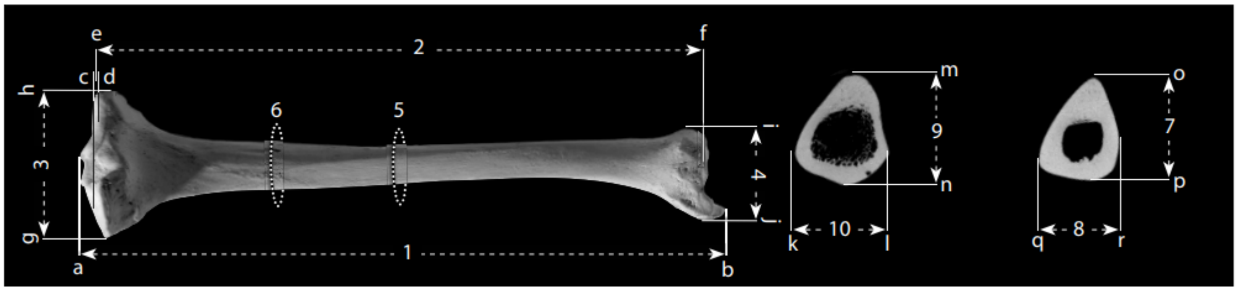

Figure 6A. Tibia Measurement Guide (White et al. 2011).

Table 8A. Measurements of the fibula

Individual	MFL	MFL	MFMD	MFMD	FMC	FMC	
4	33.8	33.8	15.0	15.0	15.0	4.5	4.5
	33.8	33.8	15.0	15.0	15.0	4.5	4.5
	33.8	33.8	15.0	15.0	15.0	4.5	4.5
	33.8	33.8	15.0	15.0	15.0	4.5	4.5
7	35.7	35.7	1.1	1.1	1.1	4.0	4.0
	35.7	35.7	1.1	1.1	1.1	4.0	4.0
	35.7	35.7	1.1	1.1	1.1	4.0	4.0
	35.7	35.7	1.1	1.1	1.1	4.0	4.0
	35.7	35.7	1.1	1.1	1.1	4.0	4.0
8	30.9	30.9	1.0	1.0	1.0	3.3	3.3
	30.9	30.9	1.0	1.0	1.0	3.3	3.3
	30.9	30.9	1.0	1.0	1.0	3.3	3.3
	30.9	30.9	1.0	1.0	1.0	3.3	3.3
1	38.0	38.0	1.8	1.8	1.8	3.3	3.3
	38.0	38.0	1.8	1.8	1.8	3.3	3.3
	38.0	38.0	1.8	1.8	1.8	3.3	3.3
	38.0	38.0	1.8	1.8	1.8	3.3	3.3
6	34.0	34.0	1.0	1.0	1.0	3.0	3.0
	34.0	34.0	1.0	1.0	1.0	3.0	3.0
	34.0	34.0	1.0	1.0	1.0	3.0	3.0
	34.0	34.0	1.0	1.0	1.0	3.0	3.0
5	33.6	33.6	1.9	1.9	1.9	3.3	3.3
	33.6	33.6	1.9	1.9	1.9	3.3	3.3
	33.6	33.6	1.9	1.9	1.9	3.3	3.3
	33.6	33.6	1.9	1.9	1.9	3.3	3.3
	33.6	33.6	1.9	1.9	1.9	3.3	3.3
9	3.4	3.4	2.5	2.5	2.5	2.3	2.3
	3.4	3.4	2.5	2.5	2.5	2.3	2.3

3.4	3.4	2.5	2.5	2.5	2.3	2.3
3.40	3.40	2.50	2.50	2.50	2.30	2.30

Key: I=Individual, MFL=Maximum Fibulae Length, MFMD=Maximum Midshaft Diameter, Fibular Midshaft Circumference.

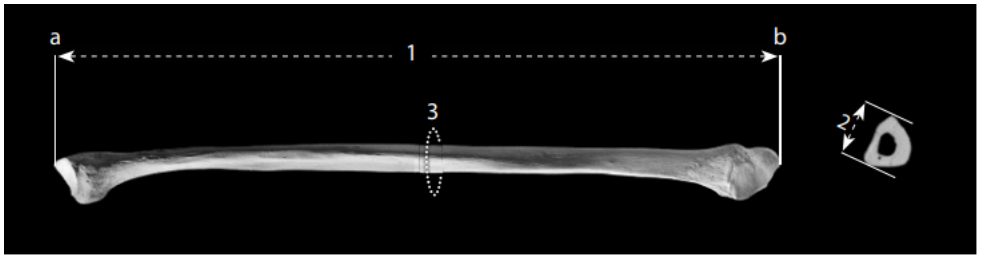

Figure 8A. Fibula Measurement Guide (White et al. 2011).