2017

Non-Metric Cranial Differentiation Between Asian and Native American Populations for Ancestry Assessment

Dominique Marie Bodoh
Louisiana State University and Agricultural and Mechanical College, bodohdom@gmail.com

NON-METRIC CRANIAL DIFFERENTIATION BETWEEN ASIAN AND NATIVE AMERICAN POPULATIONS FOR ANCESTRY ASSESSMENT

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Geography & Anthropology

by
Dominique Marie Bodoh
B.A., Beloit College, 2015
May 2017

Table of Contents

Acknowledgements

I would like to thank the Smithsonian Institution National Museum of Natural History for use of their collections and for the guidance I received during my time there.

A big thank you for the support I received from Department of Geography and Anthropology at Louisiana State University Baton Rouge for fully funding my research efforts with the West-Russell Field Research Award.

Dr. Listi, thank you for believing in my ability to do anthropology and for reading my drafts, as painful as that process can be. For always giving me guidance and perspective on the task at hand, I truly appreciate having had you as my advisor.

To my thesis committee, Dr. Chicoine and Dr. Brophy, for reviewing my thesis and for asking difficult questions. You both made my work so much stronger.

A personal thank you to Dr. Hunt at the Smithsonian Institution National Museum of Natural History for always being available for questions and for convincing me that my worries are normal.

Dr. Tague, I appreciate your advice on where to stay during my time in Washington D.C and how to prepare myself for working with collections at the Smithsonian Museum of Natural History in Suitland, MD.

Thank you to my friends, Emily, Amy, Cameron, Jourdan and Derek, for knowing how to support me and for reminding me of my purpose in this process.

Lastly, to my family for always supporting me, thank you so much. We have been through difficult times since I have moved away, and yet you continue to want what is best for my education.

List of Tables

List of Figures

Abstract

Assessing ancestry from skeletal remains provides important information to aid in personal identification. However, trying to specify ancestry for Native American and Asian populations in the United States is a current challenge in laboratory analyses. Both Native American and Asian populations are still often combined in research for a variety of reasons: small sample sizes, skeletal similarities and less emphasis in contemporary literature. Historically, Carlton Coon, in 1939, and Riesenfield, in 1956, refer to this combination of both Native American and Asian populations as “Mongoloid,” a term which is deemed by many as an offensive and inaccurate categorization of both populations by modern standards. The intent of this research is to analyze non-metric features of Native American and Asian crania to determine which traits, if any, may be used to differentiate between those two populations. Data analysis using frequency tables, chi-square and logistic regression methods show that some traits are statistically significant and are, therefore, linked to one population. By using these traits to help differentiate between Native American and Asian crania, ancestry may be identified more easily in forensic casework.

Chapter One: Introduction

Assessing ancestry from skeletal remains provides important information to aid in personal identification (Gill 1998). Having information about an individual's ancestry often assists in producing detailed missing persons reports. However, trying to specify ancestry for some populations is a current challenge in laboratory analyses. For example, in the forensic anthropology literature, there is a prevalence of using only three population groups, White, Black and "Mongoloid." The last group, Mongoloid, is comprised of both Asian and Native American populations. What makes Asian populations Asian, and Native American populations Native American, is the geographic region from which they, and their most recent ancestors, came. One problem with combining these two populations is that, not only are they geographically on different continents, but they also differ in historical background and current cultural practices (Brace 1995).

The lack of differentiation between Asians and Native Americans in early anthropology literature (Riesenfield 1956; Coon 1962; Crawford 1998) may have arisen for a variety of reasons. The first reason is their similar recent evolutionary origin. It is now widely accepted by researchers such as Howells (1989), Ossenberg (1994, 2003), and Crawford (1998), that Native American populations originated in Asia. Because the two populations are similar in cranial morphology and originate within the same region, finding methods to separate the two populations may not be as straightforward as in populations such as Europeans or Africans. The second reason for not distinguishing between the two populations may be due to the limited skeletal materials available for study (Rhine 1990). Many osteology collections used for research such as the Hamann-Todd Osteological Collection, Maxwell Museum Documented Skeletal Collection, Peabody Museum Osteological Collection and the Dr. William M. Bass Collection have limitations. Some of these collections may contain either Asian or Native American remains; however, the level of identification, sample size, and accessibility of these remains may be limited. Additionally, there has been a noticeable decrease in Native American skeletal collection sizes since 1990 due to the Native American Grave Protection and Repatriation Act (NAGPRA), which has also increased the difficulty in accessing the collections.

A third reason for not differentiating between Asian and Native American populations is that forensic anthropology research in the past places more emphasis on differentiating Black and White populations which tend to be larger than Asian and Native American populations. This emphasis is likely due to higher representations of Black and White unidentified persons in forensic anthropology casework, a trend that also correlates with demographic data. According to the U.S. Census taken in 2010, approximately 17 million individuals identify as Asian (U.S. Census Bureau, 2012), and 5.2 million individuals identify as Native American or Alaskan Native (U.S. Census Bureau, 2012). Both of these population totals are much smaller than the totals for White and Black populations (U.S. Census Bureau, 2011), which are in hundreds of millions.

In a report on Native Americans and crime (Perry 2004) and a related paper by Hartney and Vuong (2009), statistics show there are a higher number of violent crimes within the Native American identifying population than in other U.S. populations. According to the U.S. Department of Justice report, “American Indians are more likely than people of other races to experience violence at the hands of someone of a different race” (Perry 2004: 4). The report also states that Americans Indians “have experienced a per capita rate of violence twice that of the U.S. resident population” (Perry 2004: iiii). On average, American Indians “experienced an estimated one violent crime for every ten residents age twelve or older” (Greenfeld and Smith

1999: iii). Despite being less specified in the forensic anthropology literature, U.S. crime statistics and missing persons reports, shown in Tables 1-2, demonstrate that both Native American and Asian populations have need of the identification services provided by forensic anthropologists (The Federal Bureau of Investigation, 2014). Though crime statistics are smaller among the Asian populations in the U.S., the missing persons report for 2014 indicates that there is a relatively high population of Asian Americans reported as missing.

In addition to missing persons cases in the U.S., Canada has seen approximately 1,181 cases of missing and murdered Indigenous women over the past 30 years (Isler 2015). Though Indigenous women only make up 4.3% of women in Canada, they account for 16% of missing and murdered women in Canada (Isler 2015). Additionally, those who identify as Asian make up approximately 14.2% of the total population in Canada which is higher than in the U.S. (Statistics Canada 2013). While the numbers may seem relatively low overall, there is an undeniably disproportionate quantity of Indigenous women who are reported missing or murdered in Canada compared to demographic data. Therefore, the ability to differentiate these two populations also may aid in decedent identification among Asians and Native Americans in other countries.

Table 1. NCIC Missing/Unidentified Entry Comparison Chart

Year	Missing Person Entries	Unidentified Person Entries
2005	834,536	1,383
2006	836,131	1,413
2007	814,967	1,788
2008	778,164	1,133
2009	719,558	1,040
2010	692,944	1,033
2011	678,860	1,030
2012	661,593	932
2013	627,911	866
2014	635,155	876

From 2005 – 2014, number of active missing person cases which carried over or were created each year in comparison with unidentified, found, person entries.

Table 2. 2014 NCIC Missing Person Entries

Ancestry	Under 21	21 and Older	All Ages
Asian	8,047	4,500	12,547
Black	185,006	32,678	217,684
Native American	7,665	1,697	9,362
Unknown	14,175	3,841	18,016
White	283,979	93,567	377,546

From 2014, number of active missing person cases which carried over or were created in 2014 by age and ancestry.

The goal of this research is to analyze non-metric features of Native American and Asian crania to determine which of those traits, if any, may differentiate those populations and help eliminate the grouping of both populations under one name. Recent research by Hefner (2003, 2009) and Birkby et al. (2008) emphasizes the need to have a suite of differentiating characteristics to identify ancestral groups. This need is driven by the knowledge that variation among ancestral groups is extensive and overlapping, and no single trait is enough to identify an individual (Hefner 2003, 2009). From a broader perspective, the intent of this research is to improve upon the accuracy of ancestry determination during forensic cases, aiding in the decedent identification process.

Chapter Two: Literature Review

Origins of the Term Mongoloid

Previous research has shown that ancestry can be assessed by visual inspection of morphological variants of the cranium and mandible (Berry and Berry 1967; Chevraud et al. 1979; Rhine 1990; Buikstra and Ubelaker 1994; Birkby et al. 2008; Hefner 2009; Ossenberg 2013; Burns 2015). Two assumptions are implicit in these methods. The first is that the selected cranial variants are not influenced by environmental factors, subsistence activities, or cultural practices (Ossenberg 2003). The second assumption is that the presence or absence of a trait is due to genetic variations linked to the cranium. Therefore, both metric variation and non-metric traits/ features are the result of the same developmental processes, making them equally beneficial to the study of ancestry (Cheverud et al. 1979; Rhine 1990).

Traditionally, in forensic anthropology, Asian and Native American populations are combined within one category, while American White and Black populations maintain individual categories. The category that combines Native American and Asian ancestry is Mongoloid. For the sake of remaining true to the original literature and for the discussion of the original use of the word, the term Mongoloid, though inappropriate and antiquated, will be referenced multiple times in this chapter.

The use of the word Mongoloid began in the 1700s in reference to East and Southeast Asian populations (Blumenbach 1828) and was perpetuated in physical anthropology literature as recently as the 1980s (Howells 1980). Two early uses of the term were by Carlton Coon in 1939 and Alphonse Riesenfield in 1956. Coon’s work identifies six major Old World racial groups, one of which is Mongoloid, and explains that, because human populations cannot be rigidly confined into racial groups due to constant development and overlapping of phenotypic traits, racial subgroupings are also necessary. Coon's (1939) break-down of racial groups produced a diverging branch from Mongoloid called "partially Mongoloid," which separates the group across indistinct trait lines. Later, Riesenfield (1956) used the term Mongoloid to classify Native Americans, East and Central Asians, and Indonesians, while looking at the incidence of infra-orbital foramina across geographic regions. Coon (1962) continued to use the term Mongoloid in later research but broadened it to encompass East and Southeast Asian populations as well as Native American populations. Coon (1962) broadened his definition of the word because he believed that the Mongoloid population he grouped together was an isolated branch of *Homo sapiens* descended directly from *Sinanthropus pekinensis* (today, *Homo erectus*).

In 1989, C. Loring Brace used geographic trait variation as a platform for speaking out against racial stereotyping. During a prehistory conference, Brace mentioned that it would be more appropriate to use specific geographic terms to identify populations, such as "northeast, central or south eastern" Asians as opposed to the term Mongoloid. However, he was quickly contradicted by a colleague who stated, "It's all right to use the word 'Mongoloid'… if the term has meaning, and it seems to… we should just go on using the word Mongoloid. If it's a fish, let's call it a fish" (Brace 1995: 171). This disagreement fueled Brace's research to identify the issues associated with implying that certain derived human traits are an aspect of race. Referring to skeletal traits versus visual traits such as skin color, Brace (1995: 172) stated that, "there is no biological reality to the concept of 'race,' and that the confusion is caused by a failure to distinguish between traits derived through natural selection and those that simply reflect the regional community."

The word Mongoloid cannot be expunged from the old literature. However, forensic anthropology has taken many steps toward the elimination of the word, and many researchers such as Berry and Berry (1967), Chevraud et al. (1979), Rhine (1990), Buikstra and Ubelaker (1994), Birkby et al. (2008), Ossenberg (2013), Hefner (2009), Burns (2015), and too many more to list, are in agreement with Brace (1995). The general understanding of modern researchers, such as those recently mentioned, is that the idea of race is a social concept. The purpose of ancestry research is to find and understand the ways in which human variation manifests in the skeleton and can contribute to the uniqueness of populations which are concentrated in various geographic regions.

Peopling North America

In order to understand how Asian and Native American populations are unique from each other, we must first discuss their origins. A search for the understanding of how people came to be in the Americas is an ongoing topic of interest in contemporary research and, over time, divergent theories have formed. In the late 1700s, Blumenbach proposed that there were four races of humans, Caucasoids, Mongoloids/Asians, American Indians, and Africans, believing that American Indians originated in Northeastern Asia as Mongoloids, and that the Americas were populated by multiple migrations of the Mongoloid population (Crawford 1998). In 1983, Keightley postulated a slightly different theory, suggesting that, in the Late Paleolithic, there were physically variable, unspecialized Mongoloid populations throughout China and parts of Siberia who later migrated into North America. The split of this initial population represents the divergence of the Native American and Asian populations in modern times (Keightley 1983). Thus, prior research focused on the peopling of the Americas appears to share general consensus that modern Native Americans and Asians originated from an early group of Mongoloids. However, Ossenberg (1994) suggests that the answer is not that simple because it is unknown which specific populations entered the Americas through Beringia. The results of a study conducted by Ossenberg (1994) showed evidence of micro-evolutionary divergence among Native American populations in the United States. This divergence indicates that modern populations may be descended from ancestors of different regions of Asia, specifically Northeastern and Southeastern regions (Ossenberg 1994: 81). Crawford (1998) demonstrates a similar perspective that there were multiple waves of migration which would have contributed to the formation of modern day Native American populations.

Human Variation

In physical anthropology, human variability based on geography has consistently been a focal point of research (Rhine 1990). In the early 1900s, three of the founding fathers of physical anthropology, Aleš Hrdlička, Earnest Hooton, and Franz Boas, focused on how visual traits, such as race, vary across geographic regions. Both Hrdlička and Hooton claimed to use anatomy, physiology, and pathology methods for studying human variation; however, some of their observations continued to rely upon antiquated racially comparative techniques. One of Hrdlička's (1918a-c) main contributions to the field of physical anthropology is the emphasis he placed on increasing the number of populations for study, stating that research was lacking in analyses of people outside of the White population. His intent seemed to be driven by the idea that knowing more about human variation, and the factors that affect it, may help "civilized" societies control future selection to generate more ideal populations, all but referring to eugenics (as discussed in Caspari 2009: 8).

Hooton's research (1918, 1946) is similar in nature, using non-metric skeletal features (many of which are still used in modern forensic anthropology) such as muscle attachment areas of the skull, to identify more "civil" and "primitive" races. He identifies populations with more rugged muscle attachment areas as being more primitive, indicating a rougher diet or lack of successful agriculture (as discussed in Caspari 2009). Hooton posed a theory that "primitive races" were created through the interbreeding of different populations of "pure races" and that pure races still existed (Hooton 1918, 1946). The research of both Hrdlička (1918a-c) and Hooton (1918, 1946) looked at human variation with aims at maintaining a racial and class-based hierarchy.

Boas' work (1891, 1894 a-c) is divergent from this trend and emphasized the importance of understanding variation among common within-population traits as well as their variation across regions and other populations (as discussed in Caspari 2009). His work later incorporated statistical analyses of development and geographic variation and looked at the effects of environmental factors on human variation, all of which are still a large focus in modern anthropology.

Following a similar path to Boas, Berry and Berry (1967) look at genetics to confirm whether physical cranial traits are a product of human genetics and normal development or whether they are culturally affected among populations. Results of their study demonstrated that populations showing different phenotypic expression can be distinguished genetically because discontinuous variation is an average feature of the human skeleton along with inherited physical traits (Berry and Berry 1967).

More recently, three articles were published on the subject of human variation and inherited physical traits: Ousley et al. (2009), Edgar and Hunley (2009) and Hefner (2009). The work of Ousley et al. (2009) was largely focused on testing the hypothesis of physical anthropologist Norman Sauer who posed the idea that American forensic anthropologists can identify people using "racial traits" due to a concordance between an individual's social race and skeletal morphology for White and Black populations. Sauer (1992: 108) believes that race identification by forensic anthropologists is almost separate from the idea that biological races exist. He proposes that the best solution to get away from “racial identification” is by relating forensic anthropological research back to the genetic research on population variation (Sauer 1992: 109). Results of Ousley et al.’s (2009) multivariate analyses support Sauer’s hypothesis and confirm Howells’ (1989) research, thereby affirming significant geographic patterns of human variation. In contrast, Gill (1998: 295) stated that, although some anthropologists may reject the idea of race and focus on genetic research, the forensic anthropologists cannot get away from race in their analyses as long as society continues to conceptualize human variation in terms of race.

Edgar and Hunley’s work (2009) focuses on resolving conflicting opinions on the use of race in the literature. Two of the arguments against race are that: 1) it does not exist because human variation among populations is so similar to human variation within populations, and 2) that there is no geographic isolation between populations, which results in a lack of geographic discontinuities. Edgar and Hunley (2009) agree with some aspects of both arguments and go on to present three ideas to turn focus away from race in biological anthropology. The first is that there is variation among individuals within populations. Second, some biological variation is divided between individuals of different populations. Finally, race is not an efficient or accurate way to describe human biological variation (Edgar and Hunley 2009). Hefner’s (2009) work reflects the last point, and turns away from the concept of race to focus on ancestry. He states that, though group variation exists, the use of an extreme trait expression to define an individual’s ancestry is not reliable (Hefner 2009).

Non-metric Traits

Various cranial traits, such as the presence or absence of landmarks, dental morphology, and cranial sutures, have been used in the past to differentiate between White, Black and Mongoloid populations. Within these traits, there is usually some overlap among population groups, which emphasizes the importance of basing an assessment on as many features as possible. Traits can be passed on genetically or they can arise in a population epigenetically, meaning that they arise from non-genetic influences on gene expression.

Some traits, such as the visibility of the oval window in the middle ear, can be used to distinguish between Mongoloid and White populations (and even those with mixed ancestry, also known as “Admixed” populations). Specifically, the oval window is often visible in White and Admixed populations, though Admixed populations have slightly less visibility, while there is often little to no visibility of the oval window in Mongoloids (Napoli and Birkby 1990). Other traits, such as shovel-shaped incisors, wormian bones, and tented nasal bones have been used to distinguish the combined Native American and Asian populations from both White and Black populations (Haines 1972; Hinkes 1990; Gill 1995; Edgar 2005). In 1995, Gill also found that palate shape is indicative of ancestry. The results of his study demonstrated that a majority of Black individuals had hyperbolic palate shapes, while the Native American and Asian combined population showed more elliptical shaped palates, and White populations were characteristically more parabolic shaped. The maxilla also contains another trait used in separating the three groups: the expression of prognathism, or the protrusion of the upper jaw. White populations demonstrate little prognathism, Black populations have more prognathism, and Mongoloid populations demonstrate an intermediate level of prognathism (Brooks et al 1990; Howells 1995).

The use of Wormian bones as a characteristic in forensic analysis has been debated for many years. Wormian bones are considered a discontinuous morphological characteristic that are highly variable (Bennett 1965). However, despite making this concession, Bennett (1965) makes the argument that Wormian bones may be due to stress placed on the lambdoid suture during late fetal and early post-natal periods of bone growth and that evidence of genetic heritability is lacking. Contrary to this argument is research by Hanihara and Ishida (2001). They describe how groups who practice cranial modification are placing more stress on the cranium, and have a higher incidence of wormian bones; however, they also state that there is a high incidence of wormian bones in specific geographic populations that do not have such practices, populations such as the Napalese, Sikkim and Eskimos. Hanihara and Ishida (2001) also point out that wormian bones are more common in crania with an Inca bone than in those without, and that the prevalence of an Inca bone is similar in each of the previously mentioned populations.

The literature in recent years also shows an increase in research focused on distinguishing Hispanic populations in the United States due to the high number of deaths at the Mexico-United States border (Birkby et al. 2008). The research was pioneered by Rhine in 1990 where he describes the concept of Hispanic populations as having a biological, rather than just social, basis. Some of the traits he thought were indicative of Hispanic populations were slight prognathism, intermediate nasal aperture, tented nasal bones, rounded sloping orbits, and a curved zygomaxillary suture (Rhine 1990; Birkby et al. 2008). Rhine (1990) also differentiated Southwestern Amerindian populations from other Native American and Asian populations by using traits such as the presence of an inion hook, the longus capitis depression, a short basal chord, slight nasion depression, tented nasal bones, retreating zygomatics, and moderate prognathism.

Metric Methods for Ancestry Assessment

Researchers such as Chevraud et al. (1979), Bennett (1993), and Howells (1995) are proponents of non-metric methods of analyzing traits as they require less equipment and can be performed relatively quickly. Others, such as Gilbert and Gill (1990), Fisher and Gill (1990), and Gill (1995) prefer metric analyses. According to Chevraud et al. (1979), both metric and nonmetric analyses are likely to show similar results when determining ancestry because the presence or absence of a cranial non-metric trait is often an expression of size variation in the cranium.

With regard to metric analysis, early research focused on determining the actual measurable differences among populations (Howells 1969). In human crania, slight differences among recent populations are difficult to relate back to a genetic function or cause. Howell's analyses of multiple variables (using a set of discriminant functions) shows where the essential differences in crania reside, a differentiation which he identified, "cannot be reliably achieved by univariate methods" (Howells 1969: 314; Howells 1973: 3-4).

One of the first techniques for ancestry assessment using metric analysis in forensic anthropology was developed by Giles and Elliot (1962). This technique used discriminant functions for eight different cranial measurements to separate White, Black and Native American populations (Giles and Elliot 1962). This method proved to have some flaws, as ancestry classifications were often inaccurate, especially when attempting to identify black males (Fisher and Gill 1990; Ayers et al. 1990). Many of these flaws primarily were caused by errors involved with measurements of the eye orbit, palate, cranial vault, curvature fractions, lower facial protrusion, and upper facial height. These areas were all difficult to measure due to limitations in equipment or because of landmark ambiguity (Heathcote 1981). Then, in the 1990s, the Gill method was developed, which used a simometer, or an instrument specialized for measuring the naso-orbital area, thus improving upon the Giles and Elliot technique (Gilbert and Gill 1990). The Gill method allowed for more accurate results; however, the calculations were sensitive and prone to human error (Ousley and Jantz 2012).

Currently, forensic anthropologists continue to use discriminant function analyses through Fordisc software for ancestry assessment (Ousley and Jantz 2012). Fordisc is a computer program that uses multivariate statistical classification methods, in addition to discriminant function analysis, to estimate stature, sex, and ancestry from cranial and post-cranial measurements (Ousley and Jantz 2012). When used appropriately, Ousley and Jantz (2012) suggest that Fordisc analyses can aid in forensic anthropology casework and decedent identification with relatively low error.

Chapter Summary

In summary, usage of the term Mongoloid to identify both Native Americans and Asians leaves no room for potentially unique genetic traits or epigenetic traits that may have stemmed from geographic variation**.** This grouping is problematic because both populations span entire continents, much like White and Black populations, yet little research has been conducted to identify variation between them. Though previous work using non-metric traits shows an almost indistinguishable amount of similarity between both Asian and Native Americans, more recent research demonstrates the benefit of using a suite of traits rather than relying upon a seemingly characteristic few (Rhine 1990; Hefner 2009). By examining multiple non-metric traits in this research, it may be possible to separate Asian and Native American populations in the current practices of forensic anthropology.

Chapter Three: Materials and Methods

Materials

This study was conducted by analyzing non-metric traits in Native American and Asian crania. Crania were selected from the Physical Anthropology and Archaeology Series Collections, both of which are part of the Research Collections of the Smithsonian Institution National Museum of Natural History. Research was conducted at an off-site facility in Suitland, Maryland, approximately seven miles from the institute, where both collections are currently curated (Figure 1). The collections are composed of remains excavated from known cemeteries, archaeological sites as well as some acquisitions from private collectors. Each cranium was documented and stored by country of origin, region, county, city and, if the information was available for Native Americans, by a specific tribe.

Figure 1. Lab Space Inside the Osteology Collections. Photo taken by Bodoh (2016).

A total of 260 crania were examined with a sample size of 130 for each respective population (Asian and Native American). Almost all of the Asian sample, approximately 97%, is derived from East Asia and is composed of samples from relatively few countries including China, Japan, and Mongolia. The Native American samples came from a variety of regions in the United States, with the majority coming from the Southwest, Midwest and the South. Tables 3-4 list the number of crania per region for both Asian and Native American samples. In order to have sample sizes large enough for statistical analysis, unique populations within each group's broad geographic region were combined.

Table 3. Native American Sample Divided by Region in the U.S.

Region	Number of Crania
Northwest	18
Southwest	27
Midwest	37
South	32
Northeast	6
Southeast	10
Total	130

Table 4. Asian Sample Divided by Regions of Asia

Region	Number of Crania
East Asia	126
South Asia	4
Total	130

The sample sizes were controlled in this study in an effort to achieve demographic consistency between the samples. The Asian sample contained approximately 23 females and 107 males. The Native American sample contained approximately 27 females and 103 males. Age and sex data were estimated for the samples by experts at the museum and were available from curated records. Age ranges were grouped in this study as either mature (30 years and older) or other (29 years and younger, including young adults, adolescents and one child). A majority of both population samples consisted of mature individuals. There were 112 mature individuals in the Native American sample and 18 other individuals. The Asian sample had 124 mature individuals and 6 other individuals.

Methods

Non-metric trait analysis was chosen for this research as it has been utilized in the field of forensic anthropology for many years (Howells 1989; Buikstra and Ubelaker 1994; Reichs 1998, Hanihara and Ishida 2001; Hefner 2009; Ossenberg 2013). According to Berry and Berry (1967), non-metric traits are acceptable for determining ancestry because they are derived through genetic variation and normal developmental processes. The frequency in which those traits are seen in a given ancestral population is known to remain constant as, “nonmetric traits are predominantly under genetic control” (Ossenberg 2003: 40). To ensure that a wide range of traits were accounted for, a list was generated from the methods of previous research on ancestry (Berry and Berry 1967; Cheverud et al. 1979; Hefner 2009; Ossenberg 2013). Twenty-four traits were assessed in this study and are described in Table 5, (see Figures 2-4 for an example of some of the traits; permission to photograph specimens was granted by the Physical Anthropology Collections Manager at the Smithsonian Institution National Museum of Natural History). All traits are reported to be characteristic of both Asian and Native American crania. The data collected were qualitative, and include assessment of shapes, suture courses, the presence or absence of features, and the degree to which the features are expressed (Hefner 2009). An excel spreadsheet was created to record data (see Appendix), and photographs were taken of specimens to show the range of variation for each trait.

Figure 2. Malar Tubercle (Eye) Trait. Red arrow indicates feature. Photo taken by Bodoh (2016).

Figure 3. Shovel-shaped Incisors Trait. Red arrow indicates feature. Photo taken by Bodoh (2016).

Figure 4. Paracondylar Process Trait. Red arrow indicates feature. Photo taken by Bodoh (2016).

Traits from previous research have been used in this study to allow for consistency and to minimize the potential of inter-observer error. To ensure consistency in data collection, standardized images and reference texts were used during the assessment of traits (Berry and Berry 1967; Chevraud et al. 1979; Hauser and De Stefano 1989; Buikstra and Ubelaker 1994; Hefner 2009; Ossenberg 2013; Burns 2015). In addition, five crania were assessed twice for each sample population to evaluate intra-observer error. These crania were randomly selected from those already assessed on the last day of data collection.

Data were analyzed statistically with chi-square and logistic regression methods using Statistical Analysis System (SAS) (Statistical Analysis System Institute 1999). Summary tables were generated to show trait frequencies in each sample population.

Chi-square indicates goodness of fit in the distribution of a sample and was used in this study to determine whether significant differences existed in the frequencies of traits between

Asian and Native American samples. The Chi-square formula (Lancaster and Seneta 1969) consists of the frequency observed (O), the frequency expected (E), and the sum of the parts (∑):

$$x^2 = \sum \frac{(O-E)^2}{E}$$

Probability values (P-values) generated by the chi-square analysis were used to determine the likelihood of obtaining certain outcomes when observing a specific population, sex, or age group. When a P-value was below 0.05, the standard for 95% confidence and accuracy, the trait observed was determined to be significant (in opposition with the null hypothesis), indicating that one specific population was more likely to have the trait than the other population.

The null hypothesis for this research is that there are no distinguishing non-metric cranial traits among Asian and Native American populations which would allow for differentiation between their crania. The alternate is that there are distinguishing non-metric cranial traits in Asian and Native American populations that allow researchers to differentiate between their crania. Additionally, binary categorical traits (those assessed as present or absent) were analyzed using logistic regression to identify traits that may be useful for distinguishing between the two populations.

Table 5. List of Traits and Descriptions Assessed in the Current Study.

Trait	Type	Description
Malar Tubercle (Cheek)	Scored: large or small	A bony projection (tubercle) which points inferiorly on the front facial portion of the zygomatic bone (Based on Hefner 2009).
Malar Tubercle (Eye)	Presence or absence	Also known as Whittman's tubercle, it is a bony projection that sits laterally and superior to where the zygomatic bone and eye border connect (Figure 2) (Based on Hefner 2009).
Angled Zygomatic Suture	Presence or absence	A suture which is inferior to the lower border of the eye (often beginning at the lower border of the eye), marking the juncture of the maxilla and zygomatic bone, angling down toward the inferior portion of the malar (Based on Hefner 2009).
Transverse Zygomatic Suture	Presence or absence	A suture which runs horizontally across the malar bone connecting the zygomatic suture with the temporo-zygomatic suture (Based on Ossenberg 1994).
Infraorbital Suture	Presence or absence	A suture within the eye socket which marks the jointure of maxillary and zygomatic bones. The suture often reaches from the inferior orbital fissure to the zygomatic suture or infraorbital foramen (Based on Hauser and De Stefano 1989).
Nasal Bones	Scored: low and tented, rounded, or steepled	The two bones covering the nasal concha, creating a rounded, tented or pointed (steepled) shape (Based on Hefner 2009).
Alveolar Prognathism	Scored: projecting or not projecting	How far the maxilla projects anterior to the rest of the face (Based on Burns 2015).
Shovel-Shaped Incisors	Presence or absence	A shoveled/bordered appearance of the teeth on the lingual side of the mouth (Figure 3) (Based on Ossenberg 1994).
Elliptic Palate	Presence or absence	The interior/coronal base of the maxilla which can look like a semicircular shaped ellipse (Based on Ossenberg 1994).

Lateral Pterygoid Plate Foramen	Presence or absence	On the basal, inferior portion of the skull, lateral to the palate. It is a foramen on the lateral edge of the pterygoid plate (Based on Ossenberg 1994).
Pterygobasal Bridging	Presence or absence	A bony spur which appears to be bridging the pterygoid plate to the base of the skull (Based on Hauser and De Stefano 1989).
Tympanic Foramen	Presence or absence	Foramen on the margin of the tympanic plate (Based on Berry and Berry 1967).
Tympanic Dehiscence	Presence or absence	Two incomplete closures of the tympanic plate on the inferior/basal side of each tympanic bone (Based on Hauser and De Stefano 1989).
Os Inca Bone	Presence or absence	An additional bone usually larger than a wormian bone which is in the sagittal center of the jointure of the parietal bones and occipital bone (Based on Burns 2015).
Wide Ascending Ramus	Presence or absence	A mandibular ramus wide in proportion to the overall size of the mandible (Based on Hauser and De Stefano 1989).
Complex Cranial Sutures	Presence or absence	Cranial sutures which intricately weave between the bones of the skull (Based on Hauser and De Stefano 1989).
Chin Shape	Scored: blunt, square or retreating	The appearance of the inferior portion of the mandible whether it is rounded/blunt, squared at the bottom or retreating (mandibular teeth sockets are more projected anteriorly from the face than the chin) (Based on Berry and Berry 1967).
Paracondular Process	Presence or absence	A bony projection which is located laterally on either side of the condylar surface at the foramen magnum of the cranium (Figure 3) (Based on Hauser and De Stefano 1989).
Low Nasal Root	Presence or absence	When the very top of the nasal bone sits low in comparison with the eye orbitals (Based on Hauser and De Stefano 1989).
Nasal Overgrowth	Presence or absence	A projecting bony growth which often curves over the anterior portion of the nasal bones (Based on Hefner 2009).

Slight or Absent Nasion Depression	Presence or absence	A lack of a depression/indent where the nasal bones meet the supraorbital margin and frontal bone (Based on Ossenberg 1994).
Straight Transverse Palatine Suture Pattern	Presence or absence	A palatine suture pattern which cuts straight/transversely across the palatine bone (Based on Hauser and De Stefano 1989).
Sagittal Keeling	Presence or absence	A slope along the sagittal suture at the top of the cranium (Based on Ossenberg 1994).
Projecting Lower Eye Border	Presence or absence	When the lower margin of eye orbital which runs along the superior maxilla and zygomatic bone projects future from the face than the superior margin of the eye orbital (Based on Ossenberg 1994).

Chapter Four: Results

Results of frequencies of traits in each population are presented in Tables 6-9. Among the 20 traits identified as present and absent (Table 6), four are found in significantly higher frequencies among Asians (indicated by one asterisk next to the trait): Angled Zygomaxillary Suture, Low Nasal Root, Nasion Depression and Lower Eye Border. Alternatively, four of the traits are found in significantly higher frequencies among Native Americans (indicated by two asterisks next to the trait): Elliptical Palate, Os Inca Bone, Complex Cranial Sutures and Sagittal Keel. For other traits, frequencies of each are presented in Tables 7-9. Of those, nasal bone shape, alveolar prognathism, and chin shape show significant differences between the Asian and Native American samples.

For the present or absent traits, logistic regression was applied to the data using Statistical Analysis System (SAS) software to analyze significance of population, age, and sex for each trait to identify which factors, if any, influenced the likelihood of seeing the trait. Probability values (P-values) were used to determine the likelihood of obtaining certain outcomes when observing a specific population, sex or age group. When a P-value is below 0.05, the standard for 95% confidence and accuracy, the trait observed is in opposition with the null hypothesis, indicating that one specific population is more likely to have the trait than the other population. Scored traits presented in Tables 7-9 were not included in the logistic regression analysis as they were observed for descriptive differences rather than presence or absence. The results of the logistic regression for traits that are significant are presented in Tables 10-11. Standard error was used to determine the accuracy of the results produced by the logistic regression. As long as standard error remains below 2.0, the results maintain credibility.

Intra-observer error was accounted for by selecting a random sample of specimens from the data and reanalyzing them for traits. The sample data were assessed using chi-square analysis. Chi-square analysis showed no significant differences in scores between round one and round two data. Therefore, intra-observer error was not substantial and is not reported in the results.

In this study, three scored traits showed significant differences between populations. The Native American sample had a higher frequency of steepled nasal bones, non-projecting alveolar prognathism, and a square chin shape for the scored traits. The Native American sample also showed a higher frequency of elliptical palate shapes, os inca bones, complex cranial sutures and sagittal keeling. The Asian sample had a higher frequency of rounded shaped nasal bones, projecting alveolar prognathism, and a blunt chin shape. The Asian sample also had a higher frequency of angled zygomaxillary sutures, low nasal roots, little or no nasion depressions, and a projecting lower eye border.

Observation frequencies indicate how often a trait was identified in the sample and how many times it was not. Frequencies can help determine the practicality of attempting to use a trait in everyday practice. Traits that were not significant were not listed with P-values in the results as they were all above 0.05. Traits that were not significant were still listed in the frequency table, in an effort to see if there could be any visible trends regardless of sample size.

As a majority (approximately 90.76%) of the sample consisted of adults, age was never significant in this study. Sex was significant in four traits: angled zygomatic suture ($P = 0.0001$), transverse zygomatic suture trace ($P = 0.0008$), slight or no nasion depression ($P = 0.0078$), and projecting lower eye border ($P = 0.0001$). An angled zygomatic suture was the only trait more likely to be seen in males while, slight or no nasion depression, projecting lower eye border and a transverse zygomatic suture trait were more likely to be seen in females. Standard error remained below the appropriate limit in each outcome.

With regard to testing the intra-population variation, the sample size was not large enough to test for each population in the Native American group. On the other hand, although sample size was large enough in the Asian sample, over 97% came from the same region. Therefore, intra-population variation was not able to be tested in this study.

Asian Traits

Based on the results, the Asian sample is more likely to have an angled zygomaxillary suture, a low nasal root, a slight or absent nasion depression, and a lower eye border which projects from the face more so than the upper eye border. What is unique about these results is that each trait is focused in the mid-to-upper face and are majority located on the irregular bones. Standard error remained below the appropriate limit for each observation and so it is unlikely that this group of traits was statistically selected in error. Population admixture may come into effect in this sample because much of the material was as recent as the 19th century and Asia has long been connected, economically and politically, with neighboring geographic regions. As the traits are located in the face, sexual selection may have influenced the progression of certain traits as cultural standards of beauty can be very influential (HUGO Pan-Asian SNP Consortium 2009).

Scored frequency data differ between the Native American and Asian sample. The Asian sample showed a higher frequency than the Native American sample in rounded shaped nasal bones with a difference of 19.72%, projecting prognathism with a difference of 19.90%, and a blunt chin shape with a difference of 39.80%. Present or absent frequency data appear as expected and do not reveal any new or diverging information from what was found in the Chi-square analysis and logistic regression.

Native American Traits

Results show that the Native American population is more likely to have an elliptic palate shape, an Os Inca bone, complex cranial sutures, and sagittal keeling on the parietal bones. Three out of four of the traits involve the mid-to-posterior region of the cranium, which are all flat bones, with the one exception being the elliptic palate, which is an irregular bone. A possible reason these particular traits may be associated with the Native American sample is population isolation. Some of these traits may be more closely linked with genetics, and may be easily continued in Native American populations because there is less genetic diversity among Native American populations when compared with any other population (Wang et al. 2007). As the Native American sample contained a large quantity of archaeological materials, the populations may have been older and not exposed to as much gene admixture as in modern populations (Torroni et al. 1993). Conversely, the opposite may be true in which the traits are more epigenetically linked to the environment in the United States and cultural stressors which may have affected growth (Hauser and De Stefano 1989). All crania that showed intentional modification were left out of trait analyses that were dependent on vault shape and size in this study, thus eliminating those potentially confounding observations.

Scored frequency data differ in a few areas between the Native American and Asian sample. The Native American sample showed a higher frequency than the Asian sample in steepled nasal bones with a difference of 12.97%, non-projecting prognathism with a difference of 19.90%, and a square chin shape with a difference of 39.80%. Present or absent frequency data appear as expected and do not reveal any new or diverging information from what was found in the Chi-square analysis and logistic regression.

Table 6. Frequencies of Present or Absent Traits

Traits	Asian			Native American		
	Times Observed	Total Observed	Percentage	Times Observed	Total Observed	Percentage
Malar Tubercle (Eye)	73	130	56.15%	83	129	64.34%
Angled Zygomaxillary Suture*	118	121	97.52%	94	120	78.33%
Transverso-zygomatic Suture Trace	15	126	11.90%	29	130	22.31%
Infraorbital Suture	61	128	47.66%	82	127	64.57%
Shovel Shaped Incisors	81	84	96.43%	74	77	96.10%
Elliptic Shaped Palate**	93	118	78.81%	110	122	90.16%
Lateral Pterygoid Plate Foramen	38	91	41.76%	46	121	38.02%
Pterygobasal Bridge	88	130	67.69%	80	129	62.02%
Marginal Foramen of the Tympanic Plate	32	128	25%	44	129	34.11%
Tympanic Dehiscence	29	129	22.48%	32	127	25.20%
Os Inca Bone**	8	120	6.67%	27	124	21.77%
Ascending Ramus Width	85	114	74.56%	92	123	74.80%
Complex Cranial Sutures**	102	123	82.93%	114	121	94.21%
Paracondylar Process	38	128	29.69%	31	115	26.96%
Low Nasal Root*	120	127	94.49%	98	127	77.17%
Nasal Overgrowth	81	112	72.32%	76	113	67.26%
Nasion Depression*	97	128	75.78%	70	127	55.11%
Palatine Suture Pattern	90	115	78.26%	95	122	77.87%
Sagittal Keel**	87	128	67.97%	103	126	81.75%
Border of the Eye*	93	130	71.54%	67	134	50.00%

One Asterisk (*) indicates traits that are significant for the Asian sample. Two Asterisks (**) indicate traits that are significant for the Native American Sample. P-values for significant traits are included in Tables 10-11.

Table 7. Frequencies of Scored Traits: Nasal Bones

Scored Traits	Asian		Native American	
	Times Observed	Percentage	Times Observed	Percentage
Nasal Bones (Low and Tented)	86	68.25%	93	75.00%
Nasal Bones* (Rounded)	35	27.78%	10	8.06%
Nasal Bones** (Steepled)	5	3.97%	21	16.94%
Total Observed	126	100%	124	100%

Table 8. Frequencies of Scored Traits: Alveolar Prognathism

Scored Traits	Asian		Native American	
	Times Observed	Percentage	Times Observed	Percentage
Alveolar Prognathism* (Projecting)	28	25.93%	7	6.03%
Alveolar Prognathism** (Not-Projecting)	80	74.07%	109	93.97%
Total Observed	108	100%	116	100%

Table 9. Frequencies of Scored Traits: Chin Shape

Scored Traits	Asian		Native American	
	Times Observed	Percentage	Times Observed	Percentage
Chin Shape (Blunt)*	84	73.68%	41	33.88%
Chin Shape (Square)**	30	26.32%	80	66.12%
Total Observed	114	100%	121	100%

Tables 7-9. One Asterisk (*) indicates significant traits for the Asian sample. Two Asterisks (**) indicate significant traits for the Native American Sample.

Table 10. Significant Present or Absent Traits for Asian Sample

Significant Traits	Point Estimate	Standard Error	P- Value
Angled Zygomaxillary Suture	1.2643	0.3317	P = 0.0001
Low Nasal Root	0.8667	0.2254	P = 0.0001
Nasion Depression	0.4777	0.1429	P = 0.0008
Lower Eye Border	0.5317	0.1356	P = 0.0001

Table 11. Significant Present or Absent Traits for Native American Sample

Significant Traits	Point Estimate	Standard Error	P- Value
Elliptical Palate	-0.4883	0.1948	P = 0.0122
Os Inca Bone	-0.7166	0.2144	P = 0.0008
Complex Cranial Sutures	-0.5905	0.2306	P = 0.0105
Sagittal Keel	-0.4236	0.1554	P = 0.0064

Chapter Five: Discussion and Future Direction

The purpose of this research was to analyze non-metric features of Native American and Asian crania to determine which traits may be used to differentiate between those two populations. The specification of ancestry is currently a challenge in laboratory analyses as the current forensic anthropological literature replies upon the use of three population groups, one of which combines both Native American and Asian populations. This study demonstrates that, despite their recent evolutionary origin and similar cranial morphology, Native Americans and Asians may be differentiated non-metrically. The implications of this research are that these two populations, Native Americans and Asians, may now be identified separately not just historically and culturally, but skeletally as well. By differentiating these two populations skeletally, there may be more motivation among anthropologists to use different terminology in the literature when referring to ancestry, thereby ensuring the elimination of antiquated perspectives of Asian and Native Americans as “Mongoloid”.

Previous literature places more emphasis on differentiating Black and White unidentified persons as they remain the two largest demographic groups in the United States; however, there is a growing need to identify Indigenous and Asian populations. Current research in forensic anthropology has placed emphasis on addressing the rising number of deaths along the United States-Mexico border in an effort to identify and return individuals to their families (Birkby et al. 2008). Though there is truly a need for more research to assist in those cases, the U.S. and Canada also face high rates of violence against Indigenous populations (Hartney and Vuong 2009; Isler 2015). Reports in the U.S. and Canada demonstrate a disproportionate quantity of murdered and missing Indigenous people when compared with regional demographics (Perry 2004; Isler 2015). Skeletal differentiation is an important focus of current forensic anthropological research as it has the ability to produce more accurate identification standards. As identification standards and practices improve, the quantity of unidentified remains may decrease and more families will see a return of their loved ones.

The purpose of ancestry research is to find and understand the ways in which human variation manifests in the skeleton and can contribute to the uniqueness of populations which are concentrated in various geographic regions. Though often confused as a form of racial identification, ancestry does not rely solely upon an outward appearance. Historically, research by Carlton Coon (1939, 1962) and others like him conflated an understanding of biology and race. Since then, many researchers, such as Berry and Berry (1967), Chevraud et al. (1979), Rhine (1990), Buikstra and Ubelaker (1994), Brace (1995), Birkby et al. (2008), Ossenberg (2013), Hefner (2009), and Burns (2015), have demonstrated that race is a social concept and that ancestry is a question of geographic variation. The current study confirms that ancestry can identify uniqueness between populations that may appear similar, but differ skeletally because of human variation.

Ancestry identification may serve other fields of research in addition to forensic and physical anthropology. Bioarchaeologists utilize physical anthropological techniques to help confirm the presence and relationship of skeletal remains to their surroundings in fieldwork. One way in which the current research may be useful to bioarchaeologists is in the identification of Indigenous prehistoric remains in the United States and Canada. Evolutionarily, Native Americans and Asians share origins within the same region and similar skeletal features. Those who study prehistoric remains may use a similar approach to the methods presented in this research to distinguish between skeletal remains of Native Americans and Asians within separate geographic regions, but that date to similar time periods, to better understand how populations migrated. The work of Ossenberg (1994, 2003) utilized a similar method when looking at shared origins among Native American and Asian prehistoric populations; however, due to the nature of her research, she focused more on shared traits rather than differentiating traits among the two research samples.

Additionally, techniques used in this research may be applied in repatriation methods to allow for deeper analysis of skeletal variation among regional groups of Native Americans. Such an analysis might assist in identifying more specific tribal affiliations associated with the remains.

Limitations

Though there are many benefits to producing a method of differentiating Native American and Asian populations, there is no single trait which can differentiate between them. Hefner (2003) acknowledges that it is important to form a suite of traits for ancestry differentiation. This caution is because of human error: regardless of the distinctiveness of a trait, humans are still prone to interobserver and intraobserver error. These kinds of errors are mitigated by utilizing a standardized scoring system for traits as well as more than one trait. By relying upon a majority of traits which seem to indicate an ancestry identification, there is security in the assessment.

Relying upon some of the scored cranial traits for Native Americans and Asians can cause difficulty in that they can overlap with traits of Black and White populations. Specifically, steepled nasal bones, square chin shape and non-projecting alveolar prognathism are all traits which are considered most likely to occur in a White population and yet they still occur in high frequencies in the Native American sample in this study. Another confounding aspect of this study is that for presence or absence traits and scored traits, the frequency of observations among the Native American and Asian samples are numerically close. Therefore, any future work which seeks to corroborate findings or build on the current study will need to use statistical analysis methods to determine any significant differences between Native American and Asian samples.

Practical Application of the Results

In order for this research to be applicable, it was important for the methods to be easily replicated during casework analyses. Some might argue that subjectivity of observation is a major challenge in decedent ancestral identification with non-metric trait analyses and can discredit an expert witness testimony. There is reduced risk of inter-observer error in casework when standardized traits, images, and references are used to guide the identification process. Standardized collection sheets can also help minimize intraobserver error, keeping the number of traits and how they are recorded for each sample balanced. The traits determined in this study that best differentiate between Native American and Asian crania are easily replicated with the guidance of standardized references.

This study showed that some non-metric traits which are already used in common laboratory practice can help narrow down ancestry identification for these two distinct populations that were once grouped together. One of the best ways of implementing the four traits that were significantly linked to each population would be to create a suite of traits to add into standard lab practices. After determining that an individual qualifies as either Native American or Asian in a primary skeletal analysis, those presence or absence traits which are considered to be most linked to one specific population can be looked at more closely to come to a specific ancestry identification.

Future Direction

In the future it may be beneficial to conduct another study focusing on gaining a larger sample size from each region for Native American and Asian populations to be able to use in another logistic regression and chi-square. Additional analyses could help identify intra-population variations that may or may not be confounding broader perspective identification methods. However, the problem of intra-population variation creating confounding factors in identification may be mitigated by improving methods of broader ancestral identification.

Traits that are significantly linked to a population, either Native American or Asian, should be combined into a suite of traits for practical use in casework (Hefner 2003). This method would improve upon the accuracy of identification for the future because the use of multiple traits will help the observer hone in on a greater likelihood of ancestry specificity. The application is intended so that when two or more traits from the group of traits exist in a cranium, it is relatively accurate to give a positive identification of ancestry for the individual of whom it represents. The use of these traits should be applied in combination with current methods. After assessing that an individual is either Native American or Asian, the observer can look more closely at the presence or absence of the specific traits, which will direct them to a better understanding of whether the individual is Asian or Native American.

Literature Cited

Ayers HG Jantz RL, Moore-Jansen PH. 1990. Giles and Elliot race discriminant functions revisited: a test using recent forensic cases. Skeletal attribution of race methods for forensic anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 65-72.

Bennett KA. 1965. The etiology and genetics of wormian bones. Am J Phys Anthropol 23: 255 -260.

Bennett KA. 1993. A field guide for human skeletal identification. Springfield, IL: C.C. Thomas.

Berry CA, Berry RJ. 1967. Epigenetic variation in the human cranium. J Anat 101: 361.

Birkby WH, Fenton TW, Anderson BE. 2008. Identifying Southwest Hispanics using nonmetric traits and the cultural profile. J Forensic Sci 53: 29–33.

Blumenbach JF.1828. The elements of physiology. Longman, Rees, Orme, Brown, and Green.

Boas F. 1891. Physical characteristics of the Indians of the North Pacific coast. Am Anthropol 4: 25–32

Boas F. 1894a. Human faculty as determined by race. Proc Am Assoc Adv Sci 43: 301–327.

Boas F. 1894b. The half-blood Indian, an anthropometric study. Pop Sci Mon 45: 761–769.

Brace CL.1995. Region does not mean “race”—reality versus convention in forensic anthropology. J Forensic Sci 40: 171-175.

Brooks S, Brooks RH, France D. 1990. Alveolar prognathism contour, an aspect of racial identification. Skeletal attribution of race methods for forensic anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 41-46.

Buikstra JE, Ubelaker DH. 1994. Standards for data collection from human skeletal Remains. Fayetteville: Arkansas Archeological Survey Research Series 44.

Burns KR. 2015. Forensic anthropology training manual. Routledge.

Caspari R. 2009. 1918: Three perspectives on race and human variation. Am J Phys Anthropol 139: 5-15.

Cheverud JM, Buikstra JE, Twichell E. 1979. Relationships between non-metric skeletal traits and cranial size and shape. Am J Phys Anthropol 50: 191-198.

Coon CS. 1962. The origin of races. New York: Knopf.

Coon CS. 1939. The races of Europe. Macmillan.

Crawford MH. 1998. The origins of Native Americans: evidence from anthropological genetics. Cambridge University Press.

Edgar HJH. 2005. Prediction of race using characteristics of dental morphology. J Forensic Sci 50: 269-273.

Edgar HJH, Hunley KL. 2009. Race reconciled?: How biological anthropologists view human variation. Am J Phys Anthropol 139: 1-4.

Fisher TD, Gill GW. 1990. Application of the Giles-Elliot discriminant function formulae to a cranial sample of northwestern plains indians. Skeletal attribution of race methods for forensic anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 4: 59 63.

Gilbert R, Gill GW. 1990. Metric technique for identifying American Indian femora. In Skeletal attribution of race. methods for forensic anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 97-99.

Giles E, Elliot O. 1962. Race identification from cranial measurements. J Forensic Sci 7: 147 157.

Gill GW. 1995. Challenge on the frontier: discerning American Indians from Whites osteologically. J Forensic Sci 40: 783-788.

Gill GW. 1998. Craniofacial criteria in the skeletal attribution of race. Forensic osteology: Advances in the identification of human remains. C.C. Thomas Springfield, IL;293-317.

Greenfeld LA, Smith SK. 1999. American Indians and Crime. Office of Justice Programs. National Institute of Justice. Washington, DC: Government Printing Office 1-51.

Haines DH. 1972. Racial characteristics in forensic dentistry. Medicine, Science and the Law 12: 131-138.

Hanihara T, Ishida H. 2001. Os incae: variation in frequency in major human population groups. J Anat 198: 137-152.

Hartney C, Vuong L. 2009. Created equal: Racial and ethnic disparities in the US criminal justice system. National Council on Crime and Delinquency.

Hauser G, De Stefano GF. 1989. Epigenetic variants of the human skull. Schweizerbart Science Publishers, Stuttgart, Germany: 1-288.

Heathcote GM. 1981. The magnitude and consequences of measurement error in human craniometry. Canadian Rev Phys Anthropol 3: 18-40.

Hefner JT. 2003. Assessing nonmetric cranial traits currently used in forensic determination of Ancestry 1-73.

Hefner JT. 2009. Cranial nonmetric variation and estimating ancestry. J Forensic Sci 54: 985-995.

Hinkes MJ. 1990. Shovel-shaped incisors in human identification. Skeletal Attribution of Race Methods for Forensic Anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 21-26.

Hooton EA. 1918. On certain Eskimoid characters in Icelandic skulls. Am J Phys Anthropol 1: 53–76.

Hooton EA. 1946. Up from the Ape. NY: The Macmillan Company.

Howells WW. 1969. The use of multivariate techniques in the study of skeletal populations. Am J Phys Anthropol 31: 311-314.

Howells, WW. 1973. Cranial variation in man. A study by multivariate analysis of patterns of difference. Among recent human populations. Papers of the Peabody Museum of Archaeology and Ethnology 67: 1-259.

Howells WW. 1980. Homo erectus—who, when and where: a survey. Am J Phys Anthropol 23: 1-23.

Howells WW. 1989. Skull shapes and the map: craniometric analyses in the dispersion of modern Homo. Peabody Museum of Archaeology, Cambridge, MA; 79: 1-187.

Howells WW. 1995. Who's Who in Skulls, Ethnic Identification of Crania from Measurements. Peabody Museum of Archaeology, Cambridge, MA; 82: 1-108.

Hrdlička A. 1918a. Physical anthropology: its scope and aims; its history and present status in America. A. Physical anthropology, its scope and aims; Am J Phys Anthropol 1: 3–23.

Hrdlička A. 1918b. Physical anthropology: its scope and aims; its history and present status in America. B. History. Am J Phys Anthropol 1: 133–182.

Hrdlička A. 1918c. Physical anthropology: its scope and aims; its history and present status in America. C. Recent history and present status of the science in North America. Am J Phys Anthropol 1: 267–304;377–414.

HUGO Pan-Asian SNP Consortium. 2009. Mapping human genetic diversity in Asia. Science 326: 1541-1545.

Isler, Shane. 2015. La plus ça change, la plus ça reste la même: An analysis of violence and conflict in Indigenous-Canadian government relations, and missing and murdered Indigenous women. Lund University Faculty of Social Sciences Masters Thesis: 1-72. Retrieved From http://lup.lub.lu.se/student-papers/record/5469183. Accessed March 20th, 2017.

Keightley DN. 1983. The origins of Chinese civilization. University of California Press, Berkeley, CA.

Lancaster HO, Seneta E. 1969. Chi-Square Distribution. John Wiley and Sons, Ltd.

Napoli ML, Birkby WH.1990. Racial differences in the visibility of the oval window in the middle ear. Skeletal Attribution of Race Methods for Forensic Anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 27-32.

Native American Graves Protection and Repatriation Act, 25 U.S.C. ch. 32 § 3001 et seq.

Ossenberg NS. 2013. Brief communication: Cranial nonmetric trait database on the internet. Am J Phys Anthropol 152: 551-553.

Ossenberg NS. 2003. Ethnogenesis in the central and eastern Arctic: A reconstruction based on cranial nonmetric traits. The Dorset Culture 75: 33-56.

Ossenberg NS. 1994. Origins and affinities of the native peoples of northwestern North America: the evidence of cranial nonmetric traits. Methods and theory for investigating the peopling of the Americas. Center for the Study of the First Americans, Corvallis, Oregon; 79-115.

Ousley SD, Jantz RL. 2012. Fordisc 3 and statistical methods for estimating sex and ancestry. A Companion to Forensic Anthropology: 311-329.

Ousley SD, Jantz RL, Freid D. 2009. Understanding race and human variation: why forensic anthropologists are good at identifying race. Am J Phys Anthropol 139: 68-76.

Perry S. 2004. American Indians and Crime. National Institute of Justice. Washington, DC: Government Printing Office 1-56.

Reichs KJ. 1998. Forensic osteology: advances in the identification of human remains. C.C. Thomas, Springfield, IL: 1-360.

Riesenfeld A.1956. Multiple infraobaital, ethmoidal, and mental foramina in the races of man. Am J Phys Anthropol 14: 85-100.

Rhine, Stanley. 1990. Non-metric skull racing. In: skeletal attribution of race methods for forensic anthropology. Maxwell Museum of Anthropology, Albuquerque, NM; 9-20.

Sauer NJ. 1992. Forensic anthropology and the concept of race: If races don't exist, why are forensic anthropologists so good at identifying them?. Social Science and Medicine 34: 107-111.

Statistical Analysis System Institute. 1999. SAS/STAT user's guide, version 8. Vol. 2. SAS Institute.

Statistics Canada. 2013. National Household Survey Profile 2011. Retrieved from http://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/prof/index.cfm?Lang=E. Accessed March 20th, 2017.

The Federal Bureau of Investigation (2014). *NCIC Missing Person and Unidentified Person Statistics for 2014.* Retrieved from https://archives.fbi.gov/archives/about-us/cjis/ncic/ncic missing-person-and-unidentified-person-statistics-for-2014#two

Torroni A, Schurr TG, Cabell MF, Brown MD, Neel JV, Larsen M, Smith DG, Vullo CM, Wallace DC. 1993. Asian affinities and continental radiation of the four founding Native American mtDNAs. Am J Hum Genet 53: 1-563.

U.S. Census Bureau. 2012. *The Asian population: 2010*. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-11.pdf. Accessed October 15th, 2016.

U.S. Census Bureau. 2012. *The American Indian and Alaska Native Population: 2010*. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-10.pdf. Accessed October 15th, 2016.

U.S. Census Bureau. 2011. *The White Population: 2010*. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-05.pdf. Accessed October 15th, 2016.

U.S. Census Bureau. 2011. *The Black Population: 2010*. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-06.pdf. Accessed October 15th, 2016.

Wang S, Lewis Jr. CM, Jakobsson M, Ramachandran S, Ray N, Bedoya G, Rojas W. 2007. Genetic variation and population structure in Native Americans. PLoS Genet 11: 1-185.

Appendix: Data Collection Sheets

Malar Tubercle (Cheek)	Malar Tubercle (Eye)	Angled Zygomatic Suture	Transverse Zygomatic Suture	Infraorbital Suture	Nasal Bones	Alveolar Prognathism	Shovel-shaped Incisors	Elliptic Palate

Table I: Data collection sheet page 1.

Lateral Pterygoid Plate Foramen	Pterygobasal Bridging	Tympanic Foramen	Tympanic Dehiscence	Os Inca Bone	Wide Ascending Ramus	Complex Cranial Sutures	Chin Shape	Paracondylar process

Table II: Data collection sheet page 2.

Low Nasal Root	Nasal Overgrowth	Slight or Absent Nasion Depression	Straight Transverse Palatine Suture Pattern	Sagittal Keeling	Projecting Lower Eye Border

Table III: Data collection sheet page 3.

Vita

In 2015, after graduating cum laude with a Bachelor of Arts degree in Anthropology from Beloit College, Dominique Bodoh became a Masters of Arts graduate student in the Department of Geography and Anthropology at Louisiana State University Baton Rouge. Descending from the Menominee Tribe in Keshena, Wisconsin, Dominique's main research interests stay close to home, focusing on Native populations, and ancestry as they apply to forensic anthropological studies. Dominique is currently applying for Research Assistantships and preparing Ph.D. program applications in bioarchaeology for the fall of 2018.