USING FLUCTUATING ASYMMETRY TO UNDERSTAND THE BIOLOGICAL IMPLICATIONS OF SOCIAL RACE

by

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DEDICATION

To my family.

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I. INTRODUCTION

Race studies in biological anthropology have drifted through unsettling territories since its emergence as a discipline. After much contention, anthropologists came to understand race as a socially defined construct rather than a biological one (Gravlee, 2009). Although a social construct, race can harbor biological implications regarding health, class, and wealth disparities (Gravlee, 2009).

Beginning with enslavement, African Americans have continually experienced discrimination in all aspects of their lives. Other racial groups, like Hispanic populations, have been consistently overlooked in civil rights history, although they too were subjected to Jim Crow laws and educational barriers. This discrimination against people of color (POC) continues today and exhibits itself many forms, including financial and institutionalized racism. For example, the great recession (2007-2009) produced an exponential decrease in wealth, investments, and jobs ("The Great Recession," n.d.). Throughout this period, the net worth of African American and Hispanic families continued to decrease, while American White families' net worth remained virtually unchanged (Dettling et al., 2017). Divisions like this helped to sustain the continued historic wealth gap to present (McKernan et al., 2017). Based on historical and continued discrimination, environmental and developmental stress is likely to exhibit itself adversely in the skeletal remains of POC.

Developmental stress refers to the negative impacts of socioeconomic status (SES), disease, poor nutrition, and other adverse indicators, which affect the skeletal growth of an individual (Weisensee & Spradley, 2018). Developmental stress can be observed through many growth disruptions, one being the physical manifestation of fluctuating asymmetry (FA). FA occurs when bilateral structures of the body are altered by developmental stress or instability during growth and development, creating small, random changes in an individual's form and manifesting as asymmetry of the right and left sides (Palmer, 1994; Tomkins & Kotiaho, 2001; Weisensee & Spradley, 2018). Further, it is defined by the mean and variance of right and left differences, where the distribution of these differences is averaged around zero (Palmer & Strobeck, 1986).

In FA research, craniofacial asymmetry has been used to understand the indicators of developmental stress in lower SES individuals, showing that lower SES groups have higher craniofacial asymmetry (Bigoni et al., 2013; Hope et al., 2013; Weisensee & Spradley, 2018). Previous research regarding FA has focused on many types of events, including SES in regards to developmental stress (Bigoni et al., 2013; Hope et al., 2013; Özener & Fink, 2010; Özener, 2010; Weisensee & Spradley, 2018) not, however, on the social race categories that can provide insight into the differences of developmental stress. Therefore, this research will examine fluctuating asymmetry of the craniofacial skeleton using three-dimensional craniometric landmarks to assess if differences in developmental stress appear between social race groups.

Literature Review

FA has been a catalyst to understanding the ways in which environmental and developmental stress influence the biological form in animals (Fey et al., 2020; Frota, Cabrini, & Cardoso, 2019; Koeberle, Arismendi, Crittenden, Leer, & Noakes, 2020; Kontas, Bostanci, Yedier, Kurucu, & Polat, 2018; Plăiaşu & Băncilă, 2018; Raisa, Anatoliy, Timur, & Natalia, 2019; Rivera & Neely, 2020; Zhelev, Tsonev, & Angelov, 2019), insects (Nattero, Piccinali, Gaspe, & Gürtler, 2019; Pears, Ferguson, Boisvert, &

Bateman, 2019; Plăiaşu & Băncilă, 2018; Raisa, Anatoliy, Timur, & Natalia, 2019), humans (Barrett, Guatelli-Steinberg, & Sciulli, 2012; Bigoni et al., 2013; Ginot, Agret, & Claude, 2018; Graham & Özener, 2016; Kočnar, Saribay, & Kleisner, 2019; Özener & Fink, 2010; Özener, 2010; Pears et al., 2019; Sajid et al., 2018; Shackelford & Larsen, 1997; Švegar, 2016; Thornhill, Gangestad, & Comer, 1995; Weisensee, 2013; Zurawiecka, Marchewka, & Wronka, 2019), plants (Kashparova et al. 2020) and even the structure of the brain (Moodie et al., 2020). These studies have focused on the way in which specific stressors from the environment create random deviations from perfect symmetry in the biological structures of an organism. In addition to changes in the form of structures, FA has been used as an indicator of early stress and a predictor of fitness level, also referred to as biomarkers (Plăiaşu & Băncilă, 2018). By comparing stressors across species and plants, these stressors which cause FA can be better understood in human populations.

FA in Animals and Insects

Extensive research has been conducted on the effects of stress in animals and insects (Fey et al., 2020; Koeberle et al., 2020; Kontas et al., 2018; Nattero et al., 2019, 2019, 2019; Pears et al., 2019; Plăiaşu & Băncilă, 2018; Raisa et al., 2019; Rivera & Neely, 2020), and a variety of stressors have been tested for their relation to FA. For example, Fey et al. (2020) found that FA in the size and shape of the inner ear organ in rainbow trout (*Oncorhynchus mykiss*), can be induced in fish living within a few meters of electromagnetic fields. Other stressors, like environmental pollution from waste water, can cause asymmetry in some animals (Zhelev et al., 2019). In addition, FA research has been used as a proxy for implementing cave management and conservation in insect species (Plăiaşu & Băncilă, 2018).

Further research has studied the size and proportions of the limbs in animals and insects (Pears et al., 2019; Rivera & Neely, 2020). In locomotion, symmetry is important for coordination of the limbs during movement (Reeves, Auerbach, & Sylvester, 2016). However, growth trajectories of the forelimbs and hindlimbs differ in limbs which are affected by FA (Reeves et al., 2016; Rivera & Neely, 2020). Still there are indications that limbs influenced by FA have no effect on the movement of some insects (Pears et al., 2019). Although a wealth of evidence supports the idea that stress influences FA, research showing the opposite can be important when studying the craniofacial skeleton specifically, as some studies found no relationship between stress and FA (Quinto-Sánchez et al., 2017).

FA in Humans

Research in FA has not only focused on the growth of non-human animals and insects. FA studies in living human populations have been researched extensively by examining the shape of the face and proportions of the limbs (Bigoni et al., 2013; Gawlikowska et al., 2007; Ginot et al., 2018; Graham & Özener, 2016; Hope et al., 2013; Kim, Lee, Lee, & Baik, 2013; Klingenberg, Barluenga, & Meyer, 2002; Kočnar et al., 2019; Mopin, Chaumoître, Signoli, & Adalian, 2018). It has also been noted that FA in human populations can be species and sex specific, with higher FA occurring in males (Raisa et al., 2019; Weisensee, 2013). Females, unlike males, are less susceptible to environmental stressors, which might play a role in how their bodies incorporate stress, manifesting as less FA in their faces (Özener & Fink, 2010). However, the possibility that females have higher FA should not be ruled out (Bigoni et al., 2013).

In addition, dental FA has been the focus of studies in living humans, observed through the measurement of the maxilla and mandible (Barrett et al., 2012; Guatelli-Steinberg, Sciulli, & Edgar, 2006; Jeong, Woo, & Pak, 2013; Sprowls, Ward, Jamison, & Hartsfield, 2008). Further research on dental FA using the dentition of our hominid ancestors provides results which have implications in human evolution as well (Barrett et al., 2012). While some research in FA has focused on the human dentition, still, other researchers have found that FA does not influence the symmetry of the teeth (Angelopoulou, Vlachou, & Halazonetis, 2009). For example, in two Greek populations born before and after Chernobyl, one of which experienced high levels of radiation exposure, the authors found that there was no manifestation of FA in the dentition (Angelopoulou et al., 2009).

Confirmation Bias in FA

As shown, there are a variety of stressors that can influence the occurrence of FA in non-human animals, insects, and humans alike. Such stressors, such as proximity to polluted areas (Zhelev et al., 2019), SES (Özener & Fink, 2010; Weisensee & Spradley, 2018), disease or cause of death (Weisensee, 2013), and insecticides (Nattero et al., 2019), might potentially influence the occurrence of FA in a species. Although an abundant amount of research has concluded that FA is influenced by stressful experiences, scientists should be weary of seeking out examples which fit the hypotheses their research aims to confirm. This is described as confirmation bias, and it occurs when a researcher pursues evidence that affirms their research questions (Kozlov & Zvereva, 2015). As such, it is important to be mindful of this bias when conducting research regarding FA. For the current research, homologous landmarks for the crania were selected as the method for assessing FA in skeletal populations, as these landmarks are standard across all human crania. This was done to decrease confirmation bias within the current study.

Race and Disease

The idea of social race is an important variable to understand within the context of this research. Social race is a construct that is defined by the cultural experiences of an individual or group, and it has no basis in biology or genetics (Obach, 1999). As such, it cannot be determined using one's genetic ancestry (American Anthropological Association, n.d.). However, region of origin and genetic ancestry can be determined using an individual's DNA (American Anthropological Association, n.d.). Genetic ancestry *does* have basis in biology and uses an individual's DNA genotype. Meanwhile, region of origin is where an individual's life began. The difference between region of origin, genetic ancestry, and social race, is that social race is a flexible idea that is used *by* the individual to demonstrate to the outside world how a person sees themselves, and it has no genetic component in terms of DNA. The ways in which individuals experience their social race can have implications to how they are perceived or treated in their communities, including the opportunities someone receives (Haney-Lopez, 1994). Additionally, the way a person experiences their social race can have biological implications to their overall health (Dressler, Oths, & Gravlee, 2005; Gravlee, 2009). A person's social race can influence health treatment and disease types (Gravlee, 2009). Regardless, research often shows inconsistencies in defining social race and its categories.

While FA has proven useful in understanding the stress that forms undergo, the effects of FA have not been utilized to understand differences in individuals of varying social races. Although biological race does not exist, social race is experienced by the individual and perceived by groups. In addition, the ways in which individuals experience daily life can differ depending on how they perceive their social race. Although FA research concludes that SES might play a role in the stress of individuals (Bigoni et al., 2013; Hope et al., 2013; Özener & Fink, 2010; Švegar, 2016; Weisensee & Spradley, 2018), controlling for SES regardless of FA still does not explain racial disparities in health (Dressler et al., 2005).

Kuzawa and Sweet (2009) examined the literature for evidence of the biological implications of one's social race among African Americans. The authors found that the literature provides strong evidence for "…social origin to prematurity and low birth weight in African Americans, reflecting pathways such as the effects of discrimination on maternal stress physiology" (Kuzawa & Sweet, 2009, pg. 1). In turn, the authors turn to epigenetics as a way of understanding these disease disparities. Although disease plays a role in the health of individuals, it seems as though a person's perceived life experiences may influence their health as well.

Biffl et al. (2001) found that young Latina women suffered more combative types of breast cancer when compared to other young women, providing further evidence that social race affects health. In order to understand health disparities among social race groups, two theoretical models proposed by Dressler et al. (2005) might explain these discrepancies. The first model, termed the psychosocial stress model, highlights the stress of being associated with a particular minority group and the consequences of racism and discrimination (Dressler et al., 2005). The second, the structural-constructivist model, is emphasized by the union of racial social structures and cultural constructions to explain health differences in groups of people (Dressler et al., 2005). The authors state that both models should be applied in research regarding health disparities by race. This further binds the idea that health among social race groups differs based on a person's life history.

Still, much research in regards to health and disease across social race groups is used descriptively to illustrate population differences. Gravlee (2009) states that when race is used by anthropologists to describe health, it is merely used as a descriptor of health discrepancies. Regardless, some research persists in mentioning that epigenetic factors and societal racism can impact the health of social race groups (Kuzawa & Sweet, 2009). These inequalities in health will be kept in mind when understanding stress and its influence on FA within and between social race groups.

Predicted Outcomes, Purpose, and Research Questions

This research will utilize demographic characteristics, in the form of sex, age, SES, cause of death, and occupation for individuals within American Black, American Hispanic, and American White social race groups. Variables selected for this analysis were chosen because specific outcomes were predicted regarding FA in the three race groups. In addition, it was hypothesized that POC would have higher FA scores than the American White sample overall. This assumption was based off previous research and reviews which indicate that the differential treatment of marginalized groups can be embodied as stress and therefore reflect in their health (Dressler et al., 2005; Gravlee, 2009). For example, American Black women have the highest maternal deaths and lowest birth weight infants when compared to other social race groups (Martin, Hamilton, Osterman, Driscoll, & Drake, 2018), indicating discrepancies in stress across races in the United States. Because of the increased stress that POC experience, it was hypothesized that POC would have higher FA scores than White individuals.

Sex was used to compare males and females across the social race groups, as previous research has indicated that males have higher FA than females (Özener & Fink, 2010; Weisensee, 2013; Weisensee & Spradley, 2018). Therefore, when comparing sex across American Hispanics, American Blacks, and American Whites, it was expected that males within each group would have higher FA scores. This was predicted based on the idea that females are more capable of handling stress than their male counterparts, termed the female buffering hypothesis (Frayer & Wolpoff, 1985).

Age was used to compare cohorts across the three social race groups. More specifically, it was predicted that all of the age cohorts for American Blacks, followed by American Hispanics, would have higher FA than all of the American White individuals in each respective age group. This discrepancy in FA by age group is assumed because FA manifests during growth and development, specifically when an individual undergoes stressful events (Hope et al., 2013; Weisensee & Spradley, 2018). Because POC's life events are more stressful than their American White counterparts (Gravlee, 2009), it is assumed that their craniofacial complex will harbor higher FA scores across all age groups.

In addition to the age and sex variables, SES was analyzed as a possible influence of stress on FA. Previous research has indicated that lower SES plays an important role in the embodiment of higher FA in groups of people (Hope et al., 2013; Özener & Fink, 2010). Therefore, the current research predicted that lower SES groups in the American

Black and American Hispanic samples would have higher FA than American White individuals in their respective SES categories. In addition, it was hypothesized that American White individuals would have lower overall FA scores in each of the SES categories when compared to POC within the research sample.

Cause of death was selected from the demographic variables to further assess differences in FA scores across the three groups. Previous research by Weisensee (2013) found that the relationship between cause of death and FA in a historical skeletal sample was an appropriate test of the Developmental Origins of Health and Disease (DOHaD) hypothesis. This hypothesis argues that instability in early development via stress can have lasting effects on individuals in adulthood (Barker, Osmond, Kajantie, & Eriksson, 2009). As such, this research predicted that POC would exhibit higher levels of FA when compared to American White individuals across all types of cause of death. As such, it was also assumed that POC would exhibit the life-long effects of stress, in the form of FA, as interpreted by the DOHaD hypothesis.

Lastly, each individual's occupation, divided into manual or sedentary labor, was utilized in this research to predict FA across groups. Özener (2010) found that males who worked in labor intensive jobs had higher facial FA. Therefore, this research predicted that individuals who worked in manual labor positions would have higher FA scores than those who worked in sedentary ones. Due to this it was hypothesized that manual labor POC would have higher FA scores than American White individuals whose occupation was classified as manual labor.

The purpose of this research is to assess if developmental stress, in the form of demographic characteristics, manifests differently in the human craniofacial skeleton between American Black, American Hispanic, and American White social race groups. First, is FA evident at higher rates in the skeletal remains of POC? Second, what factors, including sex, age at death, SES, cause of death, and occupation, are significantly different between groups? Additionally, this research aims to understand, why differences, if any, in the craniofacial FA between groups might occur.

The objective of this research is to utilize three-dimensional craniometric landmark data and geometric morphometric analyses to calculate FA scores in the crania of three documented social race groups to investigate differences in scores. If groups representing POC have higher FA scores, one prospect that can be further investigated are the inequalities among social race groups, which might form as consequences to environmental stress.

II. MATERIALS AND METHODS

Because this research was conducted on deceased human remains, Institutional Review Board (IRB) approval was not necessary. Three social race groups, American Blacks, American Hispanics, and American Whites, with a total of 163 crania, were used to investigate craniofacial fluctuating asymmetry as it relates to developmental stress. The sample size for each social race group can be seen in Table 1.

Table 1. Sample size for American Black, American Hispanic, and American White individuals.

Social Race	Total
American Black	70
American Hispanic	27
American White	66
Grand Total	**163**

The Texas State University Donated Skeletal Collection

The Forensic Anthropology Center at Texas State (FACTS) houses the Texas State Donated Skeletal Collection (TXST-DSC), which, as of 2016, is comprised of 282 donors (Mavroudas, 2016). Individuals who donate themselves or their next of kin to the TXST-DSC provide detailed demographic information, including life history, photographs, SES, occupation, and more. All the individuals donated to the FACTS are from living donors or next of kin, as the institution does not obtain unclaimed remains. Although the vast majority of donors are from Texas, the TXST-DSC contains remains from all over the United States. Individuals within the TXST-DSC have an average age of 65 years, ranging from 26 weeks in-utero to 102 years of age at death (Mavroudas, 2016). Like most other skeletal collections in the United States, FACTS' TXST-DSC contains mostly male and American White individuals, with American Blacks and Hispanics comprising less than 5% of all donations. In addition, most of the individuals who donate to the TXST-DSC are from lower or middle SES groups, with a very small portion of the donors being upper SES.

The William M. Bass Donated Skeletal Collection and the Forensic Data Bank

The William M. Bass Donated Skeletal Collection (WMB-DSC) is an established skeletal collection at the University of Tennessee, Knoxville (UTK) within the Department of Anthropology. The WMB-DSC encompasses over 1800 individuals with birth years from 1892 to 2016, however, most of the donors have birth years after 1940 (The University of Tennessee, 2020c). Prior to 1994, the vast majority of donations to the University of Tennessee were from medical examiner's offices, with donation by the donor or their next of kin slowly increasing in number after this time (Christensen, 2006). From 2006 onward, donation by family or self-donation to the WMB-DSC began increasing drastically (Christensen, 2006). Still, the majority of donations to the WMB-DSC are from next of kin, after cases released by medical examiner's offices (Christensen, 2006). Most of the individuals within the WMB-DSC average around sixty-seven years of age at death, are majority male (64%), and American White (93%; The University of Tennessee, 2020a). Like the TXST-DSC, many individuals within the WMB-DSC are from lower SES groups (Christensen, 2006).

The Forensic Data Bank (FDB) is maintained by the University of Tennessee, Knoxville and makes up a portion of the WMB-DSC. The FDB began in 1986 with a grant provided by the National Institute of Justice and contains information for almost 3,400 individuals from positively identified forensic cases or other skeletal collections around the United States (The University of Tennessee, 2020b). The FDB contains information from forensic cases with information regarding medical history, stature, weight, occupation, and place of birth (The University of Tennessee, 2020b). In addition, most of the skeletons in the collection are of known ancestry and sex. Craniometric data pertaining to individuals from the FDB were also incorporated as part of the sample from the University of Tennessee.

The Maxwell Museum

The Maxwell Museum at the University of New Mexico (UNM) houses the Laboratory of Human Osteology and the Documented Skeletal Collection, which was established in 1984. As of 2018, there are a total of 308 individuals within the collection, made up of both males and females (Maxwell Museum of Anthropology, 2020). Comprised of mostly American White, American Black, and Hispanic groups, the Maxwell Museum's documented skeletal collection is attained via individuals before death or through their next of kin (Maxwell Museum of Anthropology, 2020). Like the TXST-DSC, WMB-DSC, and the FDB, basic demographic information is available for these donors, including their sex, social race, cause of death, age, and SES (Maxwell Museum of Anthropology, 2020). In addition, information for the occupation of the donors has been provided since 1995, allowing researchers to further understand how occupation influences disease (Maxwell Museum of Anthropology, 2020).

Samples and Methods

The American White sample consisted of self-identified American White males and females from the TXST-DSC, the WMB-DSC, the FDB, and the University of New Mexico's Maxwell Museum (N=66). Data from American Black males and females was obtained from the TXST-DSC, the WMB-DSC, the FDB, and the University of New Mexico's Maxwell Museum (N=70). The American born Hispanic sample, also comprised of males and females, was collected from the TXST-DSC, the WMB-DSC, the FDB, and the University of New Mexico's Maxwell Museum (N=27). Information regarding the sex and social race of each individual within the sample and their respective skeletal collections be seen in the appendix. Birth years for the samples range from the early to middle 20th century. In addition, the samples represent a modern population of individuals from the United States, who identified their social race before death, or whose social race was identified by their next of kin or a medical examiner's office. Although it is more important that the donors themselves identified their social race before death, those whose race was identified after death were still used in this analysis to maintain sample sizes. The total number of males and females within the sample can be seen in Table 2.

Demographic data was provided by the donor before death or their next of kin after death for most of the samples. However, some of the demographic data was not represented for all the individuals. Still, basic information, like age, sex, and social race are available for most of the individuals within the sample. When available, this demographic data was used in the analysis to assess shape changes in the craniofacial skeleton.

Table 2. Sample size for males and females.

Social Race	Sex	Total
American Hispanic	Male	19
	Female	7
Total		**26**
American Black	Male	56
	Female	14
Total		**70**
American White	Male	36
	Female	31
Total		**67**
All Social Races	Male	111
	Female	52
Grand Total	**All Sexes**	**163**

When the demographic information was available, data regarding occupation, SES, cause of death, sex, and age at death were utilized during the analysis to determine if differences in FA exist between the samples. These variables were then used to compare to FA scores across the groups. In cases where only basic information, such as social race, age, and sex were available for the analysis, the missing information was listed as unknown.

For the American Black, American White, and American Hispanic samples, males and females at varying ages at death were compared across groups. Because the samples encompassed age ranges from twenty-three to ninety-nine, age groups were divided into four cohorts. The four age groups included 20-39, 40-59, 60-79, and 80-99 years old (Table 3).

Table 3. Sample size by age group.

Social Race	Age Group	Total
American Hispanic	20-39	5
	40-59	7
	60-79	7
	80-99	6
Total		**25**
American Black	20-39	9
	40-59	33
	60-79	22
	80-99	6
Total		**70**
American White	20-39	6
	40-59	16
	60-79	33
	80-99	12
Total		**67**
All Social Races	20-39	20
	40-59	56
	60-79	62
	80-99	24
Grand Total	**All Age Groups**	**162**

Individuals were divided into low, middle, and upper SES groups based on the information provided by the donor or their next of kin (Table 4). The SES group divisions were based on the information provided from Texas State University and the University of Tennessee's donation forms, where the individual or their next of kin selected a childhood SES option. These options included lower, lower middle, middle, upper middle, and upper. In order to maintain sample sizes, SES groups were collapsed from the original five options to include three for lower, middle, and upper SES. There were too few individuals part of the upper SES group, providing a smaller sample size for this aspect of the analysis. Individuals from the Maxwell Museum of Anthropology at the University of New Mexico were not used in the SES analysis, as this facility does not collect SES data from their donors.

Table 4. Socioeconomic status by social race group.

Social Race	SES	Total
American Hispanic	Lower	6
	Middle	3
	Upper	0
Total		**9**
American Black	Lower	10
	Middle	8
	Upper	3
Total		**21**
American White	Lower	21
	Middle	24
	Upper	4
Total		**49**
All Social Races	Lower	37
	Middle	35
	Upper	7
Grand Total	**All SES**	**79**

Cause of death was extrapolated to formulate disease categories based on the classifications described in the International Classification of Diseases for Mortality and Morbidity Statistics, 11th edition (ICD-11), from the World Health Organization (WHO; The World Health Organization, 2018; Table 5). In order to maintain large sample sizes, cause of death was divided into three main types. The organ category included all organ deaths, encompassing circulatory, endocrine, genitourinary, brain and nervous system, and respiratory diseases. The uncontrolled category included neoplasms and infectious or parasitic causes of death. The external category included external causes, injury or poisoning (e.g., homicide, suicide, or overdose), and other causes of death not elsewhere specified by the WHO. Total sample sizes for the cause of death categories can be viewed in Table 6.

Table 5. Cause of death classifications used in this analysis as adapted from the ICD-11, 2018.

Category	Diseases Included
Organ	Respiratory System
	Circulatory System
	Brain/Nervous System
	Endocrine System
	Genitourinary System
Uncontrolled	Neoplasms
	Infectious or Parasitic Diseases
External	External Causes
	Injury or Poisoning
	Not Elsewhere Classified

Table 6. Sample sizes by cause of death classification.

Social Race	Cause of Death Category	Total
American Hispanic	Organ	14
	Uncontrolled	3
	External	6
Total		**23**
American Black	Organ	23
	Uncontrolled	5
	External	37
Total		**65**
American White	Organ	32
	Uncontrolled	16
	External	16
Total		**64**
All Social Races	Organ	69
	Uncontrolled	24
	External	59
Grand Total	**All COD classifications**	**152**

In addition, occupation was utilized to determine if individuals were engaged in sedentary or manual labor (Table 7). Previous research has found that individuals have higher FA when working in manual labor type occupations (Özener, 2010). Individuals within the sample were selected if their donation paperwork included an occupation. Because there is no universal standard for determining a true type of manual or sedentary labor, the author of this research used their best judgement based on the information provided by the donor or their next of kin. This information was in turn used to determine if an individual's occupation influenced their FA score. For a full list of occupations for individuals used within the sample, see the appendix.

Table 7. Sample sizes for manual and sedentary occupations.

Social Race	**Occupation Type**	**Total**
American Hispanic	Manual	7
	Sedentary	9
Total		**16**
American Black	Manual	14
	Sedentary	19
Total		**33**
American White	Manual	19
	Sedentary	40
Total		**59**
All Social Races	Manual	40
	Sedentary	68
Grand Total	**All Occupations**	**108**

Three-dimensional cranial landmarks from the skull were be obtained for this analysis. Landmark data is in the form of three-dimensional coordinate data (x, y, and z) representing standard, homologous cranial landmarks. All cranial landmarks were collected using a Microscribe 3DX digitizer, expedited by the data collection software 3Skull (Ousley, 2004) following the craniometric definitions in Howells (1973) and the Harris County Institute of Forensic Sciences' Standard Operating Procedures for Digitizing (2018). However, only the thirty-six landmarks shown in Table 8 were used for the FA analysis.

Table 8. Craniofacial landmarks used in the analysis.

Number	Landmark	Abbreviation
1, 2	Alare	alarl, alarr
3, 4	Asterion	astl, astr
5	Basion	bas
6	Bregma	brg
7, 8	Dacryon	dacl, dacr
9, 10	Ectoconchion	ectl, ectr
11, 12	Frontomalare	fmal, fmar
13	Lambda	lam
14	Nasion	nas
15, 16	Inferior Nasal Border	nlhil, nlhir
17	Opisthion	ops
18, 19	Porion	porl, porr
20	Howell's Prosthion	prosH
21, 24	Zygion	zygl, zygr
22, 23	Zygoorbitale	zygool, zygoor
25, 26	Jugale	jugl, jugr
27, 28	Marginal Process	mpll
29, 30	Nasale Inferius	nasil, nasir
31, 32	Nasale Superius	nassl, nassr
33, 34	Nasomaxillary Suture Pinch	wnbl, wnbr
35, 36	Zygomaxillare	zygoml, zygomr

The Microscribe 3DX digitizer has a moveable arm with a stylus on one end, allowing for the researcher to move the stylus around the cranium to capture landmarks efficiently. While doing so, the digitizer provides the researcher with a more precise form of landmark data collection when compared to traditional craniometric measurements with calipers. The cranial landmarks were selected to show an overall morphology of craniofacial shape to see structure variation in FA between social race groups. Individuals were excluded if one of the thirty-six landmarks were not available during the digitizing process.

After digitizing, each donor's associated craniofacial landmarks and sex were entered into the simple-text editor Microsoft Notepad for Windows (2018). Each landmark was numbered according to its order in Notepad (see Table 8). Once the data was compiled in Notepad, the data set was transferred into the MorphoJ program (Klingenberg, 2011), which utilizes geometric morphometrics to analyze three-dimensional landmarks. At this point, sex was the only classifier recognized by MorphoJ. Therefore, age, SES, occupation, social race, and cause of death were added as classifiers for each individual within the sample.

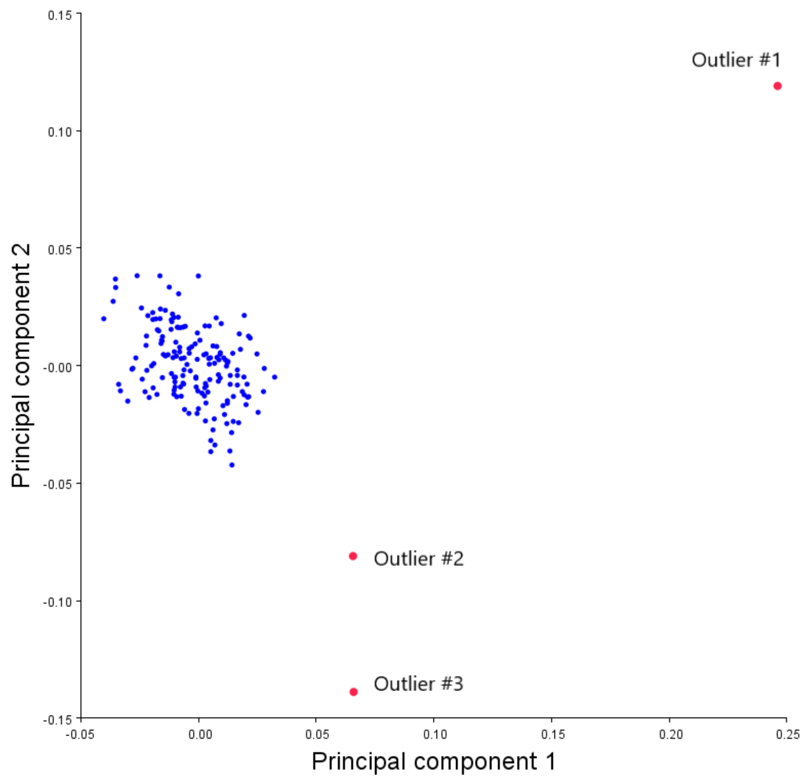

Figure 1. Principal component graph showing the three outliers.

MorphoJ has an interface which allows the researcher to find outliers within their dataset using a principal component (Figure 1). A diagram, called a lollipop graph, displays the average shape, while indicating deviations from the average in red (Klingenberg, 2019). A total of three individuals had landmark coordinates that were farther than the average shape for each landmark. Outlier one was a white female from the University of New Mexico, outlier two was a Hispanic female from the TXST-DSC, and outlier three was a Black male from the WMB-DSC. Table 1 in the appendix displays the outliers and their demographic information. Due to the extreme shape discrepancies for these three individuals when compared with the remainder of the sample, the decision was made to remove them from the analysis (Figures 2, 3, and 4).

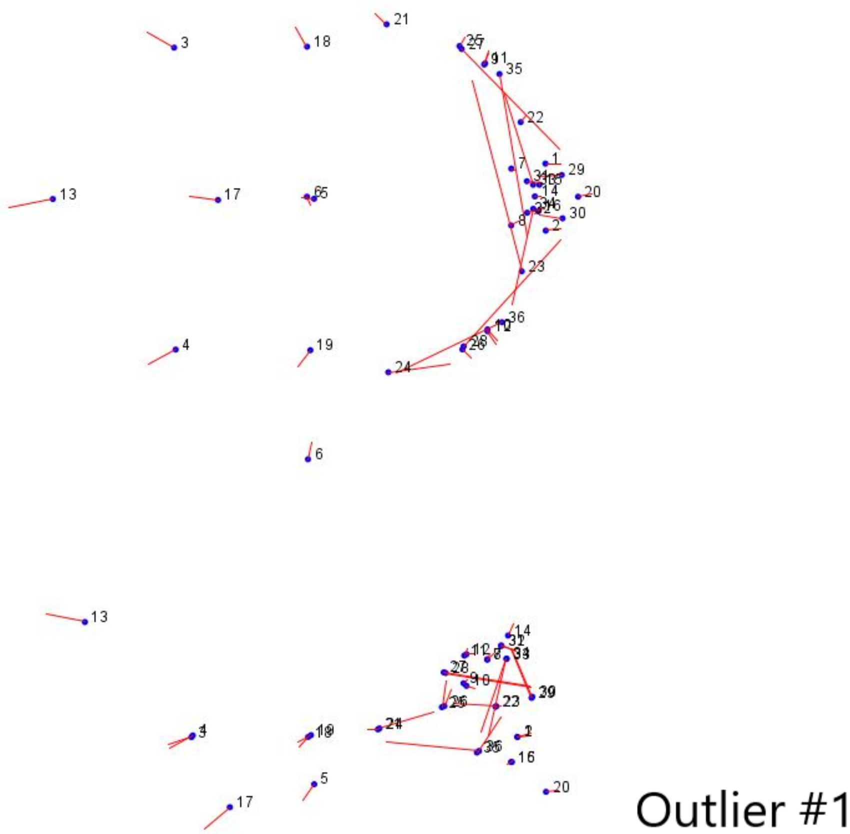

Figure 2. Lollipop graph for outlier number one.

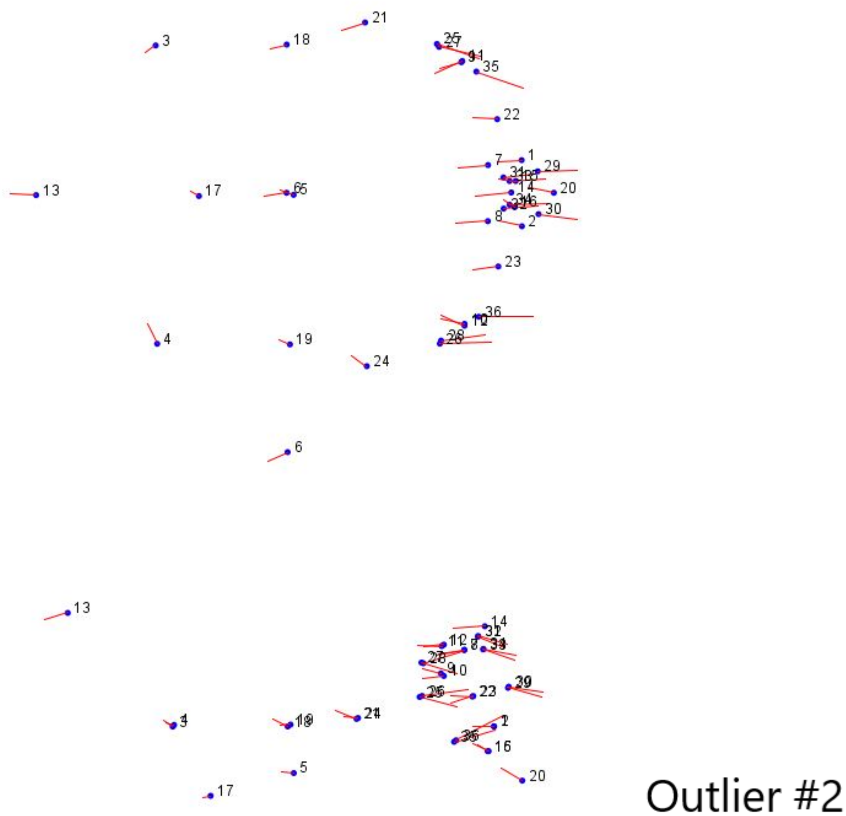

Figure 3. Lollipop graph for outlier number two.

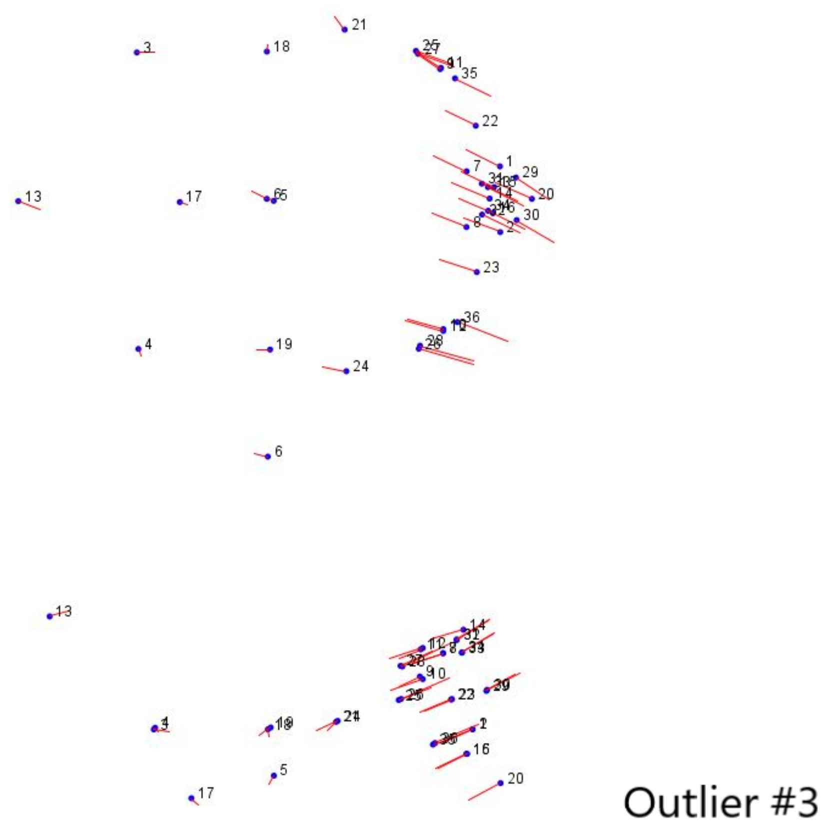

Figure 4. Lollipop graph for outlier number three.

In addition to the find outliers function in MorphoJ (Klingenberg, 2011), SPSS (IBM Corp, 2017) was used to determine if outliers existed among the social race groups according to their FA score (Figure 5). This showed that one possible outlier, an American Black female coded as individual number thirty-four, appeared to be an outlier within the dataset. This individual had an FA score of 11.99, when the average FA score for American Black individuals was 6.94. However, this individual was not determined to be an extreme outlier by the find outliers function in MorphoJ (Klingenberg, 2011). Therefore, the analysis was run with and without this individual to assess differences.

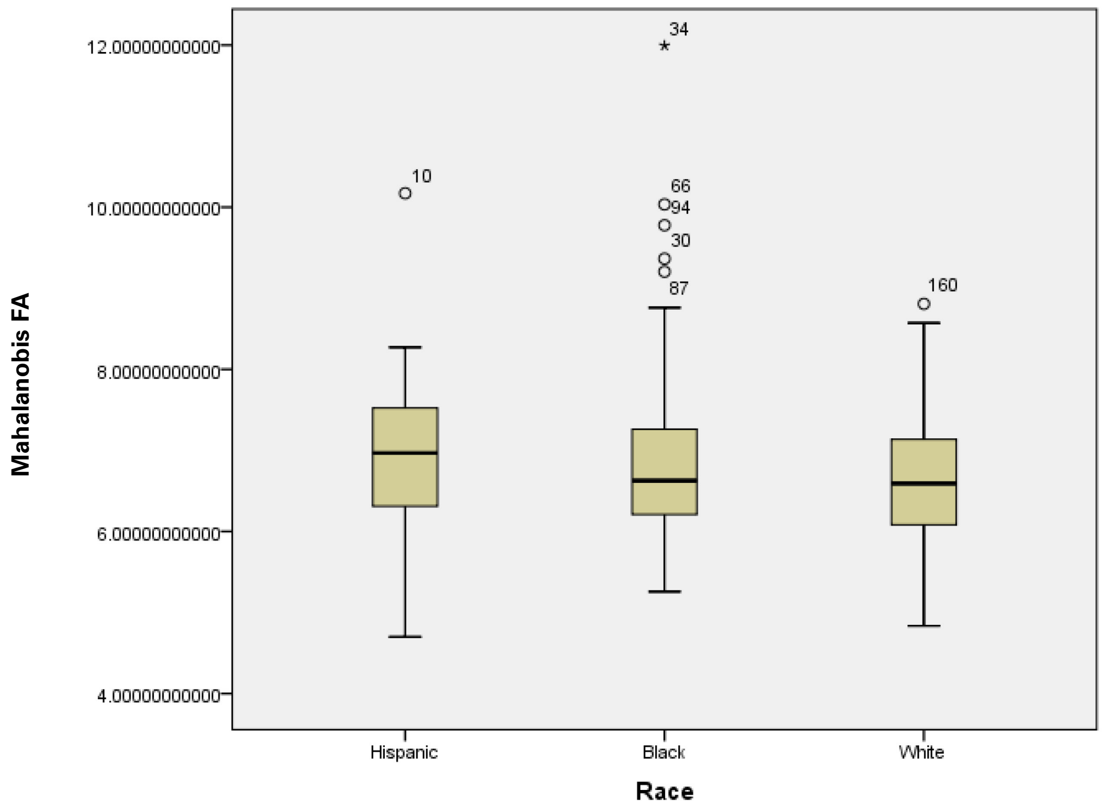

Figure 5. Box plot displaying Mahalanobis FA scores by social race with possible outliers. Outliers are displayed as a star on the graph.

Symmetries and asymmetries of shape variation were separated and analyzed in MorphoJ (Klingenberg, 2011) as outlined in Klingenberg et al. (2002) and Weisensee and Spradley (2018). Landmark coordinates were aligned using a Procrustes least-squares superimposition. This allows for the landmarks to be transposed into a similar system, removing the variation related to rotation, scale, and location prior to the analysis (Klingenberg, 2011). Because the cranium shows object symmetry, where right and left sides mirror each other on an internal plane of symmetry (Weisensee & Spradley, 2018), Procrustes superimposition allows for the landmarks on one side to be mirrored onto the other, creating a symmetrical consensus configuration. In order to calculate the asymmetry of the craniofacial skeleton, distance measurements were transformed to a space where the variation among individuals is isotropic, meaning that the size does not vary greatly based on the direction of the measurement (Klingenberg & Monteiro, 2005). From the symmetrical consensus configuration and the values obtained during data collection, Mahalanobis FA scores were created for each individual within the sample. The Mahalanobis FA scores were obtained through MorphoJ following the procedures outlined in Klingenberg & Monteiro (2005).

With the Mahalanobis FA scores and each individual's demographic data, analysis of variance (ANOVA) in SPSS (IBM Corp, 2017) was used to assess the difference in Mahalanobis FA between the social race groups and to determine if differences in FA existed between groups depending on their demographic data. ANOVA tests were first done for social race and sex to determine if differences in FA existed between social race groups and then the sexes. After this, additional ANOVA tests were attempted to see if differences in FA existed when the variables age, SES, cause of death, and occupation were included in the analysis.

III. RESULTS

Table 9. Descriptive statistics for the dependent variable Mahalanobis FA by racial group.

	Race			Statistic	Std. Error
MahalFA	Hispanic	Mean		7.033	.198
		95% CI for Mean	Lower Bound	6.625	
			Upper Bound	7.440	
		Median		6.967	
		Variance		1.060	
		Std. Deviation		1.029	
		Minimum		4.701	
		Maximum		10.171	
		Range		5.470	
	Black	Mean		6.940	.137
		95% CI for Mean	Lower Bound	6.665	
			Upper Bound	7.215	
		Median		6.627	
		Variance		1.351	
		Std. Deviation		1.162	
		Minimum		5.256	
		Maximum		11.993	
		Range		6.737	
	White	Mean		6.629	.105
		95% CI for Mean	Lower Bound	6.419	
			Upper Bound	6.840	
		Median		6.592	
		Variance		.745	
		Std. Deviation		.863	
		Minimum		4.834	
		Maximum		8.807	
		Range		3.972	

Individual Number Thirty-Four

When all ANOVA tests were run without individual number thirty-four, none of the tests produced significant results. Therefore, individual number thirty-four remained in the analysis on the basis that their cranium was large, but not significantly larger than average human variation for the American Black group.

Social Race

Descriptive statistics for the variable Mahalanobis FA by racial group can be viewed in Table 9. Histograms displaying the means for each social race group's FA scores can be seen in the appendix. A one-way ANOVA with social race as the independent variable and Mahalanobis FA as the dependent variable determined that significant differences in Mahalanobis FA did not exist between American Hispanic, American Black, and American White social race groups (Table 10).

Table 10. Tests of Between-Subjects Effects for Mahalanobis FA by social race.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.671[a]	2	2.336	2.209	.113	.027
Intercept	6427.276	1	6427.276	6077.358	.000	.974
Race	4.671	2	2.336	2.209	.113	.027
Error	171.328	162	1.058			
Total	7872.000	165				
Corrected Total	175.999	164				

a. R Squared = .027 (Adjusted R Squared = .015)

Sex

Descriptive statistics for the variable Mahalanobis FA by sex can be viewed in Table 11. The ANOVA with sex and social race as the independent variables and Mahalanobis FA as the dependent variable concluded that statistically significant differences in FA did not exist between any of the social race groups and their sex (Table 12).

Table 11. Descriptive statistics for the dependent variable Mahalanobis FA by sex and race.

Race	Sex	Mean	Std. Deviation	N
Hispanic	Male	7.162	1.051	19
	Female	6.605	.9800	7
	Total	7.012	1.044	26
Black	Male	6.927	.971	56
	Female	7.067	1.7822	14
	Total	6.955	1.163	70
White	Male	6.672	.833	36
	Female	6.579	.907	31
	Total	6.629	.863	67
Total	Male	6.885	.950	111
	Female	6.714	1.206	52
	Total	6.830	1.038	163

Table 12. Tests of Between-Subjects Effects for Mahalanobis FA by sex and social race group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.609[a]	5	1.322	1.235	.295	.038
Intercept	4878.970	1	4878.970	4559.661	.000	.967
Race	3.899	2	1.949	1.822	.165	.023
Sex	.753	1	.753	.704	.403	.004
Race * Sex	1.708	2	.854	.798	.452	.010
Error	167.995	157	1.070			
Total	7779.985	163				
Corrected Total	174.604	162				

a. R Squared = .038 (Adjusted R Squared = .007)

Age

Descriptive statistics for the variable Mahalanobis FA by age can be viewed in Table 13. The ANOVA with age and social race as the independent variables and Mahalanobis FA as the dependent variable concluded that statistically significant differences in FA did not exist in the interaction of social race groups and their age (Table 14). Race was statistically significant when analyzed with age for Mahalanobis FA, not the interaction of race and age, however. Still, when a Scheffe's post-hoc test was used to determine if differences existed by social race group, there were no statistically significant differences (Table 15). In addition, when individual number thirty-four was removed from the analysis, the ANOVA with Mahalanobis FA as the dependent variable and race and age as the independent variables showed no significant differences.

Table 13. Descriptive statistics for the dependent variable Mahalanobis FA by age and race.

Race	Age	Mean	Std. Deviation	N
Hispanic	20-39y	7.361	.798	5
	40-59y	7.044	1.462	7
	60-79y	7.065	.762	7
	80-99y	6.403	.902	6
	Total	6.960	1.0353	25
Black	20-39y	7.374	1.083	9
	40-59y	6.768	.922	33
	60-79y	6.721	.918	22
	80-99y	8.050	2.411	6
	Total	6.941	1.170	70
White	20-39y	6.513	.730	6
	40-59y	6.660	1.0008	16
	60-79y	6.658	.934	33
	80-99y	6.566	.553	12
	Total	6.629	.863	67
Total	20-39y	7.113	.965	20
	40-59y	6.772	1.007	56
	60-79y	6.726	.906	62
	80-99y	6.897	1.433	24
	Total	6.815	1.037	162

Table 14. Tests of Between-Subjects Effects for Mahalanobis FA by age and social race group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	18.047[a]	11	1.641	1.584	.109	.104
Intercept	5131.313	1	5131.313	4953.514	.000	.971
Race	9.159	2	4.579	4.421	.014	.056
Age	1.391	3	.464	.448	.719	.009
Race * Age	11.875	6	1.979	1.911	.083	.071
Error	155.384	150	1.036			
Total	7698.189	162				
Corrected Total	173.431	161				

a. R Squared = .104 (Adjusted R Squared = .038)

Table 15. Scheffe Post-Hoc test for Race.

(I) Race	(J) Race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Hispanic	Black	.018	.237	.997	-.567	.605
	White	.330	.238	.385	-.259	.920
Black	Hispanic	-.018	.237	.997	-.605	.567
	White	.311	.173	.204	-.118	.741
White	Hispanic	-.330	.238	.385	-.920	.259
	Black	-.311	.173	.204	-.741	.118

Based on observed means.

The error term is Mean Square(Error) = 1.036.

Occupation

Descriptive statistics for the variable Mahalanobis FA by occupation can be viewed in Table 16. The ANOVA with occupation and social race as the independent variables and Mahalanobis FA as the dependent variable concluded that statistically significant differences in FA did not exist between any of the social race groups and their occupation (Table 17).

Table 16. Descriptive statistics for the dependent variable Mahalanobis FA by occupation and race.

Occup	Race	Mean	Std. Deviation	N
Sedentary	Hispanic	6.646	.900	9
	Black	6.796	.902	19
	White	6.597	.846	40
	Total	6.659	.860	68
Manual	Hispanic	7.146	.665	7
	Black	6.764	.957	14
	White	6.548	1.019	19
	Total	6.729	.949	40
Total	Hispanic	6.865	.821	16
	Black	6.782	.911	33
	White	6.581	.896	59
	Total	6.685	.890	108

Table 17. Tests of Between-Subjects Effects for Mahalanobis FA by occupation and social race group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.490[a]	5	.498	.617	.687	.029
Intercept	3599.858	1	3599.858	4457.682	.000	.978
Occup	.387	1	.387	.479	.491	.005
Race	1.642	2	.821	1.017	.365	.020
Occup * Race	.975	2	.488	.604	.549	.012
Error	82.371	102	.808			
Total	4911.645	108				
Corrected Total	84.862	107				

a. R Squared = .029 (Adjusted R Squared = -.018)

Cause of Death

Descriptive statistics for the variable Mahalanobis FA by cause of death can be viewed in Table 18. The ANOVA with cause of death and social race as the independent variables and Mahalanobis FA as the dependent variable concluded that statistically significant differences in FA did not exist between any of the social race groups and their cause of death (Table 19).

Table 18. Descriptive statistics for the dependent variable Mahalanobis FA by cause of death and race.

Race	COD	Mean	Std. Deviation	N
Hispanic	organ	7.038	1.298	14
	uncontrolled	7.141	.450	3
	external	7.218	.738	6
	Total	7.098	1.070	23
Black	organ	6.854	1.110	23
	uncontrolled	6.734	.967	5
	external	6.901	1.003	37
	Total	6.871	1.025	65
White	organ	6.692	.736	32
	uncontrolled	6.412	1.010	16
	external	6.696	1.008	16
	Total	6.623	.875	64
Total	organ	6.816	.993	69
	uncontrolled	6.570	.954	24
	external	6.878	.977	59
	Total	6.801	.980	152

Table 19. Tests of Between-Subjects Effects for Mahalanobis FA by cause of death and social race group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.614[a]	8	.702	.719	.674	.039
Intercept	3812.586	1	3812.586	3906.778	.000	.965
Race	3.810	2	1.905	1.952	.146	.027
COD	.344	2	.172	.176	.839	.002
Race * COD	.351	4	.088	.090	.985	.003
Error	139.552	143	.976			
Total	7176.980	152				
Corrected Total	145.166	151				

a. R Squared = .039 (Adjusted R Squared = -.015)

Socioeconomic Status

Descriptive statistics for the variable Mahalanobis FA by SES can be viewed in Table 20. The ANOVA with SES and social race as the independent variables and Mahalanobis FA as the dependent variable concluded that statistically significant differences in FA did not exist between any of the social race groups and their SES (table 21).

Table 20. Descriptive statistics for the dependent variable Mahalanobis FA by SES and race.

Race	SES	Mean	Std. Deviation	N
Hispanic	lower	6.793	1.278	6
	middle	6.987	.586	3
	Total	6.858	1.056	9
Black	lower	7.176	2.027	10
	middle	6.839	1.254	8
	upper	6.752	1.109	3
	Total	6.987	1.599	21
White	lower	6.642	1.114	21
	middle	6.502	.794	24
	upper	6.674	.904	4
	Total	6.576	.936	49
Total	lower	6.811	1.413	37
	middle	6.621	.897	35
	upper	6.707	.905	7
	Total	6.718	1.159	79

Table 21. Tests of Between-Subjects Effects for Mahalanobis FA by SES and social race group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.719[a]	7	.531	.373	.915	.035
Intercept	1679.067	1	1679.067	1178.270	.000	.943
Race	1.134	2	.567	.398	.673	.011
SES	.136	2	.068	.048	.954	.001
Race * SES	.597	3	.199	.140	.936	.006
Error	101.177	71	1.425			
Total	3670.307	79				
Corrected Total	104.896	78				

a. R Squared = .035 (Adjusted R Squared = -.060)

IIII. DISCUSSION

Much of the basis of FA research is centered around the idea that developmental stress and instability provides a useful tool for understanding the ways in which populations and the individuals within said populations deal with their given environment (Moller, 1999). The results of the current research appear to largely contradict the conclusions of other authors in regard to FA in humans (Bigoni et al., 2013; Graham & Özener, 2016; Hope et al., 2013; Özener & Fink, 2010; Weisensee, 2013; Weisensee & Spradley, 2018). Each of the variables considered in this analysis did not show significant results by social race, sex, age, occupation, cause of death, and SES. A number of factors might have contributed to these results.

Individual Number Thirty-Four

Although this individual's FA score was larger than the average, they were not excluded from the analysis. Number thirty-four remained in the analysis at the discretion of the author because this individual did not fall outside of the spectrum of what is considered normal human variation. Since it is likely that individual thirty-four was on the larger end of the periphery in terms of cranial variation, this individual was analyzed with the remainder of the sample.

Social Race

This research predicted that POC would display significantly higher FA scores when compared with individuals within the American White sample, as POC have higher stress and increased chances for stressful events than White individuals. However, this research showed that there was no difference in FA scores when comparing the three social race groups. With the insignificant results for FA among the social race groups, one possible explanation could be that all the individuals within the samples are American-born citizens, and there is the possibility that this information was misrepresented on the donation forms for each individual. Other studies have determined significant FA differences in migrant born populations (Weisensee & Spradley, 2018) or populations where the samples are derived from the same geographic location (Özener & Fink, 2010). Because the samples in the current research are from American born populations, it is possible that their craniometric variation is much more similar than it is different. Because of this, the American White, American Black, and American Hispanic groups might show more similarities in their FA scores and craniometric data. Therefore, the insignificant effects in the variables and their resulting effect on FA might be explained by this lack of variation between groups. Lastly, it is possible that parents might buffer the perceived effects of discrimination that their offspring might experience. Because young children do not initially know that they are facing discrimination, their family might offset the negative impacts of this type of stress. In order to further understand the variation between the social race groups, additional analyses of the FA differences within groups must be explored for future research. In short, each of the social race groups should be compared to individuals within their social race categories. Lastly, a larger American Hispanic sample size is necessary to fully understand group differences.

Sex

It was assumed that males would display higher levels of FA than females in all three social race groups. However, the current research found that differences in FA by sex did not exist among the groups. Although research has found that males have higher

FA than females (Bigoni et al., 2013; Hope et al., 2013; Özener & Fink, 2010; Weisensee, 2013; Weisensee & Spradley, 2018), the current research found that there were no differences between the sexes. This could be because the female sample is drastically smaller when compared to the male group. It is not known why there are more males than females donated to documented skeletal collections, regardless, skeletal collections show this bias towards male donors. Males in the United States have a lower life expectancy when compared to females, living until about 76.1 years of age on average (World Bank Group, 2020), while females' average life expectancy is 81.1 as of 2017 (World Bank Group, 2020). This creates a discrepancy in the number of female donors to skeletal collections. If the female sample was larger, results might be different.

Age

This research predicted that POC would display higher FA scores across all age categories when compared to the age cohorts in the American White sample, as previous research has predicted that age and stress play a role in FA. Research by Hope et al. (2013) found that individuals with lower SES at age eleven were associated with higher FA scores in adult life. The authors hypothesize that early childhood stressors would influence their facial features as adults. Still, the current research found no significant differences between age cohorts and their corresponding FA. Additionally, the youngest individual within the current sample was twenty years of age at death, whereas Hope et al.'s 2013 research included individuals as young as eleven.

FA scores became significant for the three race groups only when included with the variable age (see Table 14). Still, a Scheffe post-hoc comparison concluded that there were no significant differences when racial groups were compared. This is likely due to the lack of significant differences across racial groups when considering Mahalanobis FA and race alone in a one-way ANOVA, as seen in Table 10. In short, there were not significant differences in the three social race groups when only Mahalanobis FA was considered. Because of this, there were not significant differences in the Scheffe post-hoc test when comparing the American Hispanic, American Black, and American White groups.

One would expect that FA would be seen younger age groups, as the body is more susceptible to developmental changes earlier in life when one is placed in a stressful environment, such as war, deportation, or the stress of having childhood cancer (Clarkin, 2019; Kelly-Irving et al. 2013; Martínez, Ruelas, & Granger, 2018), although the embodiment of said stress would only occur prior to the final growth spurt. Still, this embodiment of stress would reflect into the older age cohorts as well. However, that was not the case for the current research. This highlights the idea that stress and discrimination would not necessarily manifest in the bodies of children as FA.

Occupation

Because research suggests that individuals who work in manual labor jobs have higher FA of the face and limbs (Özener, 2010), the current research predicted that individuals in the POC groups who held manual labor occupations would have higher FA scores than those in the same category for American Whites. Özener (2010) found that young individuals between 17 and 20 years of age in Turkey had higher FA in males working in hard labor conditions with lower wages. However, the current research shows that occupation has no effect on FA. It is important to note that these results were found with samples born in America, versus Özener's 2010 results for males in Turkey. One possibility for this is that donor's listed occupation might not have been what their actual occupation was while living. It is possible that next of kin either listed the incorrect occupation, or even further, might not have had a relationship with the deceased and therefore might not have known what their occupation was while the donor was alive. In some cases, the next of kin do not fill out this section of the paperwork.

Another possibility is that manual labor and lower wage occupations in other countries are much different than those in the United States. For example, a laborer at a factory in Turkey may have a more strenuous job than someone working in the service industry in America. Further, the sample sizes for the donors in the current research with a listed manual occupation were small. Increasing sample sizes might offer different results. Another possibility is that there is not an extreme activity divide between sedentary and manual labor as it pertains to the intensity of the workload that is experienced. For example, working as a sales associate might have comparable intensity as someone who works as a waitress. This might be explained as the stress inherited by the body during heavy workloads is not reflected in the face. In addition, FA would most likely fail to manifest as a result of occupation, as FA is induced during the early periods of growth and development before adulthood. Instead, another identifier, such as directional asymmetry of the limbs, could be a better predictor of FA and occupational differences.

Cause of Death

Weisensee (2013) found that a skeletal collection in Portugal displayed higher FA when their cause of death was determined to be from degenerative diseases rather than infectious ones, providing a possible mechanism for studying the DOHaD hypothesis in adult skeletal remains. Due to this, the current research predicted that POC in all cause of death categories would have higher FA scores than their American White counterparts. However, the current research found no effect of cause of death on FA. For one, Weisensee's samples were historic and from a skeletal collection in Portugal, versus the modern, American-born sample used in the current research. Further, if more samples were available, collapsing of the disease categories would not have been necessary, thereby allowing for a more conclusive analysis of FA scores and cause of death. It is possible that cause of death does not influence the FA scores of these three social race groups because the influence of FA is either minimal or non-existent during the end of an individual's lifetime. This is probable, given that individuals who undergo these biological changes to their craniofacial skeleton would be more susceptible to them in utero or during early childhood while the face is still growing.

What these results show is that regardless of health, individual's FA scores are insignificant when compared to their cause of death. Like the other variables in the analysis, information for cause of death was not available for all of the donors, therefore decreasing the sample size drastically.

Socioeconomic Status

The most surprising result from this research is that SES did not influence FA scores within the social race groups, although it was predicted that all SES groups in the POC samples would have higher FA scores than SES groups in the American White sample. Other researchers have that SES plays an active part in FA (Hope et al., 2013; Özener & Fink, 2010, 2010; Weisensee, 2013; Weisensee & Spradley, 2018). Still, there is evidence that SES does not influence FA scores when analyzing individuals within the same population (Quinto-Sánchez et al., 2017). There are possible explanations for this discrepancy, one being that the individuals used in this research are from documented skeletal collections. The donors or their next of kin provide detailed information regarding sex, occupation, SES, place of birth, traumatic injury, and disease, just to name a few. While this method of data collection has proven useful for some research, it can also hinder other aspects of it. For instance, one individual's idea of low SES might be different than another donor's or what is considered the national standard.

As stated previously, many of the donations to the University of Tennessee are from medical examiner's offices, followed by a donor's next of kin (Christensen, 2006). Because of this, demographic information is not always available for the individual being donated. In addition, the social race composition for each of the SES categories was unevenly distributed, as seen in Table 4. The American White sample had more information regarding their demographic data versus the American Black and American Hispanic groups. Although it is unknown why, a possibility is that many of the remains for the American Black and American Hispanic groups were originally unclaimed or from next of kin. When the University of Tennessee procures unclaimed remains for research purposes, much of the demographic information is unavailable (Christensen, 2006). This would decrease sample sizes drastically due to lack of information. Increasing the sample size for these groups and obtaining their SES would greatly benefit this and future research.

Demographic Data and Sample Sizes

Other possible explanations for the insignificant results include the obtainment of demographic data in general. Much of the demographic data for each of the individuals was not available, as the donor or their next of kin did not fill out the information, did not know it, or the individual was unclaimed from a medical examiner's office. Therefore, much like with the SES data, sample sizes drastically decreased when each variable was considered for the analysis. In the future, larger samples sizes with adequate information regarding sex, age, race, SES, cause of death and occupation are needed in order to accurately understand the effect of FA on different racial groups.

Further, it is important that demographic data is consistent within each research facility, or if possible, consistent across research facilities. While it might not be possible to maintain consistent data between facilities, standards for obtaining demographic data from potential donors might be helpful when analyzing FA. Universal standards for SES, for example, would be a beneficial addition to donation forms. Still, next of kin might not know the information that research facilities are wanting to obtain, and the next of kin might not fill out the information.

V. CONCLUSION

Although a valuable predictor of stress in humans and non-human animals, this research has shown that FA is not an adequate predictor of stress on skeletal populations whose demographic data is documented. There are a number of reasons for this conclusion. First, sample sizes should be maintained in order to accurately analyze FA in skeletal samples. Increasing the number of demographic variables drastically decreased the sample sizes within each variable category. Second, demographic data is of the utmost importance when conducting any research regarding health, disease, and FA. Texas State University, The University of Tennessee at Knoxville, and the University of New Mexico all have documented skeletal collections, however, the way in which demographic data is obtained for each of these collections is drastically different. The University of New Mexico was only able to provide basic demographic data, such as age, sex, social race, and SES, whereas Texas State University has a detailed demographic packet which includes all geographic locations an individual has lived, their SES throughout childhood and adult life, tattoos and piercings, shoe size, and occupation, just to name a few. Third, there are discrepancies in how research facilities consider intake and claim of remains for study. Texas State University does not accept unclaimed remains, whereas other programs can and do. This can skew the results of this research when comparing claimed remains with demographic information to unclaimed individuals where the same information is not available. Fourth, it is possible that FA scores might not show significant differences across groups that are obtained from the same geographic population. This might explain why other research has found differences in FA in populations from the same location (Özener, 2010; Weisensee, 2013;

Weisensee & Spradley, 2018). Fifth, the exact types of perceived discrimination and therefore stress in marginalized groups should be more accurately standardized in order for researchers to measure these specific types of stress. Doing so would greatly aid research in the future. Lastly, more information about causes of FA are necessary in order to understand its etiology in humans. Considering the changing environment today, multiple types of stress might influence FA in human populations. These types of stress could include climate change, poverty, or responses to disease outbreaks and pandemics like COVID-19. Future research should consider the use of longitudinal data which can provide insight for individuals who have differing levels of stress, disease, occupation, and SES.

APPENDIX SECTION

Table 1. Outliers removed from the sample and their demographic information.

Outlier Number	Sex	Social Race	Age	SES	Occupation	Cause of Death
1	F	White	67	Unknown	Sedentary	Uncontrolled
2	F	Hispanic	89	Unknown	Manual	Uncontrolled
3	M	Black	59	Unknown	Unknown	External

Table 2. Donors from the TXST-DSC divided by sex and social race.

Individual	Facility	Sex	Social Race
1	TXST	Male	Hispanic
2	TXST	Male	Hispanic
3	TXST	Male	Hispanic
4	TXST	Male	Hispanic
5	TXST	Male	Hispanic
6	TXST	Male	Hispanic
7	TXST	Female	Hispanic
8	TXST	Female	Hispanic
9	TXST	Female	Hispanic
10	TXST	Male	Black
11	TXST	Male	Black
12	TXST	Male	Black
13	TXST	Male	Black
14	TXST	Male	Black
15	TXST	Female	Black
16	TXST	Male	Black
17	TXST	Male	Black
18	TXST	Female	Black
19	TXST	Male	White
20	TXST	Female	White
21	TXST	Female	White
22	TXST	Male	White
23	TXST	Female	White
24	TXST	Male	White
25	TXST	Male	White
26	TXST	Male	White
27	TXST	Female	White
28	TXST	Male	White
29	TXST	Male	White
30	TXST	Male	White
31	TXST	Female	White
32	TXST	Female	White
33	TXST	Male	White
34	TXST	Male	White
35	TXST	Female	White
36	TXST	Male	White

Table 3. Donors from the WMB-DSC and the FDB at the University of Tennessee, Knoxville (UTK) divided by sex and social race.

Individual	Facility	Sex	Social Race
1	UTK	Male	Hispanic
2	UTK	Male	Hispanic
3	UTK	Male	Hispanic
4	UTK	Male	Hispanic
5	UTK	Male	Hispanic
6	UTK	Male	Hispanic
7	UTK	Male	Hispanic
8	UTK	Male	Hispanic
9	UTK	UNK	Hispanic
10	UTK	Female	Hispanic
11	UTK	Female	Hispanic
12	UTK	Female	Black
13	UTK	Female	Black
14	UTK	Female	Black
15	UTK	Male	Black
16	UTK	Male	Black
17	UTK	Male	Black
18	UTK	Male	Black
19	UTK	Male	Black
20	UTK	Male	Black
21	UTK	UNK	Black
22	UTK	Male	Black
23	UTK	Male	Black
24	UTK	Male	Black
25	UTK	Male	Black
26	UTK	Male	Black
27	UTK	Male	Black
28	UTK	Male	Black
29	UTK	Male	Black
30	UTK	Male	Black
31	UTK	Male	Black
32	UTK	Male	Black
33	UTK	Male	Black
34	UTK	Male	Black
35	UTK	Female	Black
36	UTK	Male	Black
37	UTK	Male	Black
38	UTK	Female	Black
39	UTK	Male	Black
40	UTK	Male	Black
41	UTK	Male	Black

Table 3. Continued.

Individual	Facility	Sex	Social Race
42	UTK	Male	Black
43	UTK	Male	Black
44	UTK	Male	Black
45	UTK	Male	Black
46	UTK	Male	Black
47	UTK	Male	Black
48	UTK	Male	Black
49	UTK	Male	Black
50	UTK	Male	Black
51	UTK	Male	Black
52	UTK	Male	Black
53	UTK	Male	Black
54	UTK	Female	Black
55	UTK	Male	Black
56	UTK	Male	Black
57	UTK	Female	Black
58	UTK	Male	Black
59	UTK	Male	Black
60	UTK	Male	Black
61	UTK	Female	Black
62	UTK	Male	Black
63	UTK	Male	Black
64	UTK	Female	Black
65	UTK	Female	Black
66	UTK	Male	Black
67	UTK	Female	White
68	UTK	Male	White
69	UTK	Male	White
70	UTK	Female	White
71	UTK	Male	White
72	UTK	Male	White
73	UTK	Female	White
74	UTK	Female	White
75	UTK	Female	White
76	UTK	Female	White
77	UTK	Male	White
78	UTK	Female	White
79	UTK	Male	White
80	UTK	Female	White
81	UTK	Male	White
82	UTK	Female	White
83	UTK	Male	White

Table 3. Continued.

Individual	Facility	Sex	Social Race
84	UTK	Female	White
85	UTK	Female	White
86	UTK	Male	White
87	UTK	Male	White
88	UTK	Female	White
89	UTK	Female	White
90	UTK	Female	White
91	UTK	Male	White
92	UTK	Male	White
93	UTK	Male	White
94	UTK	Male	White
95	UTK	Male	White
96	UTK	Male	White
97	UTK	Female	White
98	UTK	Female	White

Table 4. Donors from the Maxwell Museum at the University of New Mexico (UNM) divided by sex and social race.

Individual	Facility	Sex	Social Race
1	UNM	Male	Hispanic
2	UNM	Male	Hispanic
3	UNM	Male	Hispanic
4	UNM	Male	Hispanic
5	UNM	Male	Hispanic
6	UNM	Female	Hispanic
7	UNM	Female	Hispanic
8	UNM	Female	Hispanic
9	UNM	Male	Black
10	UNM	Male	Black
11	UNM	Male	Black
12	UNM	Male	Black
13	UNM	Female	Black
14	UNM	Male	Black
15	UNM	Female	Black
16	UNM	Male	White
17	UNM	Male	White
18	UNM	Female	White
19	UNM	Male	White
20	UNM	Male	White
21	UNM	Female	White
22	UNM	Male	White
23	UNM	Male	White
24	UNM	Female	White
25	UNM	Male	White
26	UNM	Female	White
27	UNM	Male	White
28	UNM	Female	White
29	UNM	Male	White
30	UNM	Female	White
31	UNM	Female	White

Table 5. Donors and their occupation as listed from their donation paperwork, divided into manual or sedentary labor.

Donor	Facility	Occupation	Category
1	TXST	Waiter	Manual
2	TXST	Truck Driver	Sedentary
3	TXST	Truck Driver	Sedentary
4	TXST	Changed Tires	Manual
5	TXST	Steelworker	Manual
6	TXST	Surgical Technician; Caregiver	Manual
7	TXST	Homemaker	Sedentary
8	TXST	Care Taker	Manual
9	TXST	Football Player	Manual
10	TXST	Manager	Sedentary
11	TXST	Minister/Counselor	Sedentary
12	TXST	Manufacturing Laborer/Welder	Manual
13	TXST	Psych-Tech	Sedentary
14	TXST	Polic Dispatcher/Telecommunications	Sedentary
15	TXST	Homemaker	Sedentary
16	TXST	Waitress	Manual
17	TXST	Teacher	Sedentary
18	TXST	Teacher	Sedentary
19	TXST	Engineer	Sedentary
20	TXST	Systems Analyst	Sedentary
21	TXST	Handyman	Manual
22	TXST	Store Manager	Sedentary
23	TXST	Business	Sedentary
24	TXST	Dispatcher	Sedentary
25	TXST	Attorney	Sedentary
26	TXST	Teacher's Aide; Child Health Worker	Sedentary
27	TXST	Medical Transcription	Sedentary
28	TXST	Painter/General labor	Manual
29	TXST	Grocery	Sedentary
30	TXST	Carpentry	Manual
31	UNM	Electric Sales Dispatcher	Sedentary
32	UNM	None	Sedentary
33	UNM	Teacher	Sedentary
34	UNM	Gardener	Manual
35	UNM	Customer Service	Sedentary
36	UNM	Freelance Writer	Sedentary
37	UNM	Homemaker	Sedentary
38	UNM	Automotive Mechanic	Manual
39	UNM	Book Keeper	Sedentary
40	UNM	Business Executive	Sedentary
41	UNM	Administrative/Sales-insurance	Sedentary
42	UNM	Horse Trainer; Tool Pusher; Superintendant; Consultant	Manual

Table 5. Continued.

Donor	Facility	Occupation	Category
43	UNM	Tax Preparation/Enrolled IRS Agent	Sedentary
44	UNM	Pilates Instructor	Manual
45	UTK	Dishwasher	Sedentary
46	UTK	Plumber; Child Care Worker	Manual
47	UTK	Plant Maintenance	Manual
48	UTK	Public Relations	Sedentary
49	UTK	Beautician	Sedentary
50	UTK	Janitor	Manual
51	UTK	Nursing	Manual
52	UTK	Textile Worker	Manual
53	UTK	Incarcerated	Sedentary
54	UTK	Disabled	Sedentary
55	UTK	Baker	Sedentary
56	UTK	Cement Worker	Manual
57	UTK	Laborer	Manual
58	UTK	Incarcerated Most of Life	Sedentary
59	UTK	Disabled	Sedentary
60	UTK	Construction	Manual
61	UTK	Laborer	Manual
62	UTK	Office Supervisor	Sedentary
63	UTK	Welder	Manual
64	UTK	Disabled	Sedentary
65	UTK	Disabled	Sedentary
66	UTK	Unemployed	Sedentary
67	UTK	Laborer	Manual
68	UTK	Disabled	Sedentary
69	UTK	Driver	Sedentary
70	UTK	Customer Service	Sedentary
71	UTK	Licensed Practical Nurse	Manual
72	UTK	Courier	Sedentary
73	UTK	Unemployed	Sedentary
74	UTK	Teacher	Sedentary
75	UTK	Nurse	Manual
76	UTK	Unemployed	Sedentary
77	UTK	Payroll Clerk	Sedentary
78	UTK	Care Taker	Manual
79	UTK	Construction; Cashier	Manual
80	UTK	X-ray Technician	Manual
81	UTK	Management	Sedentary
82	UTK	Laboratory Technician	Sedentary
83	UTK	Bartender; Book Keeper	Sedentary
84	UTK	Clerical	Sedentary

Table 5. Continued.

Donor	Facility	Occupation	Category
85	UTK	Esthetician	Sedentary
86	UTK	Day Care	Manual
87	UTK	Construction	Manual
88	UTK	Waitress	Manual
89	UTK	Supervisor	Sedentary
90	UTK	Clerical	Sedentary
91	UTK	Mechanic	Manual
92	UTK	Housekeeper	Sedentary
93	UTK	Farmer and Machine Technician	Manual
94	UTK	Sales	Sedentary
95	UTK	Sales	Sedentary
96	UTK	Teacher	Sedentary
97	UTK	Teacher	Sedentary
98	UTK	Factory Owner	Manual
99	UTK	Book Keeper	Sedentary
100	UTK	Homemaker	Sedentary
101	UTK	Manufacturer	Manual
102	UTK	Electrician	Manual
103	UTK	Businessman	Sedentary
104	UTK	Truck Driver	Sedentary
105	UTK	Electrician	Manual
106	UTK	Marketing	Sedentary
107	UTK	Cashier	Sedentary
108	UTK	Homemaker	Sedentary

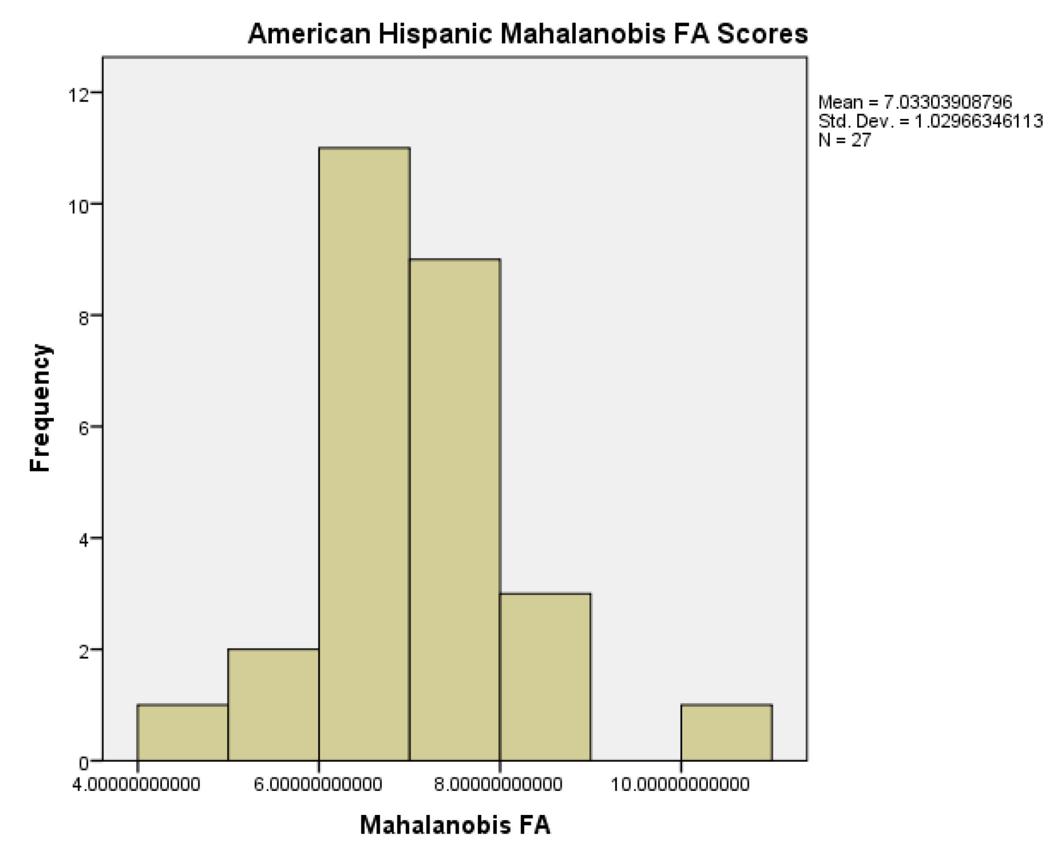

Figure 1. Histogram for American Hispanics with the frequency of Mahalanobis FA scores graphed.

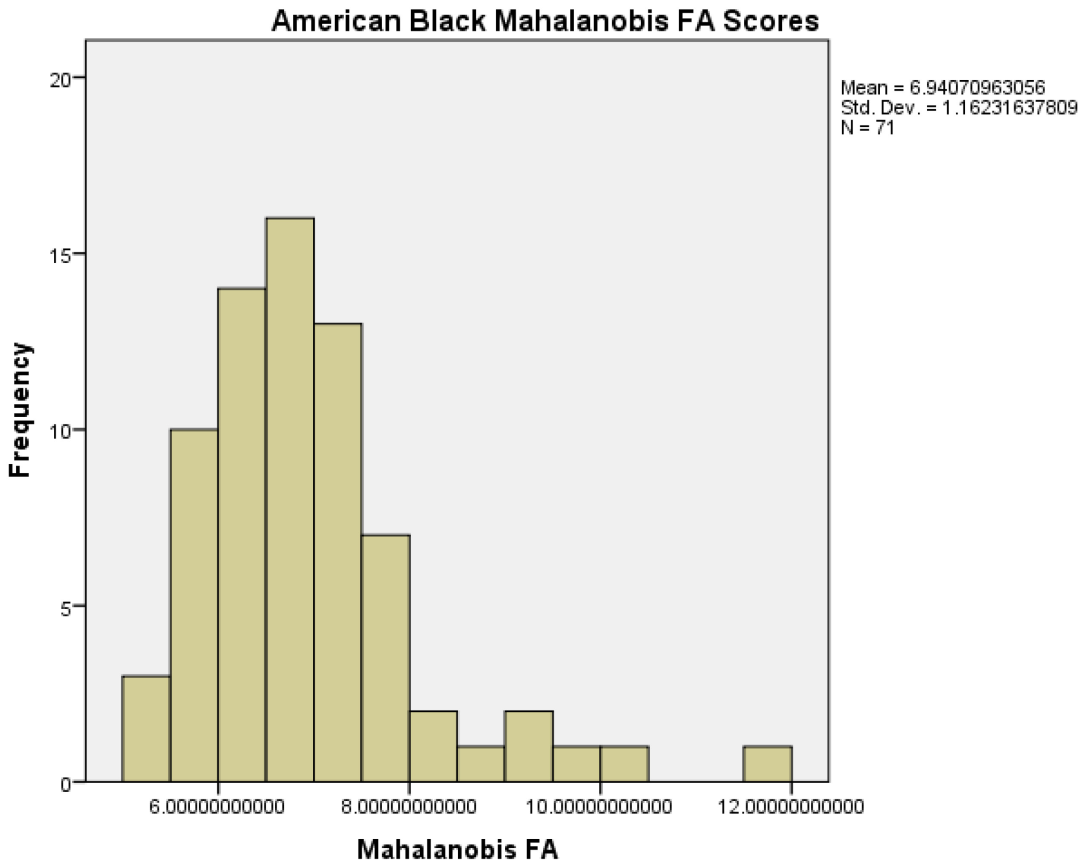

Figure 2. Histogram for American Blacks with the frequency of Mahalanobis FA scores graphed.

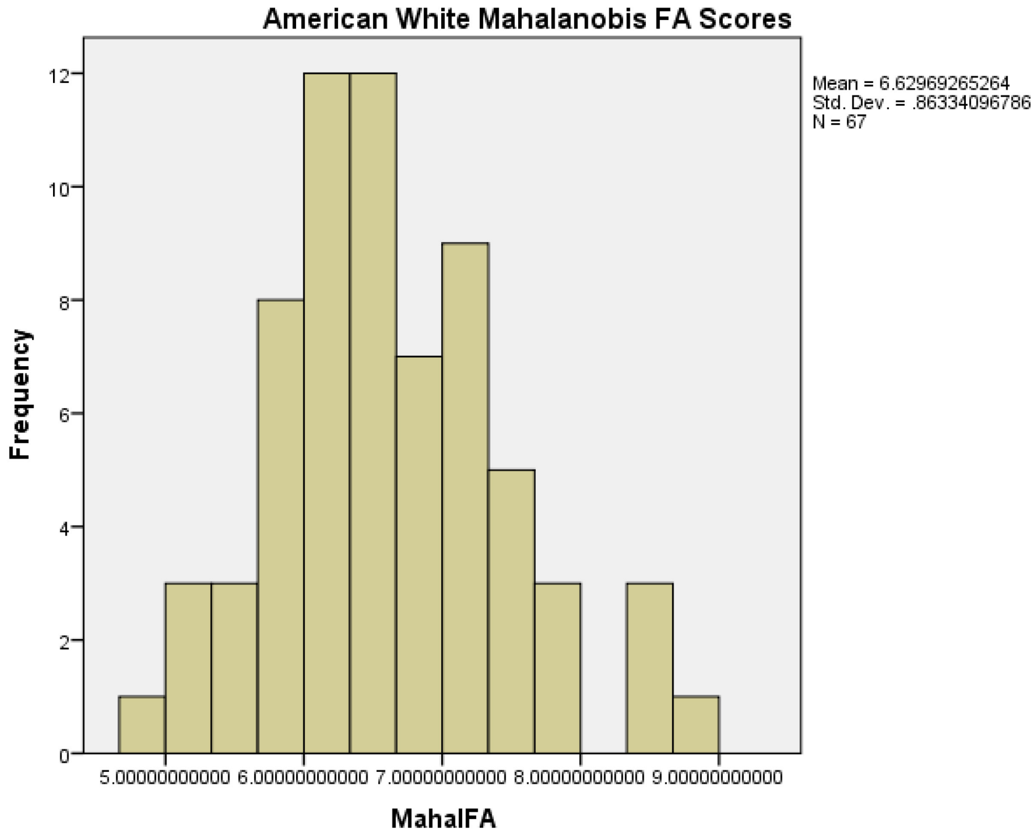

Figure 3. Histogram for American Whites with the frequency of Mahalanobis FA scores graphed.

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