SEXUAL DIMORPHISM AND SOCIOECONOMIC STATUS:

COMPARISON BETWEEN MIGRANT AND

NON-MIGRANT POPULATIONS

THESIS

Presented to the Graduate Council of
Texas State University-San Marcos
in Partial Fulfillment
of the Requirements

for the Degree

Master of ARTS

by

Cristina Figueroa-Soto, B.S.

San Marcos, TX
May 2012

SEXUAL DIMORPHISM AND SOCIOECONOMIC STATUS:

COMPARISON BETWEEN MIGRANT AND

NON-MIGRANT POPULATIONS

Committee Members Approved:

M. Katherine Spradley, Chair

Michelle D. Hamilton

Elizabeth M. Erhart

Approved:

J. Michael Willoughby
Dean of the Graduate College

FAIR USE AND AUTHOR'S PERMISSION STATEMENT

Fair Use

Duplication Permission

"Mother love is the fuel that enables a normal human being to do the impossible."

~ Marion C. Garretty

To *Mami*, *Abuela and Titi Mery*

For your unconditional love.

ACKNOWLEDGEMENTS

I would like to thank my advisor Dr. Kate Spradley for her support and guidance, and for believing in me and providing me with so many opportunities during the past two years. I will be forever grateful for your mentoring and expertise. Thank you for the privilege of working on your grant and for allowing me to use your data for my own project. I would like to also thank Dr. Michelle D. Hamilton and Dr. Elizabeth M. Erhart for their guidance and unconditional support during my time at Texas State. A special thanks to Dr. Grady Early for his generosity, and whose funding made this project possible. Thanks to Abigail Meza for her hospitality and advice during my trips to Mexico. Thanks to all my friends in my cohort, especially to Lauren Springs for always listening and being there for me, and to Caryn Tegtmeyer, who was always willing to lend a hand. Thanks to Sophia Mavroudas and Maggie McClain for your feedback and editing skills. Special thanks to my family for being there every step of the way: to my Mom, who put her own plans in second place to help me achieve my dreams; and to my Dad and my brother, who always cheered for me with every goal I accomplished. Thanks to Tom and Sherry, who loved me like one of their own children and encouraged me to follow my dreams. To George Mason, who has been by my side unconditionally during this journey; thank you for showing me what a true companion is all about. Finally, to my beloved grandmother, who believed in me and always knew I was going to accomplish any goal I set out to achieve.

This manuscript was submitted on March 23, 2012.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

SEXUAL DIMORPHISM AND SOCIOECONOMIC STATUS:

COMPARISON BETWEEN MIGRANT AND

NON-MIGRANT POPULATIONS

by

Cristina Figueroa - Soto, B.S.

Texas State University-San Marcos

May 2012

SUPERVISING PROFESSOR: M. KATHERINE SPRADLEY

Variation in sexual dimorphism is related to average body size differences and limb proportions between males and females between and within populations (Charisi et al. 2011). The Female Buffering Hypothesis suggests that expression of sexual dimorphism relies on male susceptibility to impairment in long bone length during episodes of stress, while females are buffered from the same conditions due to reproductive demands (Charisi et al. 2011; Frayer and Wolpoff 1985; Gray and Wolfe 1980; Greulich 1951; Rickland and Tobias 1986; Stini 1969; Stinson 1985). This study evaluates the degree of sexual dimorphism to determine if differences in the expression of sexual dimorphism exist between a migrant and non-migrant sample from Mexico.

The sexual dimorphism index (SDI) was calculated for 26 postcranial measurements in a migrant group of United States–Mexico border crossing fatalities from Tucson, Arizona (n=119), non-migrant groups from the state of Hidalgo in Mexico (n=44), and American White individuals from the Forensic Anthropology Data Bank (FDB) (n=92). A Multivariate Analysis of Variance (MANOVA) indicated no significant differences in the expression of sexual dimorphism between the three samples, suggesting that sexual dimorphism cannot be used as a proxy to estimate the health and nutritional status of a population (Eveleth 1975). Results from an Analysis of Variance (ANOVA) with a Tukey test indicated no significant difference on long bone length dimensions between migrant and non-migrant samples. Because no significant differences were found in the expression of sexual dimorphism between the three samples, possible environmental factors affecting the variation seen in most of the measurements were examined. Significant differences in long bone length, articular surfaces, proximal and distal ends and the midshaft of long bone lengths were found when the migrant and non-migrant samples were compared to the American White samples. Potential explanations for the significant differences can be attributed to the interaction of diet, socioeconomic status, and division of labor. Furthermore, the observed differences in long bone length when comparing American Whites to both Mexican samples demonstrate the need for population specific methods for the identification of individuals considered Hispanic.

CHAPTER I

INTRODUCTION

Sexual dimorphism is related to differences in body size and dimension in the proportion of skeletal remains between males and females (Charisi et al. 2011; Hamilton 1975; Iscan et al. 1998; Rios-Frutos 2005; Stinson 1985). Many studies have demonstrated that there is variation in the expression of sexual dimorphism between and within populations (Charisi et al. 2011; Hamilton 1982; Himes et al. 1976; Iscan et al. 1998; Malina et al. 1981; Rickland and Tobias 1986; Rios-Frutos 2005; Stini 1969; Stini 1975; Stinson 1985). Previous studies have suggested that population groups experiencing some type of environmental stress will present a lower degree of sexual dimorphism, while population groups not exposed to the same conditions will show a higher degree of sexual dimorphism (Hamilton 1975; Malina et al. 1981; Rickland and Tobias 1986; Stini 1969; Stini 1972). There is no single factor that contributes to the variation in sexual dimorphism between populations, but rather an interaction of many factors (Frayer and Wolpoff 1985). This study evaluates the degree of sexual dimorphism between three populations in an attempt to examine different environmental factors affecting individuals within and between migrant and non-migrant population groups from Mexico.

Anthropometric dimensions of humans respond to environmental factors in both positive and negative ways (Bogin et al. 2002; Frayer and Wolpoff 1985; Steckel 2005;

Stinson 1985). Environmental factors may include diet, socioeconomic status, and division of labor. Previous studies have also indicated that sexual dimorphism can be affected by the genetic composition of an individual (Deng et al. 2003; Koller et al. 2001; Liu et al. 2004). For example, population groups living in environments of high socioeconomic development with a stable and balanced nutrition should fully develop and reach their full genetic potential, while population groups living under conditions of malnutrition and lower socioeconomic development should experience growth retardation (Frayer and Wolpoff 1985; Hamilton 1982; Inwood and Roberts 2010; Stinson 1985). The many factors that influence sexual dimorphism may partly explain why it is so difficult to distinguish and explain the degrees to which it varies within a population.

It is known that males are usually larger in body size and skeletal dimensions than females, therefore there is a basic level of sexual dimorphism expected across all populations (Hall 1978). However, this is not always the case and deviations from the expected level can occur between males and females. Previous studies have suggested that environmental stressors can affect males more than females during growth and development (Frayer and Wolpoff 1985; Stinson 1985). This is known as the Female Buffering Hypothesis and it suggest that males are more vulnerable to fluctuations in times of nutritional shortage, as a result reducing the degree of sexual dimorphism in the population group (Frayer and Wolpoff 1985; Stinson 1985). This is in contrast to females, which are less affected by environmental stress and are more stable under the same conditions (Gray and Wolfe 1980; Iscan et al. 1998; Rios-Frutos 2005). A possible factor affecting female buffering to environmental stress is the burden of childbirth (Frayer and Wolpoff 1985; Greulich 1951; Stini 1975; Stinson 1985). It is presumed that the metabolic and physiological demands of pregnancy activate hormonal mechanisms to mediate deficiencies in the presence of nutritional shortage (Frayer and Wolpoff 1985; Greulich 1951; Stini 1975; Stinson 1985).

One of the earliest studies demonstrating that males are more affected by the environment was conducted by Greulich with Guamanian children in 1951. Greulich found that the skeletal age of males was greatly retarded by food deprivation and poverty during the Japanese occupation, resulting in males being smaller than females. After Greulich, similar studies have been conducted over the years comparing environmentally stressed groups with less stressed groups to further document the impact of environmental factors on sexual dimorphism (Hamilton 1982; Rickland and Tobias 1986; Stini 1975; Stinson 1985; Wolfe and Gray 1982).

In 1978, Hall identified several factors that contribute to variation in sexual dimorphism while researching Amerindian populations from the Northwest Coast. She identified secular and age related changes that affected males more than females. Specifically, Hall states that environmental fluctuations such as climate, nutrition, and "culture's economic base" (Hall 1978:170) could be a factor in average male size. Tobias in 1962 showed that the secular trend in stature among the Bushmen had affected males and females to different degrees. He classified the Bushman groups into three linguistic categories; Northern, Southern and Central Bushman. Among the Northern and Central groups an increase in stature was evident almost twice as much in males than females, and consequently an increase in the degree of sexual dimorphism was reflected. An increase in stature was also evident for the Southern group, were by 1937 the male increment was of 22 mm in comparison to the female increment of 14 mm (Tobias 1962).

Together, these studies offer insight into how dietary and socioeconomic factors can influence the degree of sexual dimorphism between and within population groups (Bogin et al. 2002; Hall 1978; Tobias 1962).

Environmental and Genetic Factors of Sexual Dimorphism

Diet

Diet is one of the most important environmental factors that affects sexual dimorphism (Charisi et al. 2011). Malnutrition of a population usually leads to a reduction in sexual dimorphism, while a well-nourished population is expected to have higher degrees of sexual dimorphism (Frayer and Wolpoff 1985; Greulich 1957). Stini (1972) demonstrated that under severe and prolonged nutritional stress, delays in growth appear to be more pronounced in males. His research compared the upper arm circumference of older individuals suffering from chronic protein malnutrition with published data of individuals from the United States and Peru. Stini found that sexual dimorphism in the upper arm is reduced by protein deficiencies, which delay muscle growth and resorption of muscle tissue in males. A similar study comparing a Guatemalan and a Unites States population group found that deficiencies in muscle fat and muscle protein reduced sexual dimorphism in the Guatemalan sample (Martorell et al. 1976).

Jantz and Jantz (1999) studied changes in long bone lengths in several skeletal collections from the United States, and found a generally positive trend over time toward increased long bone length for males and females. One of the most important findings was that the overall increase in bone length was associated with improvements in the nutritional and health environments in which the people lived.

Previous studies have also suggested that nutrition varies from urban to rural communities around the world. Malina et al. (1981) studied children from a rural indigenous community and two urban communities in Oaxaca, Mexico and found that the urban children were significantly taller, heavier, and more muscular than the rural children. They found that these differences are more pronounced in males than females, and a reduction in the mid-arm muscle circumference in rural boys was evident. According to Malina et al. (1981), the cause for such differences is that children in rural communities are relatively undernourished compared to children from urban areas in Oaxaca. They also suggested a possible protein deficiency in the diet of most rural communities to be one of the causes for the differences between boys and girls (Malina et al. 1981).

Socioeconomic Status (SES)

Socioeconomic factors play a significant role in the variation of sexual dimorphism. Being of low SES may contribute to variation in sexual dimorphism among individuals, particularly in stature or long bone length proportions (Fogel et al. 1982; Komlos 1994) . As a result, changes in stature can be considered a good estimator of the standards of living of a population (Fogel et al. 1982; Komlos 1994). Stature tends to be lower for groups under conditions of nutritional stress and low SES, and can increase with improved diet during growth and development (Bogin 2002; Frayer and Wolpoff

1985; Steckel 1994). In particular, leg growth is more susceptible to environmental and physiological changes than other regions of the skeleton (Nyati et al. 2006).

Goldstein (1943) compares stature and hand dimensions in a series of children born in Texas with Mexican born parents with children born and raised in Mexico. Stature and hand dimensions tended to increase in size between parents and their children in Texas, and these differences are greater than the families that stayed in Mexico (Goldstein 1943). The author believes the new and beneficial environment play a key role in the differences in stature.

Division of Labor

Another factor that affects the degree of sexual dimorphism is work load, which is dependent on division of labor. Previous studies have shown that sexual dimorphism was greater in groups in which division of labor was practiced (Carlson et al. 2007; Charisi et al. 2011). In studying robusticity and sexual dimorphism, Carlson et al. (2007) found significant sexual dimorphism in the upper limbs rather than in the lower limbs of modern hunter-gatherers from Australia. The authors point out that possible explanations for this phenomenon could relate to weapon choice, food preparation activities, transportation of heavy loads, swimming, or paddling (Carlson et al. 2007).

Holden and Mace (1999) conducted a similar study on non-industrialized populations and found that when females had a significant contribution to food production, thus elevating their nutritional status, they were relatively taller than males. Wolfe and Gray (1982) tested whether contemporary agricultural populations are less sexually dimorphic than modern hunter-gatherers. Using stature data for males and females, they found that agriculturalists were more sexually dimorphic than hunter-gatherers.

Genetics

In addition to environmental factors, an individual's genetic composition is believed to have a significant impact on the degree of sexual dimorphism. It has been stated that long bone length is determined genetically, but not in the same manner between and within populations (Charisi et al. 2011; Hall 1985). Genetic studies on bone size variation have found several regions on chromosome 17 for the hip, wrist, and spine that account for bone size variation (Deng et al. 2003). Additionally, Koller et al. (2001) identified a genomic region that is responsible for the size variation of the femoral head on Chinese populations.

A previous study conducted on a Chinese sample of 393 families found a major gene of codominant inheritance for the size of some vertebral bones (Liu et al. 2004). Results of the study also found that the same gene may be interacting with sex and age related genes. This suggests a possible differentiation in bone size between males and females, and furthermore within populations (Liu et al. 2004). The results of research on the relationship between genetics and sexual dimorphism further add to the complexity of understanding the factors that determine sexual dimorphism.

Sexual Dimorphism and Mexican Migration to the United States

The expression of sexual dimorphism seen between population groups has been an important focus in studies of migrants and non-migrant populations (Bogin et al 1997; Malina et al. 1981; Goldstein 1943; Lasker and Evans 1961). Lasker and Evans (1961) compared anthropometric measurements in migrant and non-migrant from Michoacán, Mexico. They examined whether or not there are significant differences in the mean dimensions between individuals born in and who have always lived in Michoacán, individuals born in Michoacán but who migrated to the United States at some point in their lives, and individuals living in Michoacán who were born in the United States of Mexican parents. One of the significant differences found between the samples was that the migrant sample from the Unites States who returned to Michoacán shows longer upper limbs in males compared to the other two samples (Lasker and Evans 1961).

Bogin et al. (1997) conducted research between Mayan populations that migrated to the United States and a Mayan population that lived in a rural village in Guatemala. They observed that families that invested economic and social resources in their children tended to have taller children. They state that children who continue to live in the rural villages are shorter on average than the Guatemalan children who migrated to the United States. Studies on migrant and non-migrant populations present a platform on which to conduct new studies on the variation of sexual dimorphism between migrant and non-migrant samples from Mexico. In the present study the expression of sexual dimorphism was examined between a migrant sample that attempted to cross the Unites States–

Mexico border with and non-migrant samples from Zimapán in the State of Hidalgo in Mexico.

There has been a continuous influx of Mexican migrants to the United States ever since the agricultural and railroad employers in the United States began recruiting workers from Mexico around the mid-1880s (Cornelius 1981). Based on previous nationwide surveys in Mexico, the northern and central regions of the country supplied the majority of Mexican migrants to the United States (Cornelius 1981). By 1942 United States–Mexico migration was induced by the Bracero Program, a temporary worker program initiated by the United States government (Cornelius 1981; Duran and Massey 1992). The program lasted 22 years, and approximately 4.6 million Mexican migrants entered the United States (Duran and Massey 1992). After the program ended, almost 5 million Mexicans were detained and deported to Mexico, thus supporting the belief that the program had created an incentive for undocumented individuals to cross the United States–Mexico border. After these events, many individuals from Mexico are still crossing through the Sonora desert every year to enter the United States. As a result, hundreds of individuals from Mexico die every year while attempting to cross the border between Mexico and the United States illegally (Anderson and Parks 2008).

As the number of border crosser fatalities increase, the creation of population-specific methods to identify these individuals becomes imperative. In the Unites States, forensic identification criteria for the estimation of age, ancestry, sex and stature are based on known collections from American Black and White individuals. Yet, the demographic structure of the Unites States has been shifting with the significant immigration waves from Mexico, Central and South America. Current methods of sex estimation used by forensic anthropologist misclassify Hispanic males as females approximately 60 percent of the time (Spradley et al. 2008). Because methods of identification are dependent on a population's degree of sexual dimorphism, especially the influence of many environmental factors, these factors should be taken into account in the creation of a biological profile for skeletal remains of Hispanic ancestry.

Individuals from Mexico have experienced a distinctive set of environmental stressors that makes them a unique population to study. Economic fluctuation and political instability have been important factors affecting the biological conditions of individuals from Mexico. This was most apparent by the late 19th century, when the president of Mexico Porfirio Diaz set a rapid economic growth and industrialization without benefiting the lower-class Mexicans (Carson 2008). A previous study has shown that the height of adult Mexicans in the late 19th century declined by 1 centimeter (cm) when Porfirio Diaz took control of Mexico (Carson 2008). Therefore, the stature of many communities in Mexico was affected in comparison to Mexicans born in the U.S, who tended to grow taller. These events suggest that the differences in SES between populations in Mexico had a significant impact on the growth and development of many population groups in Mexico (Carson 2008).

Understanding that the growth and development of Mexican populations has been influenced by significant factors, this study will examine the degree of sexual dimorphism between two groups from Mexico (migrants and non-migrants), and compare the groups to an American White group. The goal of this research is twofold: 1) to test the Female Buffering Hypothesis using migrant and non-migrant groups from Mexico;

and 2) to apply the knowledge of previous studies based on sexual dimorphism into forensic practice by examining the variation between groups in Mexico.

It is expected to see the migrant group to present the lowest degree of sexual dimorphism, and the American White sample to present the highest degree of sexual dimorphism (Figure 1). The non-migrant sample is expected to show an intermediate degree between the migrant and American White sample. It is assumed that the non-migrant sample belongs to a higher SES than the migrant sample because they never had to leave their country of origin to improve their economic status.

One widely studied aspect of Mexican migration to the Unites States is the question of which social classes migrate (Duran and Massey 1992) and various studies suggest that migrants come from a low SES, based on the rationale that the wealthy and middle sector of the population have no motivation to migrate (Cornelius 1981; Duran and Massey 1992). The American White sample used in this study is assumed to belong to a middle-high SES based on demographic information provided by the Forensic Anthropology Data Bank (FDB); therefore, the sample will also serve as a way to compare the SES of individuals between the United States and Mexico.

Based on the Female Buffering hypothesis, it is expected for migrant males to be more affected by the possible environmental stressor than males from the non-migrant and American White sample. By examining the variation between migrants and non-migrants, a new understanding of the biological variation of individuals that attempt to cross the United States–Mexico border, as well as individuals from Mexico, will be available for many forensic anthropologists across the United States.

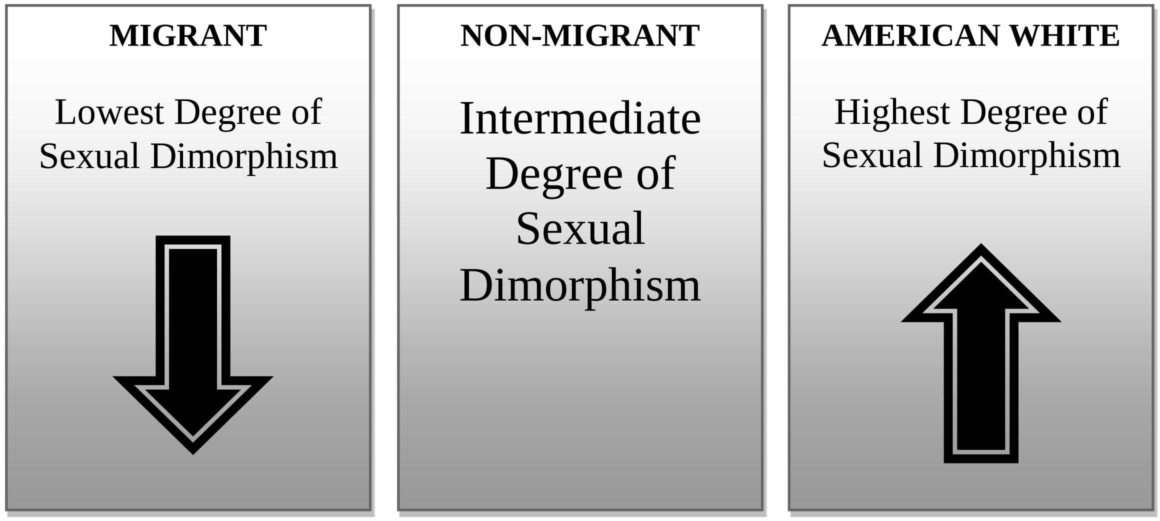

Figure1: Predictions for the Present Study.

CHAPTER II

MATERIALS AND METHODS

Materials

In order to determine any degree of sexual dimorphism between the migrant and non-migrant population, three samples were obtained. The skeletal materials of the migrant population were obtained from the Pima County Office of the Medical Examiner (PCOME) in Tucson, Arizona. This group represents recent deaths from migrants who died crossing the United States–Mexico border. The United States Border Patrol (USBP) finds and delivers border crossing fatalities from the Arizona and Mexico border to the PCOME all year round (Anderson 2008). With the collaboration of different agencies, the PCOME attempts to identify these individuals. Between 2001 and 2007, the PCOME reported over 1,000 deaths resulting from crossing the United States–Mexico border, and death rates continue to increase every year (Anderson and Parks 2008). Even though the remains found along the Arizona border are known for having poor preservation due to the harsh conditions from the Sonora desert, the PCOME has a 70 percent rate of identification for these individuals (Anderson 2008; Spradley et al. 2008). Additionally, approximately 94 percent of the border crossing fatalities are identified as Mexican nationals (Anderson 2008; Spradley et al. 2008). This high percentage of migrants from

Mexico is beneficial to the study because it places the migrant and non-migrant samples within the same geographical region.

One trip was made to the PCOME during December of 2010, and the postcranial elements of 28 individuals considered Hispanic were measured. To increase the sample size of this project, additional postcranial measurements from the PCOME database maintained by Dr. Kate Spradley were added. These additional data were collected during the periods of 2009 to 2011 by other trained researchers associated with *Project Identification*, directed by Dr. Kate Spradley. In total, the PCOME sample consists of 41 females and 78 males considered Hispanic.

Many of these border crossing fatalities are pending identification; as a result, only individuals contextually identified or with a present pelvis for the estimation of sex were used in the study. If the sex of an individual needed to be determined, pelvic morphology was utilized. The morphological traits used to determine sex on the pelvis included the ventral arc, subpubic concavity, and medial aspect of the ischiopubic ramus (Phenice 1969). Studies found that these morphological traits on the pelvis have an accuracy of over 95 percent when estimating the sex of an individual (France 1997; Phenice 1967; Ubelaker and Volk 2002). All human remains were completely skeletonized, and only well-preserved adults were used in the sample. Based on the nature of this sample, most individuals did not have demographic information available. However, based on previous studies, migrants that travel via the United States–Mexico border are thought to come from lower-middle income areas (Cornelius 1981; Duran and Massey 1992).

The second population group used in this study is from the municipality of Zimapán in the state of Hidalgo in Mexico. This collection is curated at the *Universidad Nacional Autónoma de México (UNAM)* and represents a modern, non-migrant population whose birth years range from early to mid-20th century. Most of the adult males practiced the occupation of mining. The community of Zimapán asked a group of students from the *Instituto Nacional de Antropología e Historia* to relocate a cemetery located in the atrium of the Santiago Apóstol church. The removal of all the burials from the cemetery was necessary in order to proceed with the restoration of the church. After the cleaning and inventory of each individual, relatives were able to relocate the remains of their family member to other cemeteries. However, many skeletal remains were donated to *UNAM* due to the fact that many families did not have money for the relocation of the remains. Skeletal remains not claimed by relatives were ceded to *UNAM* by the State of Hidalgo. The current curator in charge of the Zimapán Collection conducted several investigations in order to obtain demographic information from the unclaimed donations.

Two trips were made to Mexico City by the author during April and August of 2011. Over this period, postcranial elements of 20 females and 24 males were measured, for a total of 44 individuals. Based on previous investigations, demographic information was obtained on some individuals, including occupation, age at death, and cause of death. This information was utilized to predict what, if any, environmental factors are involved in the levels of expression of sexual dimorphism.

A third sample of American White individuals from the Forensic Anthropology Data Bank (FDB) was added to the study for comparative purposes. The postcranial measurements available at the FDB are submitted from forensic cases by forensic anthropologists from all over the United States, although it has a southeastern bias (Spradley et al. 2008). Each case is positively identified with known demographic information, including sex, ancestry, age, and occupation. This population sample is made up of 92 American White individuals, consisting of 30 females and 62 males. Birth years for this sample include individuals born after 1940 to account for secular trends in stature in the United States. A complete count of the samples used in this study and the distribution of the postcranial elements used is presented in Table 1.

Table 1: Total Sample Size and Distribution of the Postcranial Elements Studied (Left Side Only)

Group	Sex	No. of Individuals	Clavicle	Humerus	Ulna	Femur	Tibia	Fibula
Migrant (PCOME)	Males	78	25	22	17	49	40	31
	Females	41	14	18	10	26	19	13
	Total	119	39	40	27	75	59	44
Non-migrant (ZIMAPAN)	Males	24	18	16	16	23	21	17
	Females	20	14	16	15	17	17	16
	Total	44	32	32	31	40	38	33
American White (FDB)	Males	62	48	52	46	52	53	44
	Females	30	19	22	18	25	23	17
	Total	92	67	74	64	77	76	61

Measurements

The same measurement definitions for data collection were used on the migrant and non-migrant populations. Postcranial measurements outlined in Zobeck (1983) were used on all migrant and non-migrant samples. A copy of the data sheet collection and definitions can be found in Appendices A and B, respectively. Measurements from the FDB were previously collected using the *Standards for Data Collection for Human Skeletal Remains* compiled by Buikstra and Ubelaker (1994). Table 2 presents the abbreviation and description of each measurement used in the present study. Based on standard procedures, only postcranial measurements from the left side were recorded. Measurements were taken with an osteometric board, a GPM spreading caliper, a GPM sliding caliper, and a tape measure. Bones with healed fractures or severe degenerative disorders were not included in the sample due to possible changes on the length and size of the bone.

Methods

Postcranial measurements from all three samples were entered into an Excel worksheet and separated by sex for each sample. Statistical analysis was conducted with the aid of the Statistical Analysis Software (SAS 9.1.3) to assess the significance of sexual dimorphism and interpopulation variation in the sample. Descriptive statistics were generated for each group of males and females in each sample. The sexual dimorphism index (SDI) was calculated using the average value for each measurement on each group of males and females. The SDI formula used in this study is based on Hamilton (1975):

$$\frac{\bar{X}male - \bar{X}female}{\bar{X}male} \times 100$$

The SDI provides an indicator of male to female size differences within each population group. However, the SDI does not take into account sample size or variation. To explore any significant variation in the expression of sexual dimorphism a statistical approach is necessary.

A Multivariate Analysis of Variance (MANOVA) was performed to test the effects of group, sex, and interaction between group and sex for the migrant, the non-migrant, and the American White sample for all postcranial elements. The MANOVA is a statistical test that compares the multivariate means of the three samples used in this study, and tests the significance of the mean differences. The MANOVA will test for the presence of sexual dimorphism. If a significant effect or interaction is found in the MANOVA results, an Analysis of Variance (ANOVA) with Tukey (Post Hoc) was performed to determine where the significant differences lie between the group means.

Table 2: Abbreviation and Description of Each Measurement Used in the Present Study

Abbreviation	**Description**
CLAXLN	Clavicle maximum length (Bass 1987)
CLAAPD	Clavicle anterior-posterior diameter at midshaft (Moore-Jansen et al. 1994)
CLAVRD	Clavicle superior-inferior diameter at midshaft (Moore-Jansen et al. 1994)
HUMXLN	Humerus maximum length (Bass 1987)
HUMMXD	Hum maximum diameter at midshaft (Zobeck 1983)
HUMMWD	Hum minimum diameter at midshaft (Bass 1987)
HUMHDD	Hum maximum diameter of head (Bass 1987)
HUMEBR	Humerus epicondylar breadth (Zobeck 1983)
ULNXLN	Ulna maximum length (Bass 1987)
ULNDVD	Ulna anterior-posterior diameter of midshaft (Moore-Jansen et al. 1994)
ULNTVD	Ulna medial-lateral diameter of midshaft (Moore-Jansen et al. 1994)
ULNCIR	Ulna least circumference of shaft (Bass 1987)
FEMXLN	Femur maximum length (Bass 1987)
FEMMAP	Femur anterior-posterior diameter at midshaft (Bass 1987)
FEMMTV	Femur medial-lateral diameter at midshaft (Bass 1987)
FEMHDD	Femur maximum vertical diameter of head (Zobeck 1983)
FEMEBR	Femur epicondylar breadth (Zobeck 1983)
FEMCIR	Femur circumference midshaft (Moore-Jansen et al. 1994)
TIBXLN	Tibia condylo-malleolar length (Zobeck 1983)
TIBPEB	Tibia maximum breadth of proximal epiphysis (Zobeck 1983)
TIBDEB	Tibia maximum breadth of distal epiphysis (Zobeck 1983)
TIBNFX	Tibia anterior-posterior diameter of nutrient foramen (Bass 1987)
TIBNFT	Tibia medial-lateral diameter nutrient foramen (Bass 1987)
TIBCIR	Tibia circumference at nutrient foramen (Bass 1987)
FIBXLN	Fibula maximum length (Bass 1987)
FIBMDM	Fibula maximum diameter of midshaft (Moore-Jansen et al. 1994)

CHAPTER III

RESULTS

Sexual Dimorphism Index

The sexual dimorphism index was calculated using Hamilton's (1975) equation. The sexual dimorphism index indicates what percent larger the male sample is compared with the female sample. A complete count of the sexual dimorphism index results can be found in Table 3.

Clavicle

Results for the maximum length of the clavicle (CLAXLN) show the migrant sample as the most dimorphic, followed by the non-migrant and the American White sample, respectively. For the clavicle anterior-posterior diameter of the midshaft (CLAAPD), the American White sample is the most dimorphic, followed by the non-migrant and migrant sample. For the clavicle superior-inferior diameter of the midshaft (CLAVRD), the non-migrant sample shows the highest levels of sexual dimorphism, followed by the American White and the migrant samples. Results are presented in Figure 2.

Table 3: Sexual dimorphism index (%)

Bone	Measurements	MIGRANTS	NON-MIGRANT	AMERICAN WHITE
Clavicle	CLAXLN	11.17	10.12	9.45
	CLAAPD	14.74	18.51	20.00
	CLAVRD	11.74	18.59	14.14
Humerus	HUMXLN	8.70	9.52	10.25
	HUMMXD	12.51	10.44	15.40
	HUMMWD	18.08	11.81	19.59
	HUMHDD	13.00	14.07	14.25
	HUMEBR	14.86	11.21	16.29
Ulna	ULNXLN	8.12	10.89	10.91
	ULNDVD	15.63	13.45	17.91
	ULNTVD	18.81	16.79	21.70
	ULNCIR	16.10	11.65	12.31
Femur	FEMXLN	7.61	8.74	9.51
	FEMMAP	11.71	10.94	10.41
	FEMMTV	11.83	13.80	13.74
	FEMHDD	14.23	11.00	13.97
	FEMEBR	15.52	9.48	11.86
	FEMCIR	11.64	12.10	10.50
Tibia	TIBXLN	9.26	9.08	10.13
	TIBPEB	13.35	10.41	12.55
	TIBDEB	14.81	10.46	12.015
	TIBNFX	10.70	13.31	12.78
	TIBNFT	9.62	14.82	13.10
	TIBCIR	11.60	14.65	13.49
Fibula	FIBXLN	11.48	9.52	11.22
	FIBMDM	10.89	9.23	10.42

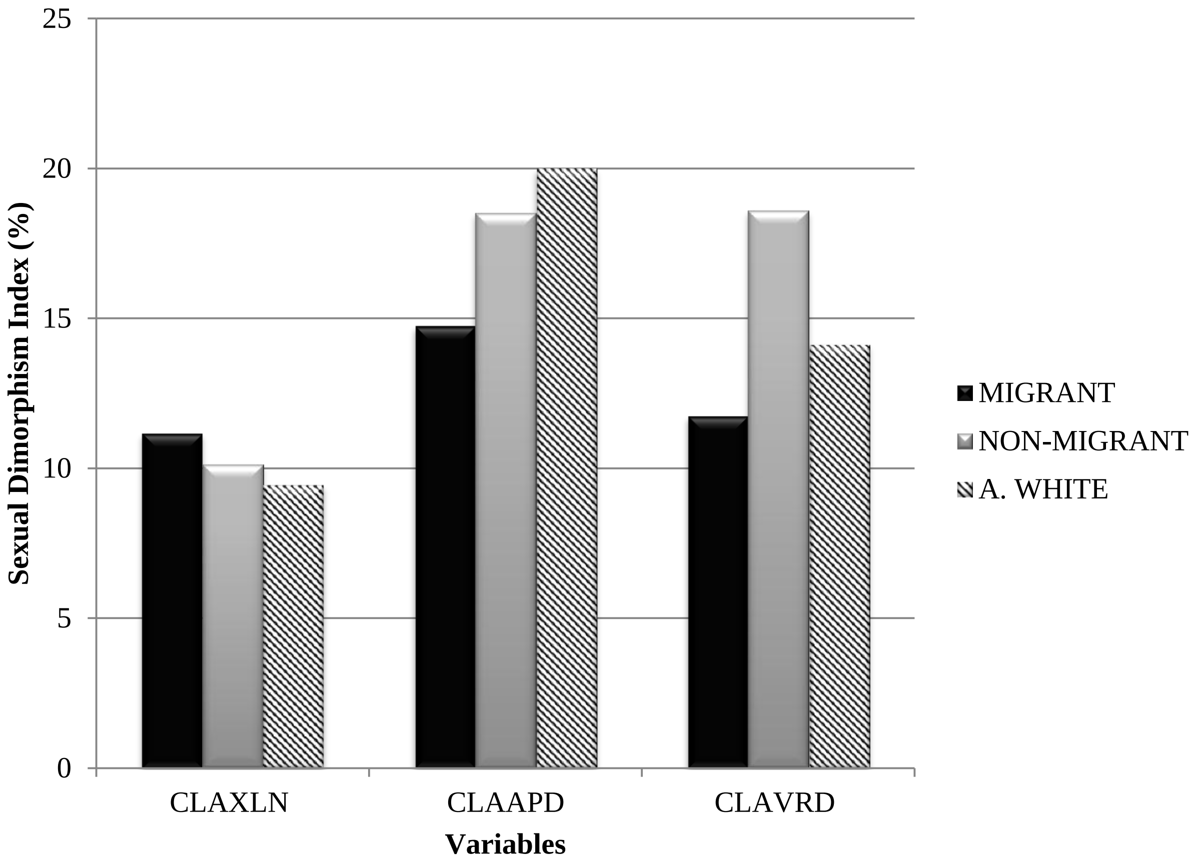

Figure 2: Sexual Dimorphism Index for the Clavicle for the Migrant, Non-migrant, and American White Samples.

Humerus

Results for the maximum length of the humerus (HUMXLN) indicate that the American White sample has the highest levels of sexual dimorphism, followed by the non-migrant sample. The migrant sample showed the lowest levels of sexual dimorphism for this same measurement. The American White sample showed the highest degree of sexual dimorphism in the humerus maximum and minimum diameter of the midshaft (HUMMXD, HUMMWD) and humeral epicondylar breadth (HUMEBR), while the migrant sample showed degrees of sexual dimorphism higher than the non-migrant samples in the same three measurements. The American White and non-migrant sample presented similar levels of sexual dimorphism for the maximum diameter of the humeral head (HUMHDD), while the migrant showed the lowest levels of sexual dimorphism. Results are presented in Figure 3.

Ulna

The American White and non-migrant sample show similar degrees of sexual dimorphism for the maximum length of the ulna (ULNXLN), while the migrant sample shows the lowest levels of sexual dimorphism. For the anterior-posterior and medial-lateral diameter of the midshaft (ULNDVD, ULNTVD), the American White sample presents the highest degrees of sexual dimorphism, followed by the migrant and non-migrant sample, respectively. The highest degree of sexual dimorphism for the circumference at the midshaft (ULNCIR) is seen on the migrant sample, followed by the American White sample. The non-migrant sample presented the lowest level of sexual dimorphism for this measurement. Results are presented in Figure 4.

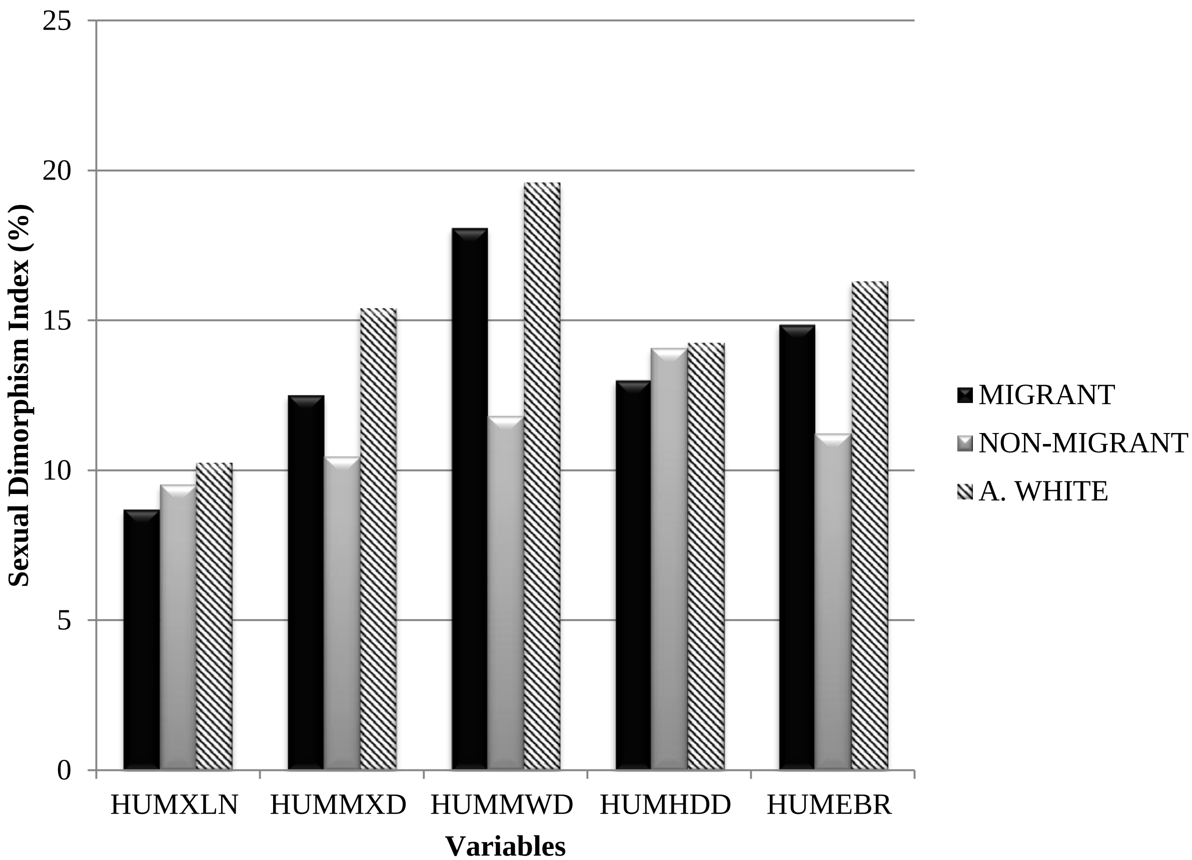

Figure 3: Sexual Dimorphism Index for the Humerus for the Migrant, Non-migrant, and American White Samples.

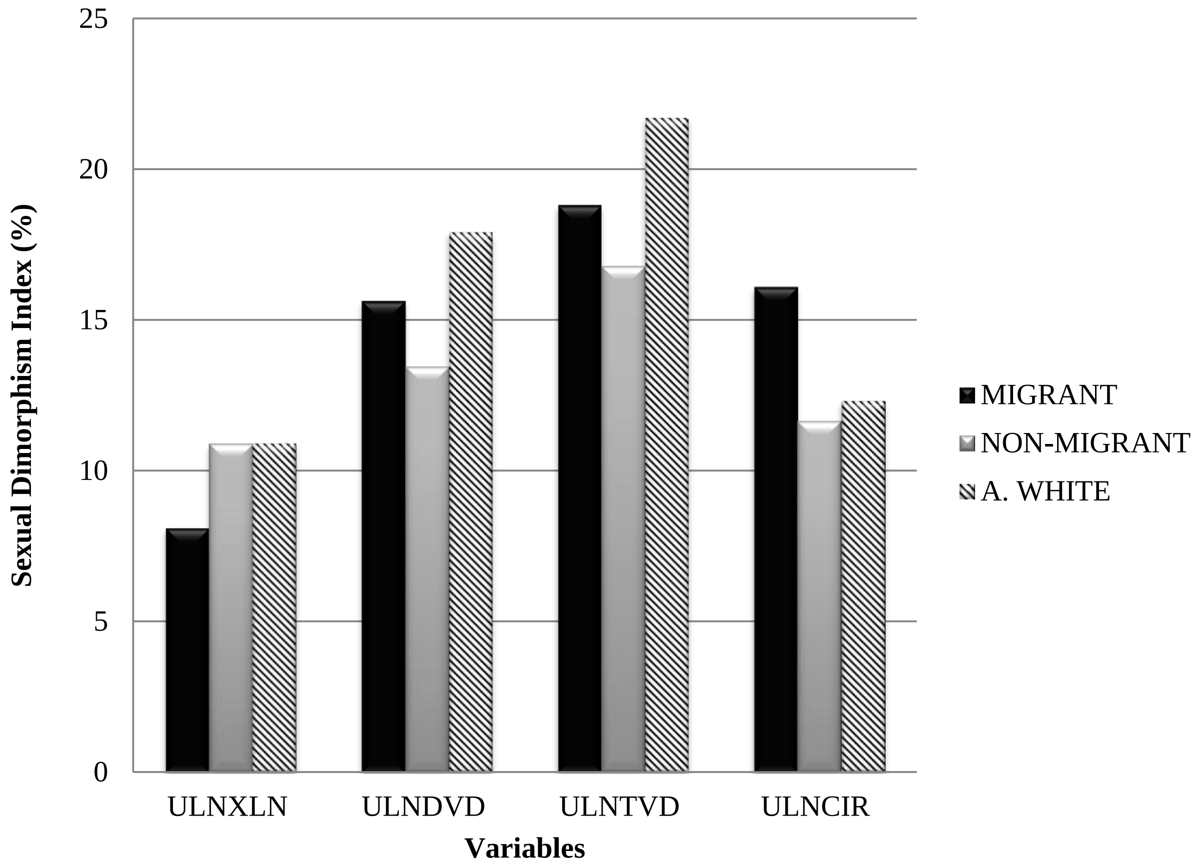

Figure 4: Sexual Dimorphism Index for the Ulna for the Migrant, Non-migrant, and American White Samples.

Femur

Results for the maximum length of the femur (FEMXLN) show that the American White sample has the highest levels of sexual dimorphism, and the non-migrant and migrant sample follow, respectively. For the femur anterior-posterior diameter of the midshaft (FEMMAP), the migrant sample has the highest levels of sexual dimorphism. The American White sample presents the lowest degree of sexual dimorphism, while the non-migrant sample presents an intermediate degree between the migrant and American White sample. The medial-lateral diameter of the midshaft (FEMMTV) presents the lowest levels of sexual dimorphism in the non-migrant sample, while the migrant and American White sample present similar results (Figure 5).

Results for the vertical diameter of the femoral head (FEMHDD) show that the American White and migrant samples display similar results, while the non-migrant sample presents the lowest degree of sexual dimorphism. The epicondylar breadth of the femur (FEMEBR) presents the highest degree of sexual dimorphism for the migrant sample, followed by the American Whites and the non-migrant sample, respectively. For the circumference at the midshaft (FEMCIR), the non-migrant sample presents the highest degree of sexual dimorphism, followed by the migrant and the American White sample (Figure 5).

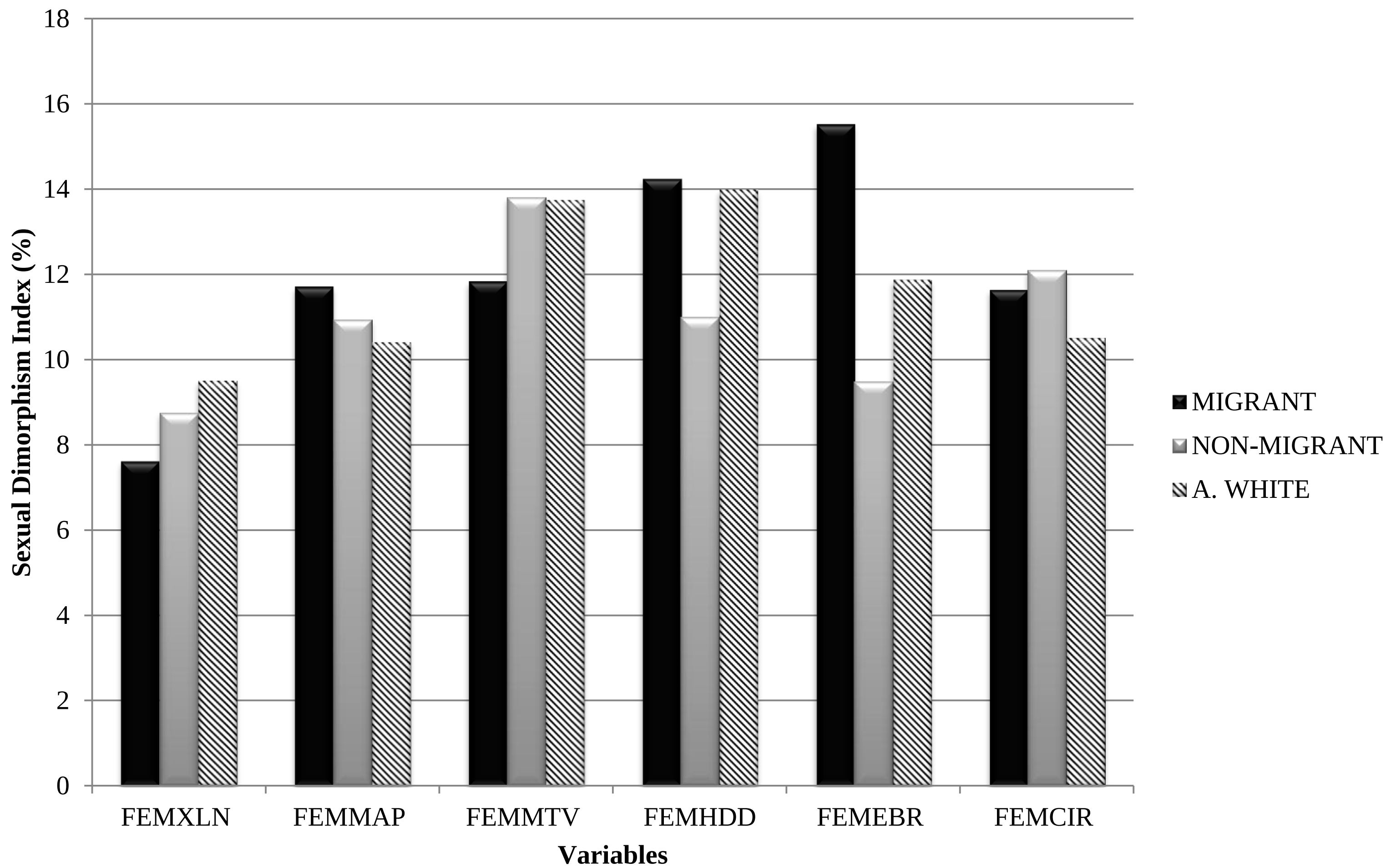

Figure 5: Sexual Dimorphism Index for the Femur for the Migrant, Non-migrant, and American White Samples.

<u>Tibia</u>

For the tibia condylo-malleolar length (TIBXLN) the American White sample presents the highest degree of sexual dimorphism, followed by the migrant and non-migrant sample, respectively. For the maximum breadth of the proximal and distal epiphysis (TIBPEB, TIBDEB), the non-migrant sample presents the highest degree of sexual dimorphism. The American White sample presents the lowest degree of sexual dimorphism, while the non-migrant sample shows intermediate results from the American White and migrant sample (Figure 6).

The tibia anterior-posterior and medial-lateral diameter at the nutrient foramen (TIBNF, TIBNFT) show that the non-migrant sample has the highest degree of sexual dimorphism, whereas the migrant sample presents the lowest levels of sexual dimorphism. The American White sample presents an intermediate degree between the migrant and non-migrant sample. For the circumference of the tibia at the nutrient foramen (TIBCIR), the non-migrant sample presents the highest level of sexual dimorphism, followed by the American White and the migrant samples, respectively (Figure 6).

<u>Fibula</u>

For the fibula maximum length (FIBXLN) and the maximum diameter at the midshaft (FIBMDM), the migrant sample presents the highest levels of sexual dimorphism, followed by the American White sample. The non-migrant sample presents the lowest degree of sexual dimorphism for both measurements. Results are presented in Figure 7.

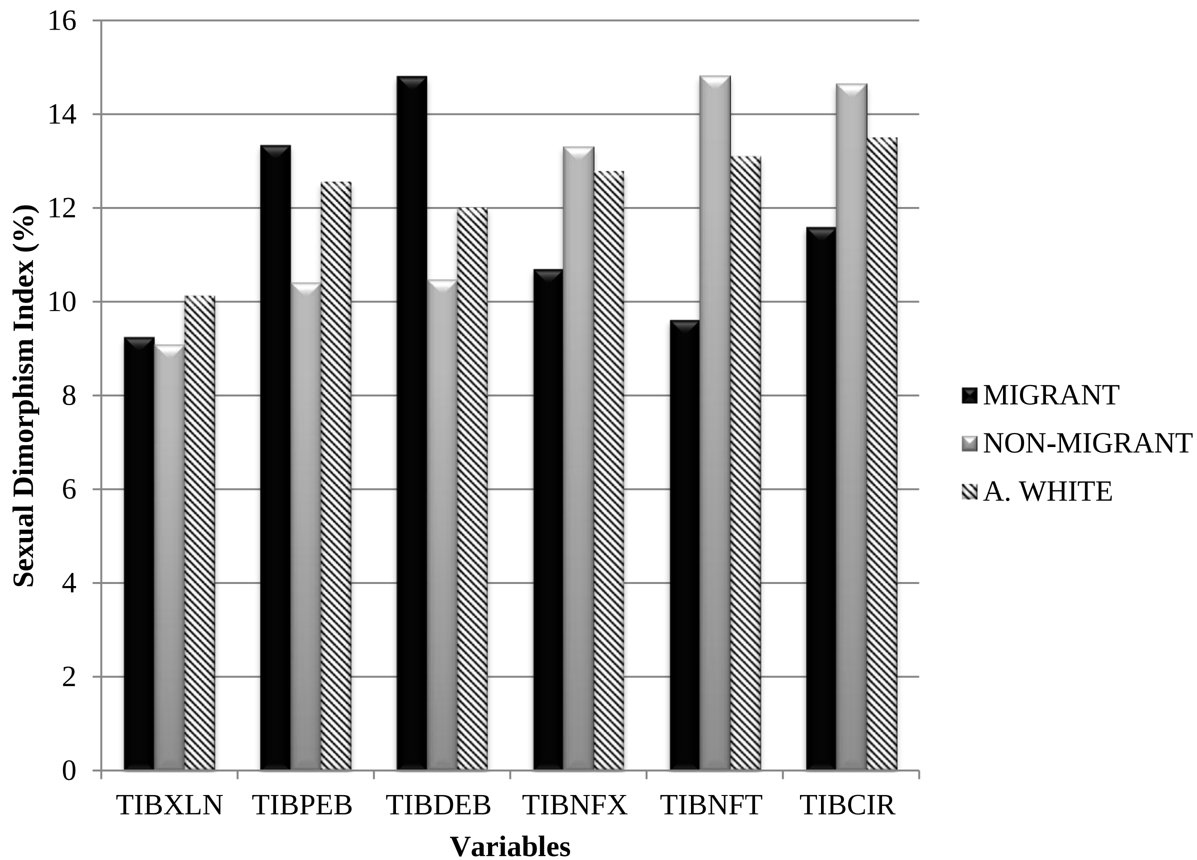

Figure 6: Sexual Dimorphism Index for the Tibia for the Migrant, Non-migrant, and American White Samples.

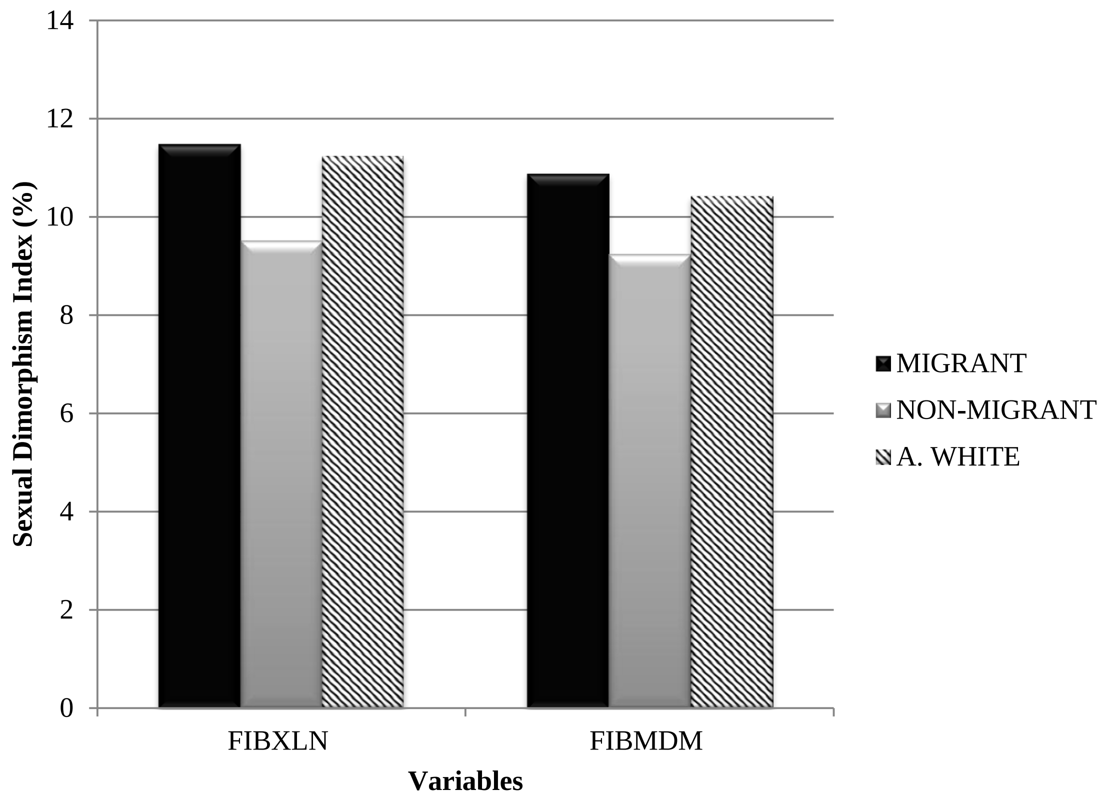

Figure 7: Sexual Dimorphism Index for the Fibula for the Migrant, Non-migrant, and American White Samples.

Descriptive Statistics

Descriptive statistics for each set of measurements include mean, standard deviation, and maximum and minimum value (Appendix C). It is evident that males have higher values than females for all dimensions examined on each sample. The results for the significance differences between means in the Analysis of Variance (ANOVA) also demonstrate that the differences of the mean value between males and females are statistically significant in all cases (p<0.0001).

Multivariate Analysis of Variance (MANOVA)

The Multivariate Analysis of Variance (MANOVA) tested the effects of group, sex, and the interaction of group and sex for each sample. The MANOVA results indicate that significant differences exist in both group and sex between the three samples in all the postcranial elements studied. No significant group and sex interaction was found between the three groups. Table 4 presents the results for the MANOVA, which include Wilk's lamba, F value, degrees of freedom, and probability.

All postcranial elements showed a significant difference in both group and sex at the $p < 0.0001$ level. Results for the effect of group and sex interaction in the clavicle show a probability of 0.6980, indicating no significant differences in the interaction between group and sex. Same results were found for the humerus (probability: 0.188), ulna (probability: 0.4271), femur (probability: 0.2360), tibia (probability: 0.1822) and fibula (probability: 0.2707) where no significant interaction between group and sex was found (Table 4).

Table 4: Multivariate Analysis of Variance (MANOVA) Results for the Effect of Group, Sex, and an Interaction between Group and Sex for the Migrant, Non-migrant, and American White Samples

Element	**Effect**	**Wilk's Lamba**	**F Value**	**Degrees of freedom**	**Pr>F**
Clavicle	*Group*	0.6875	6.80	6,198	**<.0001***
	Sex	0.4233	44.95	3,99	**<.0001***
	Group and Sex	0.9623	0.64	6,198	0.6980
Humerus	*Group*	0.3932	13.08	10,220	**<.0001***
	Sex	0.3357	43.53	5,110	**<.0001***
	Group and Sex	0.8850	1.38	10,220	0.188
Ulna	*Group*	0.5305	5.67	10,152	**<.0001***
	Sex	0.4130	21.60	5,76	**<.0001***
	Group and Sex	0.8779	1.02	10,152	0.4271
Femur	*Group*	0.3365	7.88	18,196	**<.0001***
	Sex	0.2768	28.44	9,98	**<.0001***
	Group and Sex	0.8065	1.24	18,196	0.2360
Tibia	*Group*	0.4428	7.12	12,170	**<.0001***
	Sex	0.3393	27.58	6,85	**<.0001***
	Group and Sex	0.8309	1.37	12,170	0.1822
Fibula	*Group*	0.5163	16.84	4,172	**<.0001***
	Sex	0.4517	52.18	2,86	**<.0001***
	Group and Sex	0.9420	1.30	4,172	0.2707

*Significant Differences at the p<.0001.

Analysis of Variance (ANOVA) with Tukey (Post Hoc)

After significant differences were identified between the three samples, an Analysis of Variance (ANOVA) with Tukey test was performed to locate significant differences between the means on each measurement for each sample at $p<0.05$ (Table 5 and Table 6).

Males

Significant differences were found between the migrant and non-migrant samples at the p<0.05, which include the clavicle maximum length (CLAXLN), ulna anterior-posterior diameter of the shaft (ULNDVD), anterior-posterior diameter of femoral shaft (FEMMAP), maximum vertical diameter of femoral head (VHD), femur epicondylar breadth (FEMEBR), tibia maximum breadth of distal epiphysis (TIBPEB), and the tibia medial-lateral diameter of the nutrient foramina (TIBNFT) (Table 5).

When comparing the migrant and American White samples, significant differences were found on most of the measurements, except for the clavicle maximum length (CLAXLN), clavicle anterior-posterior diameter of the midshaft (CLAAPD), clavicle superior-inferior diameter of the midshaft (CLAVRD), ulna anterior-posterior diameter of shaft (ULNDVD), ulna least circumference of the shaft (ULNCIR), femur epicondylar breadth (FEMEBR), tibia maximum breadth of distal epiphysis (TIBPEB), the tibia medial-lateral diameter of the nutrient foramina (TIBNFT), and the fibula maximum diameter of the midshaft (TIBNFT) (Table 5).

Significant differences were found on most of the measurements when comparing the non-migrant sample to the American White sample. No significant differences were found on the ulna least circumference of the shaft (ULNCIR), the femur medial-lateral diameter at midshaft (FEMMAP), tibia maximum breadth of the distal epiphysis (TIBDEB), and the fibula maximum diameter of the midshaft (FIBMDM) (Table 5).

Table 5: Analysis of Variance (ANOVA) with Tukey (Post Hoc) Results for the Differences in Males between the Migrant, Non-migrants, and American White Samples

Bone	Measurement	Group Comparison	Mean Difference	Significance
Clavicle	CLAXLN	Migrant vs. A. White	-1.152	.864
		Non-migrant vs. Migrant	-7.980	**.012***
		Non-migrant vs. A. White	-9.132	**.000***
	CLAAPD	Migrant vs. A. White	-.835	.118
		Non-migrant vs. Migrant	-.567	.480
		Non-migrant vs. A. White	-1.402	**.009***
	CLAVRD	Migrant vs. A. White	-.640	.184
		Non-migrant vs. Migrant	-.971	.062
		Non-migrant vs. A. White	-1.611	**.000***
Humerus	HUMXLN	Migrant vs. A. White	-29.491	**.000***
		Non-migrant vs. Migrant	-7.855	.358
		Non-migrant vs. A. White	-37.346	**.000***
	HUMMXD	Migrant vs. A. White	-1.630	**.005***
		Non-migrant vs. Migrant	-1.290	.115
		Non-migrant vs. A. White	-2.920	**.000***
	HUMMWD	Migrant vs. A. White	-1.984	**.000***
		Non-migrant vs. Migrant	-1.080	.122
		Non-migrant vs. A. White	-3.064	**.000***
	HUMHDD	Migrant vs. A. White	-3.988	**.000***
		Non-migrant vs. Migrant	-1.981	.096
		Non-migrant vs. A. White	-5.969	**.000***
	HUMEBR	Migrant vs. A. White	-4.570	**.000***
		Non-migrant vs. Migrant	-2.813	.083
		Non-migrant vs. A. White	-7.382	**.000***
Ulna	ULNXLN	Migrant vs. A. White	-19.886	**.003***
		Non-migrant vs. Migrant	-2.375	.932
		Non-migrant vs. A. White	-22.261	**.000***
	ULNDVD	Migrant vs. A. White	.647	.536
		Non-migrant vs. Migrant	-2.397	**.004***
		Non-migrant vs. A. White	-1.750	**.017***
	ULNTVD	Migrant vs. A. White	-2.672	**.001***
		Non-migrant vs. Migrant	.651	.711
		Non-migrant vs. A. White	-2.021	**.016***
	ULNCIR	Migrant vs. A. White	-3.059	.230
		Non-migrant vs. Migrant	-.370	.983
		Non-migrant vs. A. White	-3.429	.123

*Significant Differences at $p<0.05$

Table 5: Continued

Bone	Measurement	Group Comparison	Mean Difference	Significance
Femur	FEMXLN	Migrant vs. A. White	-40.724	**.000***
		Non-migrant vs. Migrant	-13.077	.099
		Non-migrant vs. A. White	-53.801	**.000***
	FEMMAP	Migrant vs. A. White	-1.296	**.021***
		Non-migrant vs. Migrant	-2.030	**.002***
		Non-migrant vs. A. White	-3.326	**.000***
	FEMMTV	Migrant vs. A. White	-1.685	**.004***
		Non-migrant vs. Migrant	1.152	.153
		Non-migrant vs. A. White	-.500	.702
	VHD	Migrant vs. A. White	-3.137	**.000***
		Non-migrant vs. Migrant	-1.724	**.023***
		Non-migrant vs. A. White	-4.861	**.000***
	FEMEBR	Migrant vs. A. White	-.417	.919
		Non-migrant vs. Migrant	-5.839	**.000***
		Non-migrant vs. A. White	-6.256	**.000***
	FEMCIR	Migrant vs. A. White	-3.976	**.022***
		Non-migrant vs. Migrant	-2.736	.201
		Non-migrant vs. A. White	-6.712	**.001***
Tibia	TIBXLN	Migrant vs. A. White	-34.341	**.000***
		Non-migrant vs. Migrant	-5.321	.733
		Non-migrant vs. A. White	-39.662	**.000***
	TIBPEB	Migrant vs. A. White	-2.884	**.011***
		Non-migrant vs. Migrant	-3.235	**.013***
		Non-migrant vs. A. White	-6.119	**.000***
	TIBDEB	Migrant vs. A. White	-.464	.840
		Non-migrant vs. Migrant	-1.050	.520
		Non-migrant vs. A. White	-1.514	.173
	TIBNFX	Migrant vs. A. White	-2.642	**.000***
		Non-migrant vs. Migrant	-.426	.853
		Non-migrant vs. A. White	-3.068	**.000***
	TIBNFT	Migrant vs. A. White	-.092	.985
		Non-migrant vs. Migrant	-2.006	**.015***
		Non-migrant vs. A. White	-2.098	**.008***
	TIBCIR	Migrant vs. A. White	-4.653	**.048***
		Non-migrant vs. Migrant	-2.216	.549
		Non-migrant vs. A. White	-6.869	**.009***
Fibula	FIBXLN	Migrant vs. A. White	-28.484	**.000***
		Non-migrant vs. Migrant	-14.774	.186
		Non-migrant vs. A. White	-43.258	**.000***
	FIBMDM	Migrant vs. A. White	-.658	.363
		Non-migrant vs. Migrant	-.664	.455
		Non-migrant vs. A. White	-1.322	.057

*Significant Differences at $p<0.05$

Females

Significant differences were found between the migrant and non-migrant samples at $p<0.05$, which include the maximum diameter of the humeral head (HUMHDD), the femur maximum length (FEMXLN), the femur medial-lateral diameter at midshaft (FEMMAP), and the tibia maximum breadth of distal epiphysis (TIBPEB) (Table 6).

When comparing the migrants with the American White samples, significant differences were found on the maximum length of the humerus (HUMXLN), humerus maximum diameter of the midshaft (HUMMXD), maximum diameter of the humeral head (HUMHDD), femur maximum length (FEMXLN), femur medial-lateral diameter at midshaft (FEMMAP), maximum vertical diameter of femoral head (VHD), femur epicondylar breadth (FEMEBR), femur circumference at the midshaft (FEMCIR), the tibia maximum length (TIBXLN), tibia maximum breadth of the distal epiphysis (TIBDEB), and fibula maximum length (FIBXLN) (Table 6).

For the comparison of non-migrants with the American White samples, significant differences were found on most of the measurements except for clavicle anterior-posterior diameter of the midshaft (CLAAPD), clavicle superior-inferior diameter of the midshaft (CLAVRD), maximum diameter of the humeral head (HUMHDD), ulna anterior-posterior diameter of shaft (ULNDVD), ulna medial-lateral diameter of the midshaft (ULNTVD), femur medial-lateral diameter at midshaft (FEMMTV), tibia maximum breadth of the distal epiphysis (TIBDEB), and fibula maximum length (FIBXLN) (Table 6).

Table 6: Analysis of Variance (ANOVA) with Tukey (Post Hoc) Results for the Differences in Females between the Migrant, Non-migrants, and American White Samples

Bone	**Measurement**	**Group Comparison**	**Mean Difference**	**Significance**
Clavicle	CLAXLN	Migrant vs. A. White	-3.732	.273
		Non-migrant vs. Migrant	-5.208	.119
		Non-migrant vs. A. White	-8.939	**.001***
	CLAAPD	Migrant vs. A. White	-.017	1.00
		Non-migrant vs. Migrant	-.879	.380
		Non-migrant vs. A. White	-.896	.334
	CLAVRD	Migrant vs. A. White	-.302	.908
		Non-migrant vs. Migrant	-1.451	.161
		Non-migrant vs. A. White	-1.752	.055
Humerus	HUMXLN	Migrant vs. A. White	-21.604	**.003***
		Non-migrant vs. Migrant	-9.846	.293
		Non-migrant vs. A. White	-31.450	**.000***
	HUMMXD	Migrant vs. A. White	-.737	.260
		Non-migrant vs. Migrant	-.778	.289
		Non-migrant vs. A. White	-1.515	**.009***
	HUMMWD	Migrant vs. A. White	-1.338	**.005***
		Non-migrant vs. Migrant	.178	.916
		Non-migrant vs. A. White	-1.161	**.024***
	HUMHDD	Migrant vs. A. White	-2.847	**.000***
		Non-migrant vs. Migrant	-2.277	**.005***
		Non-migrant vs. A. White	-5.123	**.000***
	HUMEBR	Migrant vs. A. White	-2.950	.068
		Non-migrant vs. Migrant	-.200	.989
		Non-migrant vs. A. White	-3.150	**.048***
Ulna	ULNXLN	Migrant vs. A. White	-10.619	.168
		Non-migrant vs. Migrant	-8.571	.333
		Non-migrant vs. A. White	-19.190	**.001***
	ULNDVD	Migrant vs. A. White	.887	.597
		Non-migrant vs. Migrant	-1.700	.177
		Non-migrant vs. A. White	-.813	.592
	ULNTVD	Migrant vs. A. White	-1.675	.101
		Non-migrant vs. Migrant	.871	.539
		Non-migrant vs. A. White	-.804	.511
	ULNCIR	Migrant vs. A. White	-2.532	.112
		Non-migrant vs. Migrant	-.397	.944
		Non-migrant vs. A. White	-2.929	**.028***

*Significant Differences at p<0.05

Table 6: Continued

Bone	Measurement	Group Comparison	Mean Difference	Significance
Femur	FEMXLN	Migrant vs. A. White	-28.519	**.000***
		Non-migrant vs. Migrant	-16.409	**.037***
		Non-migrant vs. A. White	-44.929	**.000***
	FEMMAP	Migrant vs. A. White	-1.548	**.040***
		Non-migrant vs. Migrant	-1.604	**.050***
		Non-migrant vs. A. White	-3.152	**.000***
	FEMMTV	Migrant vs. A. White	-.929	.111
		Non-migrant vs. Migrant	.583	.465
		Non-migrant vs. A. White	-.345	.774
	VHD	Migrant vs. A. White	-2.817	**.001***
		Non-migrant vs. Migrant	.100	.991
		Non-migrant vs. A. White	-2.717	**.001***
	FEMEBR	Migrant vs. A. White	-3.464	**.003***
		Non-migrant vs. Migrant	.011	1.00
		Non-migrant vs. A. White	-3.452	**.007***
	FEMCIR	Migrant vs. A. White	-4.559	**.014***
		Non-migrant vs. Migrant	-2.807	.156
		Non-migrant vs. A. White	-7.366	**.000***
Tibia	TIBXLN	Migrant vs. A. White	-27.676	**.000***
		Non-migrant vs. Migrant	-3.500	.843
		Non-migrant vs. A. White	-31.176	**.000***
	TIBPEB	Migrant vs. A. White	-3.136	**.028***
		Non-migrant vs. Migrant	-.173	.988
		Non-migrant vs. A. White	-3.309	**.013***
	TIBDEB	Migrant vs. A. White	-1.889	.163
		Non-migrant vs. Migrant	1.514	.319
		Non-migrant vs. A. White	-.375	.899
	TIBNFX	Migrant vs. A. White	-1.597	.093
		Non-migrant vs. Migrant	-1.128	.362
		Non-migrant vs. A. White	-2.726	**.003***
	TIBNFT	Migrant vs. A. White	.810	.511
		Non-migrant vs. Migrant	-3.033	**.001***
		Non-migrant vs. A. White	-2.223	**.014***
	TIBCIR	Migrant vs. A. White	-2.239	.546
		Non-migrant vs. Migrant	-4.555	.078
		Non-migrant vs. A. White	-6.795	**.008***
Fibula	FIBXLN	Migrant vs. A. White	-26.235*	**.000***
		Non-migrant vs. Migrant	-6.067	.463
		Non-migrant vs. A. White	-32.302	**.000***
	FIBMDM	Migrant vs. A. White	-.662	.593
		Non-migrant vs. Migrant	-.272	.914
		Non-migrant vs. A. White	-.933	.332

*Significant Differences at $p<0.05$

CHAPTER IV

DISCUSSION

This study evaluates the degree of sexual dimorphism between migrant and non-migrant population groups from Mexico to determine if differences in sexual dimorphism exist. Previous studies have shown that variation in sexual dimorphism can be used as a sensitive indicator of the quality of life, and have supported the assumption that males are more adversely affected by stressful environmental factors than females (Charisi et al. 2011; Gray and Wolfe 1980; Greulich 1951; Rickland and Tobias 1986; Stini 1969; Stinson 1985) However, results from this study do not support this theory.

Sexual Dimorphism

Results of this study demonstrate there is sexual dimorphism expressed in each sample, which results in morphological differences between males and females. However, the analysis of this study suggests that no major difference in the expression of sexual dimorphism was found between the migrant, non-migrant and American White samples. Due to the fact that many studies have demonstrated that sexual dimorphism responds to environmental stress (Charisi et al. 2011; Gray and Wolfe 1980; Greulich 1951; Rickland and Tobias 1986; Stini 1969; Stinson 1985), it was expected that both migrant and non-migrant samples would show lower levels of sexual dimorphism than the American White sample, due to the biological conditions most Mexican individualsfaced during the 19th century with the political and economic instability of Mexico(Carson 2008). During the 1846 and 1848 Mexico and the United States engaged in a major conflict, which did not benefit the lower class Mexicans. Additionally, by the time of the Porfiriato, during the end of the 19th century, was characterized by a rapid economic growth and a severe impoverishment for many rural areas in Mexico.

Based on numerous theories claiming that migrant groups tend to belong to a lower socioeconomic class (SES) (Cornelius 1981; Duran and Massey 1992; Heyman 2001; Singer and Massey 1998), it was expected that migrants would present the lowest expression of sexual dimorphism of the three samples based on evidence that males are more affected by environmental stressors than females (Charisi et al. 2011; Gray and Wolfe 1980; Greulich 1951; Rickland and Tobias 1986; Stini 1969; Stinson 1985). However, results from this study do not confirm these assumptions. This unexpected result may suggest that sexual dimorphism is not an indicator of the environmental conditions a population experiences over time. Similar results were found by Eveleth (1975), who compared stature data from Amerindian, European, and Black populations and concluded that the greatest sexual dimorphism was found in Amerindian populations. Eveleth (1975) suggests that Amerindian populations as a whole are not better nourished than European populations, indicating that the higher degree in sexual dimorphism could be caused by genetics, rather than the environment. Thus, she claims that the use of sexual dimorphism as an indicator of environmental conditions in a population could lead to many errors.

The Sexual Dimorphism Index (SDI) formula used in this study was formulated by Hamilton (1975) and it represents a numerical scale of sexual dimorphism from each measurement in each population. Thus, it only reports how much larger males are from females in each population group, without taking into account sample size or variation. After estimating the SDI, a Multivariate Analysis of Variance (MANOVA) should be conducted to determine statistical significance. If a MANOVA is not included along with the SDI, results can be misleading. Only results that are statistically significant on the interaction of sex and group can suggest that a variation in the expression of sexual dimorphism between populations exist. If no significant differences are present, the SDI should not be used to determine the expression of sexual dimorphism between groups. An example of this problem can be seen in Hamilton's (1975) work were most of her reported results from the MANOVA are non-significant; however, Hamilton suggests that a pattern in sexual dimorphism is seen between five Amerindian groups (Hamilton 1975). Caution is recommended when utilizing and interpreting the SDI.

Female Buffering Hypothesis

Along with this, these results also challenge the basis of the Female Buffering Hypothesis, which states that males are more susceptible to environmental changes than females, in both positive and negative aspects (Charisi et al. 2011; Gray and Wolfe 1980; Greulich 1951; Rickland and Tobias 1986; Stini 1969; Stinson 1985). Significant differences were seen when comparing migrant and non-migrant females for the femur maximum length (FEMXLN) and the vertical diameter of the humeral head (HUMHDD).

This significant variation in both of these measurements is another factor that contrasts with the Female Buffering Hypothesis on the grounds that if males are more sensitive to environmental stressors than females, variation in any measurement should be noted more in males than in females. However, this significant difference in females is important because it highlights the existence of differences in the measurements of population groups within Mexico.

Many studies use sexual dimorphism as a proxy of the nutritional and health status of populations, and consequently the Female Buffering Hypothesis has been widely accepted. However, the results of several studies contradict this theory (Greulich 1957; Gustafsson et al. 2007). Greulich (1957) compared the physical growth of American-born Japanese children living in California to children of the same sex and age in Japan. Greulich found that both American-born Japanese and Japanese girls exceed in stature compared to boys in each group. He points out that the average stature of males and females increased in Japan between 1900 and 1952; however, the increase in males was by only 2.4 percent, whereas females increased by 4.4 percent (Greulich 1957). If the assumption is that males are more sensitive to environmental stress, then males would have been expected to grow taller than females in Japan.

A recent study from Sweden using stature data on males and females from the 10th to the end of the 20th century on males and women found an increase in stature during the 20th century due to improved living conditions (Gustafsson et al. 2007). However, no significant evidence for an increase in the degree of sexual dimorphism was seen by the 20th century. Gustafsson et al. (2007) suggests that if environmental conditions improved, males would have been expected to grow faster than females, based on the assumption that males are more sensitive to environmental factors than females. However, his results show no significant differences in the degree of sexual dimorphism by the time the increase in stature occurred (Gustafsson et al. 2007).

Postcranial Differences between Population Groups

Although no significant differences were found in the interaction of group and sex between the samples, significant differences were found within groups and among the sexes. Significant differences in long bone lengths, articular surfaces, proximal and distal epiphysis and midshaft of long bone lengths are apparent when comparing the three samples. The American White sample show greater mean values than the migrant and non-migrant sample.

Migrant vs. Non-migrants

When comparing bone lengths between migrant and non-migrant males, no significant differences were found. Additionally, significant differences were found between the migrant and non-migrant males on the vertical diameter of the femoral head (FEMHDD), the anterior-posterior diameter at the midshaft of the femur (FEMMAP), the epicondylar breadth of the femur (FEMEBR), the tibia proximal breadth (TIBPEB) and the tibia medial-lateral diameter at the nutrient foramen (TIBNFT). Results could indicate differences in the level of robusticity for the lower limbs in both samples. Previous studies attribute variation in the dimensions of the lower limb to robusticity, which could be related to higher mobility and sex-based division of labor (Carlson et al. 2007; Ruff

1988). Based on the occupations of the non-migrant sample, it could be inferred that strenuous mining activity may be a factor in the variation of most of these measurements. However, due to differences in the division of labor, hormonal factors, and musculature in males and females, it is difficult to assess the differences in both migrant and non-migrant samples (Pomeroy and Zakrzewski 2009; Ruff and Larsen 2001).

Migrant and Non-migrant vs. American White

Differences in measurements are more significantly apparent when comparing the American White sample with migrant and non-migrant samples. Significant differences in long bone length were found on all measurements for both male and females, except for the maximum length of the ulna in females. This suggests significant differences between males and females from Mexico and the United States on most of the long bone lengths.

The magnitude of the variation in long bone length varies between societies and is susceptible to diet and SES (Carson 2008; Hall 1978). A study on the skeletal growth of residents from Heliconia, Colombia, was performed to test for the relative effects of protein deficiency on the skeleton (Stini 1969). When the sample was compared to Unites States standards, a reduction in stature was seen and attributed to the lack of protein in their diet (Stini 1969). Based on this previous study, it could be inferred that the variation in the long bone measurements seen between the American White sample and both migrant and non-migrant samples could also be attributed to a possible lack of protein. Diets in most regions of Mexico are mainly vegetarian, consisting of beans, rice, chiles, bread, and tortillas, with very limited protein (Carson 2008). When comparing both migrant and non-migrant samples with the American White sample, diet could be a possible environmental factor affecting these significant differences.

Previous studies have also suggested that variation in lower limb proportions can be used as a sensitive indicator of the quality of life (Carson 2008; Fogel et al. 1983; Hall 1978; Komlos 1990; Wolfe and Gray 1982). Stature tends to be lower for groups under conditions of nutritional stress and low SES, and can be increased with improved diet during growth and development (Bogin et al. 2002; Frayer and Wolpoff 1985; Steckel 2005). In particular, leg growth is more susceptible to environmental and physiological changes than other regions of the skeleton (Jantz and Jantz 1999; Nyati et al. 2006). During the first half of the 20th century, stature increased considerably in most developed countries around the world (Carson 2008; Lopez-Alonso and Condey 2003). However, Mexico only encountered a slight increase in stature, suggestive of the declining biological standards of living at the time (Lopez-Alonso and Condey 2003). These events might indicate that both the migrant and non-migrant samples may have lived in a harsher environment than the American White sample.

Additionally significant differences were also found on some of the articular surfaces, proximal and distal ends, and midshafts of long bones on both migrant and non-migrant males and females, when compared to the American White sample. Midshaft locations are the site at which the highest bending loads occur. With this knowledge, the results of this study suggest that any of these three samples was possibly performing some type of strenuous job (Carlson et al. 2007). Another explanation for these differences may be hormonal differences between males and females. For example, some studies have shown that hormones mediate osseous responses to mechanical load differently in males and females, especially later in life when females lose more bone density than males (Carlson et al. 2007; Holliday and Ruff 2001; Ruff 1988).

It must be noted that environmental forces are acting on predetermined genetic models unique for a population (Charisi et al. 2011). It is known that the dimensions and size of individual bones, especially the length, is in part dependent on the genetic factors of a population (Charisi et al. 2011; Cowgill and Hager 2007). Because both migrant and non-migrant samples come from Mexico, genetics could be a possible factor for the variation between the samples from Mexico and the U.S. sample.

Sex Estimation in Hispanic Individuals

Even though no significant variation was seen in most of the postcranial measurements between migrants and non-migrants, a significant difference between both samples from Mexico and the United States is evident. This emphasizes the need to create population-specific criteria for individuals from Mexico for all forensic anthropologists across the United States. However, this study only refers to individuals from Mexico, and does not necessarily reflect the biological variation found in populations considered Hispanic as defined by the United States Census Bureau (www.census.org).

Results from this study were compared to a research on classification rates for sex estimation on Hispanic individuals by Tise et al. (forthcoming). She ranked the postcranial elements according to their accuracy in estimating sex, and determined a cross-validated classification rate for each element using a similar sample of migrants from the Pima County Office of the Medical Examiner (PCOME). When cross-validated classification rates are compared to previous research on American White and Black individuals, these rates do not exceed 90 percent (Spradley and Jantz 2011). Several reasons may account for the low cross-validated classification rate, including differences in the expression of sexual dimorphism and differences in the dimensions of long bones between the samples. This study suggested that there is no evidence in the expression of sexual dimorphism within groups in Mexico; however significant differences in the dimensions of some postcranial elements were found within the two samples from Mexico.

Significant differences were found between the migrant, non-migrant and American White male samples for the maximum length of the clavicle (CLAXLN). Tise et al. (forthcoming) have suggested that the clavicle is one of the best elements for sex estimation on Hispanic individuals with a cross-validation rate for males of 81.25 percent. The low classification rate could be a reflection of the significant differences present between males from Mexico and the United States, but also within individuals from Mexico. Results from this study provide evidence to suggest that the maximum length of the clavicle (CLAXLN) is not one of the best elements for sex estimation due to the significant variation between the migrant and non-migrant sample.

Similar results are found when comparing migrant and non-migrant females on the vertical diameter of the humeral head (HUMHDD), which is considered one of the most accurate single measurements when estimating the sex of Hispanic individuals (Tise et al. forthcoming). Significant differences in the vertical diameter of the humeral head were found between all three female samples in this study. Significant differences were also found between the migrant and non-migrant males at the anterior-posterior diameter of the ulna (ULNDVD), the vertical diameter of the femoral head (FEMHHD), the femur epicondylar breadth (FEMEBR) and proximal breadth of tibia (TIBPEB). Cross-validated classification rates for these measurements on Hispanic males did not exceed 91 percent (Tise et al. forthcoming).These significant differences are a possible cause for the lower classification rates found in the previous research. Further studies on the creation of population specific methods for individuals considered Hispanic should take into account these significant differences, especially the maximum length of the clavicle (CLAXLN) and vertical diameter of the humeral head (HUMHDD) .

Limitations and Recommendations for Future Research

Some limitations within this research were encountered. The small sample size of females for the migrant sample is of concern, but it was the only migrant sample available at the time. Even though most of the migrant individuals are most likely from Mexico, the lack of demographic information was also a challenge. Mexico is a country with vast biological variation, and individuals that live in northern regions may not have the same environmental conditions or genetic makeup as a population from the south. Due to the lack of identification for this sample, individuals could have belonged to different regions in Mexico. To overcome these limitations, data with all positively identified individuals and from specific regions in Mexico should be used, as it accumulates, in the future. Additionally, the non-migrant sample belongs to a community from a low SES, and may not be representative of all non-migrant groups in Mexico.

CHAPTER V

CONCLUSION

This study of sexual dimorphism in a migrant and non-migrant sample attempts to examine if variation in the expression of sexual dimorphism exists in all three samples, and if so, to identify possible environmental factors impacting this variation. No variation in the degree of sexual dimorphism was seen between the three samples. Results from this study suggest that using the sexual dimorphism index (SDI) in regards to the Female Buffering Hypothesis leads to false assumptions. No significant evidence in this study was provided to suggest that environmental factors are affecting the expression of sexual dimorphism between the migrant, non-migrant and American White samples. Nonetheless, differences were seen between the three samples in some long bone lengths, articular surfaces, proximal and distal ends and at the midshaft of long bones.

The significant differences observed in some of the postcranial measurements between the two Mexican groups and the American Whites may have been influenced by many environmental factors, including diet, socioeconomic status (SES), and work load. The lack of protein in many diets across Mexico could have impacted the developmental growth of individuals from this sample. Additionally, the occupation of mining could have also impacted negatively on the articular surfaces, and proximal and distal ends of the non-migrant sample. Finally, the variation of many long bone lengths in both Mexican groups when compared to American White sample suggests that many of the individuals from the Mexican sample could belong to a lower SES. These results emphasize the need for understanding the cause of variation between populations from Mexico and the United States, as well as the need to incorporate the findings into forensic practice when identifying remains of Hispanic ancestry.

Results from this study present significant variation between migrants and non-migrants in the maximum length of the clavicle (CLAXNL) and the vertical diameter of the humeral head (HUMHDD), providing evidence of the variation seen within regions in Mexico. Thus, using these measurements for the estimation of sex in individuals considered Hispanics can provide some challenges. It must be taken into consideration that this study only examines the biological variation of individuals from Mexico and no other Hispanic populations. Based on the 2010 U.S. Census, the term Hispanic or Latino is defined as "a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture regardless of race" (www.census.org). This means that similar studies need to be undertaken in other areas of Central and South America in order to create appropriate identification methods for individuals considered Hispanic in the United States. The results of this research begin to provide evidence of the complex variation seen in individuals considered Hispanic when compared to American White individuals. Without the understanding of this large and diverse group, population-specific methods cannot be created and many Hispanic individuals will continue to remain unidentified.

APPENDIX A

TEXAS STATE UNIVERSITY-SAN MARCOS
SKELETAL MEASUREMENTS

ID #________________ Recorder:___________________ Date:_____________

Postcranial Measurements

Measurement	Code	Left	Right	Measurement	Code	Left	Right
1. Clavicle max length*	(CML-CLAXLN)	_____	_____	35. Ulna A-P diam shaft*	(UAB-ULNDVD)	_____	_____
2. Clavicle A-P diam midshaft*	(CSD-CLAAPD)	_____	_____	36. Ulna M-L diam midshaft*	(UMD-ULNTVD)	_____	_____
3. Clav S-I diam midshaft*	(CVD-CLAVRD)	_____	_____	37. Ulna least circum shaft*	(UMD-ULNCIR)	_____	_____
4. Scapula max height*	(SML-SCAPHT)	_____	_____	38. Sacrum anterior length*	(SAL-SACAHT)	_____	
5. Scapula max breadth*	(SMB-SCAPBP)	_____	_____	39. Sacrum A-S breadth*	(SAB-SACABR)	_____	
6. Scapula spine length	(SLS)	_____	_____	40. Sacrum max breadth S1*	(SMB-SACS1B)	_____	
7. Scapula supraspinous length	(SSL)	_____	_____	41. Innominate height*	(INH-INNOHT)	_____	_____
8. Scapula infraspinous length	(ISL)	_____	_____	42. Iliac breadth*	(ILB-ILIABR)	_____	_____
9. Scap glenoid cavity breadth	(GCB)	_____	_____	45. Femur max length*	(FML-FEMXLN)	_____	_____
10. Scap glenoid cavity height	(GCH)	_____	_____	46. Femur bicondylar length*	(FOL-FEMBLN)	_____	_____
11. Scap glenoid to inf angle	(GIL)	_____	_____	47. Femur trochanteric length	(FTL)	_____	_____
12. Manubrium length	(MML)	_____		48. Fem subtroch A-P diam	(APD)	_____	_____
13. Mesosternum length	(MSL)	_____		49. Fem subtroch M-L diam	(MLD)	_____	_____
14. Stenebra 1 width	(S1W)	_____		50. Fem A-P diam midshaft*	(APS-FEMMAP)	_____	_____
15. Stenebra 3 width	(S3W)	_____		51. Fem M-L diam midshaft*	(MLS-FEMMTV)	_____	_____
16. Humerus max length*	(HML-HUMXLN)	_____	_____	52. Fem max vert diam head*	(VDH-FEMHDD)	_____	_____
17. Hum prox epiph breadth	(BUE)	_____	_____	53. Fem max horiz diam head	(HHD)	_____	_____
18. Hum max diam midshaft*	(MDS-HUMMXD)	_____	_____	54. Fem A-P diam lat condyle	(APL)	_____	_____
19. Hum min diam midshaft*	(MDM-HUMMWD)	_____	_____	55. Fem A-P diam med condyle	(APM)	_____	_____
20. Hum max vert diam head*	(MDH-HUMHDD)	_____	_____	56. Fem epicondylar breadth*	(FEB-FEMEBR)	_____	_____
21. Hum epicondylar breadth*	(EBR-HUMEBR)	_____	_____	57. Fem bicondylar breadth	(BCB)	_____	_____
22. Hum least circum of shaft	(LCS)	_____	_____	58. Fem min vert diam neck	(VDN)	_____	_____
23. Radius max length*	(RML-RADXLN)	_____	_____	59. Femur circum midshaft*	(FCS-FEMCIR)	_____	_____
24. Radius max diam head	(RDH)	_____	_____	60. Tibia condylo-malle length*	(TML-TIBXLN)	_____	_____
25. Radius A-P diam of shaft*	(RSD-RADAPD)	_____	_____	61. Tibia max br prox epiph*	(BPE-TIBPEB)	_____	_____
26. Radius M-L diam of shaft*	(RTD-RADTVD)	_____	_____	62. Tibia max br dist epiph*	(BDE-TIBDEB)	_____	_____
27. Radius neck shaft circum	(MCS)	_____	_____	63. Tibia A-P diam nut for*	(APN-TIBNFX)	_____	_____
28. Ulna max length*	(UML-ULNXLN)	_____	_____	64. Tibia M-L diam nut for*	(MLM-TIBNFT)	_____	_____
29. Ulna physiological length*	(UPL-ULNPHL)	_____	_____	65. Tibia position of nut for	(CFL)	_____	_____
30. Ulna max br olecranon	(BOP)	_____	_____	66. Tibia cirum at nut for*	(PCN-TIBCIR)	_____	_____
31. Ulna min br olecranon	(MBO)	_____	_____	67. Fibula maximum length*	(BML-FIBXLN)	_____	_____
32. Ulna max wd olecranon	(WOP)	_____	_____	68. Fibula max diam midshaft*	(FMD-FIBMDM)	_____	_____
33. Ulna olec-radial notch	(ORL)	_____	_____	69. Calcaneus maximum length*	(CLL-CALCXL)	_____	_____
34. Ulna olec-coronoid length	(OCL)	_____	_____	70. Calcaneus middle breadth*	(CMB-CALCBR)	_____	_____

Mandible

Chin Height	(GNI)	_____		Bicondylar breadth	(CDL)	_____	
Body height @ mental for	(HMF)	_____	_____	Bigonial diameter	(GOG)	_____	
Body thickness @ mental for	(TMF)	_____	_____	Minimum ramus breadth	(WRB)	_____	_____

Numbers refer to associated Zobeck definition.
* Standard measurements

SAMPLE NUMBER: ____________________

Sex: ____________ **Age:** ____________

Date of birth: ________________________ **Place of birth:** ______________________________

Date of death: ________________________ **Place of death:** ______________________________

Height: Self Reported _______________ **Cadaver** ____________________

Ancestry (nationality): ________________________________

SES information:

____

____

NOTES:

____

____

____

____

____

____

____

____

____

____

____

____

APPENDIX B

Postcranial Measurements

(Taken from the *Manual for Post-cranial Measurements* by Javier Urcid (1992))

1. **Clavicle Maximum Length** (CML-CLAXLN): *Osteometric board*; maximum distance between the lateral and medial extremities. Place the sterna end of the clavicle against vertical end board and press the movable upright against the acromial end. The bone is moved from side to side and up and down until the maximum length is obtained. (Bass 1987)

2. **Clavicle Antero-Posterior Diameter of Midshaft** (CSD-CLAAPD): *Sliding caliper*; the distance from the anterior to the posterior surface of the midshaft. Determine the midpoint of the diaphysis on the osteometric board and mark it with a pencil. (Moore-Jansen et al. 1994)

3. **Clavicle Superior-Inferior Diameter of Midshaft** (CVD-CLAVRD): *Sliding caliper*; the distance from the cranial to the caudal surface of the midshaft. (Moore-Jansen et al. 1994)

4. **Humerus Maximum Length** (HML-HUMXLN): *Osteometric board*; Place the head against the fixed vertical of the board and adjust the movable upright to the distal end. Raise the bone slightly and move it up and down as well as from side to side until the maximum length is obtained. (Bass 1987)

5. **Humerus Breadth of Proximal Epiphysis** (BUE): *Osteometric board*; widest distance across the upper epiphysis; being sure to include the greater tubercle. (Zobeck 1983)

6. **Humerus Maximum Diameter of Midshaft** (MDS-HUMMXD): *Sliding Calipers*; taken at exactly mid length. Maximum diameter in an anterior – medial direction. (Bass 1987)

7. **Humerus Minimum Diameter of Midshaft** (MDM-HUMMWD): *Sliding calipers*; Diameter taken at right angle to the humerus maximum diameter of midshaft. (Bass 1987)

8. **Humerus Maximum Diameter of Head** (MDH-HUMHDD): *Sliding calipers*; Taken from a point at the edge of the articular surface of the bone across to the opposite side. The bone is rotated until the maximum distance is obtained. (Bass 1987)

9. **Humerus Epicondylar breadth** (EBR-HUMEBR): *Sliding calipers*; maximum distance across the epicondyles on the distal end. (Zobeck 1983)

10. **Humerus Least Circumference of Shaft** (LCS): *Steel tape*; taken at about the second third of the shaft, distal to the deltoid tuberosity. (Bass 1987)

11. **Ulna Maximum Length** (UML-ULNXLN): *Osteometric board*; maximum length from the olecranon- process to the tip of the styloid process. (Bass 1987)

12. **Ulna Anterior-Posterior Diameter of the Shaft** (UAD-ULNDVD): *Sliding calipers*; the maximum diameter of the diaphysis where the crest exhibits the great development. (Moore-Jansen et al. 1994)

13. **Ulna Medial-Lateral Diameter of the Shaft** (UMD-ULNTVD): *Sliding calipers*; the diameter measured perpendicular to the anterior-posterior diameter at the level of the graters curve. (Moore-Jansen et al. 1994)

14. **Ulna Least Circumference of the Shaft** (ULC-ULNCIR): *Steel tape*; located a little above the distal epiphysis, where the shaft, through the reduction of the muscular ridges and crest becomes nearly cylindrical. (Bass 1987)

15. **Femur Maximum Length** (FML-FEMXLN): *Osteometric board*; place the distal condyles against the fixed vertical of the board and the movable upright to the head. Raise the bone slightly and move up and down as well as from side to side until maximum length is obtained. (Bass 1987)

16. **Femur Anterior-Posterior Diameter of the Midshaft** (APS-FEMMAP): *Sliding calipers*; locate midshaft point on osteometric board and mark bone with pencil. Measure maximum anterior-posterior diameter. (Bass 1987)

17. **Femur Medial-Lateral Diameter of the Midshaft** (MLS-FEMMTV): *Sliding calipers*; taken at right angel to the anterior-posterior diameter of the midshaft. (Bass 1987)

18. **Femur Maximum Vertical Diameter of the Head** (VHD-FEMHDD): *Sliding calipers*; the greatest vertical diameter in the vertical plane passing through the axis of the neck. (Zobeck 1983)

19. **Femur Epicondylar Breadth** (FEB-FEMEBR): *Spreading calipers*; Measured over the most outstanding points of the epicondyles, parallel to the infracondylar plane. (Zobeck 1983)

20. **Femur Minimum Vertical Diameter of the Neck** (VDN): *Sliding calipers*; the minimum vertical diameter of the neck. (Zobeck 1983)

21. **Femur Circumference at Midshaft** (FCS-FEMCIR): *Steel tape*; the circumference measured at the midshaft at the same level as the anterior posterior and medial lateral diameters. If the linea aspera exhibits a strong projection which is not evenly expressed across a larger point of the diaphysis, then this measurement is recorded approximately 10 millimeters (mm) above the midshaft. (Moore-Jansen et al. 1994)

22. **Tibia Condylo-Malleolar Length** (TML-TIBXLN): *Osteometric board*; end of the malleolus against vertical wall of the osteometric board, bone resting on its dorsal surface with its long axis parallel with the long axis of the board, block applied to the most prominent part of the lateral half of the lateral condyle. (Zobeck 1983)

23. **Tibia Maximum Breadth of the Proximal Epiphysis** (BPE-TIBPEB): *Osteometric board*; maximum distance between the medial and lateral condyle. (Zobeck 1983)

24. **Tibia Maximum Breadth of the Distal Epiphysis** (BDE-TIBDEB): *Osteometric board*; maximum distance between the fibular articular surface and the medial surface of the medial malleolus. (Zobeck 1983)

25. **Tibia Anterior-Posterior Diameter at the Nutrient Foramen** (APN-TIBNFX): *Sliding calipers*; maximum anterior-posterior diameter of the shaft at the nutrient foramen. (Bass 1987)

26. **Tibia Medial-Lateral Diameter at the Nutrient Foramen** (MLM-TIBNFT): *Sliding calipers*; maximum transverse diameter at right angel to the anterior-posterior diameter at the nutrient foramen. (Bass 1987)

27. **Tibia Position of the Nutrient Foramen** (CFL): *Sliding calipers*; measured from the top of the lateral intercondylar eminence to the most distal point of the foramen. (Zobeck 1983)

28. **Tibia Circumference at Nutrient Foramen** (TCF-TIBCIR): *Steel tape*; the circumference measured at the level of the nutrient foramen. (Bass 1987)

29. **Fibula Maximum Length** (BML-FIBXLN): *Osteometric board*; maximum distance between the proximal and distal extremities. (Bass 1987)

30. **Fibula Maximum Diameter at Midshaft** (FMD-FIBMDM): *Sliding calipers*; the maximum diameter is most commonly located between the anterior and lateral crest. Find the midpoint on the osteometric board and mark with a pencil. Place the diaphysis of the bone between the two branches of the caliper while turning the bone to obtain the maximum diameter. (Moore-Jansen et al. 1994)

APPENDIX C

Summary Statistics for the Clavicle.

Variables (mm)	MIGRANT			NON-MIGRANT			AMERICAN WHITE		
	CLAXLN	CLAAPD	CLAVRD	CLAXLN	CLAAPD	CLAVRD	CLAXLN	CLAAPD	CLAVRD
MALES									
Mean	156.36	12.4	10.36	148.38	11.83	9.38			
Standard deviation	6.52	1.41	1.18	8.261	1.723	1.576	8.793	1.615	1.370
Minimum value	141	9	8	127	10	7	140	10	9
Maximum value	165	14	13	162	16	13	180	16	15
N	19	25	25	18	18	18	48	34	34
FEMALES									
Mean	138.90	10.57	9.14	133.35	9.64	7.64	142.63	10.58	9.44
Standard deviation	8.06	2.65	2.74	5.123	0.744	0.841	5.519	1.121	1.947
Minimum value	125	8	6	126	8	6	136	9	6
Maximum value	153	19	17	142	11	9	157	13	14
N	10	14	14	14	14	14	19	17	18

Summary Statistics for the Humerus.

Variables (mm)	MIGRANT			NON-MIGRANT			AMERICAN WHITE		
	HUMXLN	HUMMXD	HUMMWD	HUMXLN	HUMMXD	HUMMWD	HUMXLN	HUMMXD	HUMMWD
MALES									
Mean	313.10	22.22	16.95	305.25	20.93	11.81	342.59	23.85	18.93
Standard deviation	15.71	1.63	2.12	18.61	1.87	1.14	16.65	2.09	1.54
Minimum value	291	20	12	270	17	14	304	18	16
Maximum value	340	28	22	333	24	19	396	29	22
N	19	22	22	16	16	16	52	49	49
FEMALES									
Mean	285.84	19.44	13.88	276.18	18.75	14.00	307.45	20.18	15.22
Standard deviation	22.76	1.68	1.71	8.94	1.43	0.96	17.46	1.25	1.02
Minimum value	227	17	11	263	16	13	280	18	13
Maximum value	318	24	18	295	21	16	346	23	17
N	13	18	18	16	16	16	20	22	22

Summary Statistics for the Humerus – Continued

Variables (mm)	MIGRANT		NON-MIGRANT		AMERICAN WHITE	
	HUMHDD	HUMEBR	HUMHDD	HUMEBR	HUMHDD	HUMEBR
MALES						
Mean	46.05	61.31	44.07	58.5	50.04	65.88
Standard deviation	2.57	3.07	2.33	3.63	2.79	3.84
Minimum value	41	56	37	50	45	58
Maximum value	51	66	46	66	57	75
N	19	16	14	16	49	51
FEMALES						
Mean	40.06	52.2	37.86	51.93	42.90	55.15
Standard deviation	2.08	4.64	1.45	2.81	1.99	3.64
Minimum value	38	45	35	48	39	46
Maximum value	46	62	40	57	47	61
N	16	15	15	16	22	20

Summary Statistics for the Ulna.

Variables (mm)	MIGRANT		NON-MIGRANT		AMERICAN WHITE	
	ULNXLN	ULNDVD	ULNXLN	ULNDVD	ULNXLN	ULNDVD
MALES						
Mean	245.37	15.64	252	13.25	274.26	15
Standard deviation	15.84	1.83	17.56	1.29	14.35	2.39
Minimum value	233	12	208	11	250	11
Maximum value	275	18	278	16	313	21
N	8	17	16	16	18	16
FEMALES						
Mean	233.71	13.2	224.53	11.46	244.33	12.31
Standard deviation	15.26	2.14	7.98	1.68	14.88	2.67
Minimum value	218	11	209	9	219	9
Maximum value	259	17	238	15	275	18
N	7	10	15	15	18	16

Summary Statistics for the Ulna – Continued

Variables (mm)	MIGRANT		NON-MIGRANT		AMERICAN WHITE	
	ULNTVD	ULNCIR	ULNTVD	ULNCIR	ULNTVD	ULNCIR
MALES						
Mean	14.41	37.08	15	36	17.08	38.36
Standard deviation	2.00	7.36	1.52	2.48	2.78	5.81
Minimum value	11	30	11	30	11	28
Maximum value	17	43	17	40	23	60
N	17	12	16	16	36	30
FEMALES						
Mean	11.7	31.11	12.53	30.86	13.37	33.64
Standard deviation	1.76	2.93	1.50	1.80	2.36	3.60
Minimum value	9	28	10	29	10	30
Maximum value	15	37	15	35	19	44
N	10	9	15	15	16	14

Summary Statistics for the Femur.

Variables (mm)	MIGRANT			NON-MIGRANT			AMERICAN WHITE		
	FEMXLN	FEMMAP	FEMMTV	FEMXLN	FEMMAP	FEMMTV	FEMXLN	FEMMAP	FEMMTV
MALES									
Mean	440.46	29.63	26.27	427.39	27.60	27.43	481.19	30.93	27.93
Standard deviation	24.46	2.54	1.75	24.90	2.03	3.57	21.14	2.16	2.35
Minimum value	389	25	23	391	24	22	423	27	22
Maximum value	480	37	30	483	31	37	535	36	33
N	32	47	47	23	23	23	52	46	46
FEMALES									
Mean	406.90	26.16	23.16	390	24.58	23.64	435.42	27.71	24.09
Standard deviation	20.78	2.27	1.60	18.68	1.37	1.45	19.04	20.40	2.23
Minimum value	369.00	22	21	369	23	22	404	399	22
Maximum value	442.00	30	27	438	28	26	476	473	31
N	22	24	24	17	17	17	21	21	21

Summary Statistics for the Femur – Continued.

Variables (mm)	MIGRANT			NON-MIGRANT			AMERICAN WHITE		
	FEMHDD	FEMEBR	FEMCIR	FEMHDD	FEMEBR	FEMCIR	FEMHDD	FEMEBR	FEMCIR
MALES									
Mean	45.29	84.79	88.12	44.21	78.95	85.39	49.07	85.20	92.10
Standard deviation	2.45	4.21	6.77	2.48	3.87	5.49	2.74	4.40	5.81
Minimum value	40	76	65	38	68	75	44	78	80
Maximum value	50	92	102	49	84	99	57	98	105
N	31	24	47	23	21	23	51	48	29
FEMALES									
Mean	39.61	71.63	77.86	39.35	71.46	75.05	42.217	75.09	82.42
Standard deviation	1.56	3.21	4.72	2.44	3.56	3.64	1.82	2.73	5.21
Minimum value	36	63	68	36	67	70	39	68	74
Maximum value	42	76	89	46	82	83	46	80	91
N	21	17	23	17	15	17	23	21	14

Summary Statistics for the Tibia**.**

Variables (mm)	MIGRANT			NON-MIGRANT			AMERICAN WHITE		
	TIBXLN	TIBPEB	TIPDEB	TIBXLN	TIBPEB	TIPDEB	TIBXLN	TIBPEB	TIPDEB
MALES									
Mean	363.13	77.23	52.95	357.81	74	51.90	397.47	80.11	53.41
Standard deviation	22.37	3.81	2.62	24.55	2.82	2.99	23.39	3.43	3.43
Minimum value	323	72	49	313	68	46	347	72	40
Maximum value	396	88	60	404	80	58	467	87	60
N	23	17	22	21	20	21	53	42	43
FEMALES									
Mean	329.5	66.92	45.11	325.29	66.29	46.47	357.18	70.05	47
Standard deviation	17.59	3.27	1.83	14.51	3.75	3.00	17.07	2.94	2.19
Minimum value	301	62	41	311	59	42	330	65	44
Maximum value	370	71	48	371	75	56	387	76	52
N	12	13	9	17	17	17	17	17	18

Summary Statistics for the Tibia – Continued

Variables (mm)	**MIGRANT**			**NON-MIGRANT**			**AMERICAN WHITE**		
	TIBNFX	TIBNFT	TIBCIR	TIBNFX	TIBNFT	TIBCIR	TIBNFX	TIBNFT	TIBCIR
MALES									
Mean	33.95	25.62	94.02	33.52	23.61	91.80	36.59	25.71	98.67
Standard deviation	3.23	2.71	8.53	2.31	2.94	7.88	2.92	2.38	6.59
Minimum value	22	19	61	29	17	75	30	20	84
Maximum value	40	33	110	38	29	105	43	31	113
N	40	40	39	21	21	21	49	46	28
FEMALES									
Mean	44.81	29.26	83.11	29.05	20.11	78.35	31.91	22.34	85.35
Standard deviation	2.62	3.41	6.91	2.35	1.36	5.85	2.27	1.69	4.08
Minimum value	26	19	74	25	18	70	29	19	81
Maximum value	35	34	101	33	23	90	37	27	95
N	11	19	17	17	17	17	23	23	14

Summary Statistics for Fibula .

Variables (mm)	MIGRANT		NON-MIGRANT		AMERICAN WHITE	
	FIBXLN	FIBMDM	FIBXLN	FIBMDM	FIBXLN	FIBMDM
MALES						
Mean	361.53	15.19	346.76	14.52	390.02	15.85
Standard deviation	20.78	1.66	23.78	1.90	22.68	1.95
Minimum value	331	12	304	12	344	14
Maximum value	392	18	390	18	453	22
N	13	31	17	17	44	27
FEMALES						
Mean	320	13.53	313.75	13.18	346.23	14.2
Standard deviation	8.58	1.98	7.22	1.72	15.14	1.61
Minimum value	305	11	301	9	320	12
Maximum value	332	17	326	15	375	17
N	8	13	16	16	17	15

REFERENCES

U.S. Census Bureau
2000-2006. Hispanics in the United States: Population Estimates July 1, 2000 to July 1, 2006. http://www.census.gov/population/www/socdemo/hispanic /hispanic.html, accessed January 13, 2012

Anderson, Bruce E.
2008 Identifying the Dead: Methods Utilized by the Pima County (Arizona) Office of the Medical Examiner for Undocumented Border Crossers: 2001-2006. Journal of Forensic Science 53(1):8-15.

Anderson, Bruce E., and Bruce O. Parks
2008 Symposium on Border Crossing Deaths: Introduction. Journal of Forensic Science 53(1):6-7.

Bass, WM.
1987 Human Osteology: A laboratoty and Field Manual. Missouri: Missouri Arachaeological Society, Special Publication.

Bogin, B., P. Smith, A.B. Orden, M.I. Veralla-Silva, and J. Loucky
2002 Rapid Change in Height and Body Proportions of Mayan American Children American Journal of Human Biology 14:753-761.

Buikstra, JE, and D Ubelaker
1994 Standars for Data Collection from Human Skeletal Remains: Arkansas Archaeological Survey.

Carlson, Kristian J., Frederick E. Grine, and Osbjorn M. Pearson
2007 Robusticity and Sexual Dimorphism in the Postcranium of Modern Hunter-Gatherers from Australia. American Journal of Physical Anthropology 134:9-23.

Carson, Scott A.
2008 The Stature and Body Mass of Mexicans in the Nineteenth-Century United States. Journal of Interdisciplinary History 39(2):211-232.

Charisi, Drosia, Constantine Eliopoulos, Velissaria Vanna, Christos G. Koilias, and Sotiris K. Manolis
2011 Sexual Dimorphism of the Arm Bones in a Modern Greek Population. Journal of Forensic Science 56(1):10-18.

Cornelius, Wayne A.
1981 Mexican Migration to the United States. Proceeding of the Academy of Political Science 34(1):67-77.

Cowgill, L.W., and L.D. Hager
2007 Variation in the Development of Postcranial Robusticy: An Example from Catalhoyuk, Turkey. International Journal of Osteoarchaeology 17:235-252.

Deng, Hong-Wen, Hui Shen, Fu-Hua Xu, Hongyi Deng, Theresa Conway, Yong-Jun Liu, Yao-Zhong Liu, Jin-Long Li, Qing-Yang Huang, K.M. Davies, and Robert R. Recker
2003 Several Genomic Regions Potentially Containing QTLs for Bone Size Variation Were Identified in a Whole-Genome Linkage Scan. American Journal of Medical Genetics 119A:121-131.

Duran, Jorge, and Douglas S. Massey
1992 Mexican Migration to the United States: A Critical Review. Latin American Research Review 27(2):3-42.

Eveleth, P.B.
1975 Differences Between etnich groups in Sex Dimorphism of Adult Height. Ann. Human Biology 2:35-39.

Fogel, Robert W., Stanley L. Engerman, Roderick Floud, Gerald Friedman, Robert A. Margo, Kenneth Sokoloff, Richard H. Steckel, T. james Trussell, Georgia Villaflor, and Kenneth W. Wachter
1983 Secular Change in American and British Stature and Nutrition. The Journal of Interdisciplinary History 14(2):445-481.

Fogel, Robert W., Stanley L. Engerman, and James Trussell
1982 Exploring the Uses of Data on Heigh: The Analysis of Long-Term Trends in Nutrition, Labor Welfare, and Labor Productivity. Social Science History Association 6(4):401-421.

France, DL
1997 Observation and Metric Analysis of Sex in the Skeleton. *In* Forensic Osteology: Adavances in the Identification of Human Remains. K. Reichs, ed. Springfield: Charles C. Thomas, Publisher, Ltd.

Frayer, David W., and Milford H. Wolpoff
1985 Sexual Dimorphism. Ann. Rev. Anthropol. 14:429-473.

Goldstein, Marcus Solomon
1943 Demographic and Bodily Changes in Descendants of Mexican Immigrants: With Comparable Data on Parents and Children in Mexico. Austin: Institute of Latin American Studies.

Gray, J. Patrick, and Linda D. Wolfe
1980 Height and Sexual Dimorphism of Stature Among Human Societies. American Journal of Physical Anthropology 53:441-456.

Greulich, William W.
1951 The Growth and Developmental Status of Guamanian School Children in 1947. American Journal of Physical Anthropology 9(2):55-70.

—
1957 A Comparison of the Physical Growth and Development of American-Born and Native Japanese Children. American Journal of Physical Anthropology 15(4):489-515.

Gustafsson, Anders, Lars Werdelin, Birgitta S. Tullberg, and Patrik Lindenfors
2007 Stature and Sexual Stature Dimorphism in Sweden, from the 10th to the End of the 20th Century. American Journal of Human Biology 19:861-870.

Hall, Roberta L.
1978 Sexual Dimorphism for Size in Seven Nineteenth Century Northwest Coast Populations. Human Biology 50(2):159-171.

Hamilton, Margaret E.
1975 Variation Among Five Groups of Amerindians in the Magnitud of Sexual Dimorphism of Skeletal Remains. Dissertation, University of Michigan.

—
1982 Sexual Dimorphism in Skeletal Samples *In* Sexual Dimorphism in Homo Sapiens: A Question of Size. R.L. Hall, ed. Pp. 107-149. New York: Praeger.

Heyman, Josiah McC
2001 Class and Classification at the U.S-Mexico Border. Human Organization 60(2):128-140.

Himes, John H., Reynaldo Martorell, Jean-Pierre Habicht, Charles Yarbrough, Robert M. Malina, and Robert E. Klein
1976 Sexual Dimorphism in Bone Growth as a Function of Body Size in Moderately Malnourished Guatemalan Preschool Age Children. American Journal of Physical Anthropology 45(2):331-335.

Holden, Clare, and Ruth Mace
1999 Sexual Dimorphism in Stature and Women's Work: A Phylogenetic Cross-Cultural Analysis. American Journal of Physical Anthropology 110:27-45.

Holliday, Trenton W., and Christopher B. Ruff
2001 Relative Variation in Human Proximal and Distal Limb Segment Lengths. American Journal of Physical Anthropology 116:26-33.

Inwood, Kris, and Evan Roberts
2010 Longitudinal Studies of Human Growth and Health: A Review of Recent Historical Research Journal Economic Surveys 24(5):801-840.

Iscan, M. Yasar, Susan R. Loth, Christopher A. King, Ding Shihai, and Mineo Yoshino
1998 Sexual Dimorphism in the Humerus: A Comparative analysis of Chinese, Japanese and Thais. Forensic Science International 98:17-21.

Jantz, Lee Meadows, and R.L. Jantz
1999 Secular Change in Long Bone Lenght and Proportion in the United States, 1800-1970. American Journal of Physical Anthropology 110:57-67.

Koller, DL, G Liu, MJ Econs, P Morin, JC Christian, SL Hui, LA Rodriguez, PM Conneally, G Joslyn, CC Johnston, T Foroud, and M Peacock
2001 Genome Screen for QTLs Contributing to Normal Variation in Femoral Structure. Journal of Bone Miner Res 16:985-991.

Komlos, John
1990 Height and Social Status in Eighteenth Century Germany. The Journal of Interdisciplinary History 20(4):607-621.

—
1994 Stature, Living Standards, and Economic Development: Essays in Anthropometric History Chicago: University of Chicago Press.

Lasker, Gabriel Ward, and F. Gaynor Evans
1961 Age, environment and migration: Further anthropometric findings on migrant and non-migrant Mexicans. American Journal of Physical Anthropology 19(2):203-211.

Liu, Peng-Yuan, Yue-Juan Qin, Robert R. Recker, and Hong-Wen Deng
2004 Evidence for a Major Gene Underlying Bone Size Variation in the Chinese. American Journal of Physical Anthropology 16:68-77.

Lopez-Alonso, Moramay, and Raul Porras Condey
2003 The Ups and Downs of Mexican Economy Growth: The Biological Standards of Living and Inequality, 1870-1950. Economics and Human Biology 1:169-186.

Malina, Robert M., John H. Himes, Carol Dutton Stepick, Francisca Gutierrez-Lopez, and Peter H. Buschang
1981 Growth of Rural and Urban Children in the Valley of Oaxaca, Mexico. American Journal of Physical Anthropology 54:327-336.

Martorell, Reynaldo, Charles Yarbrough, Aaron Lechtig, Hernan Delgado, and Robert E. Klein
1976 Upper Arm Anthropometric Indicators of Nutriotional Status. The American Journal of Clinical Nutrition 29:46-53.

Moore-Jansen, PH, SD Ousley, and RL Jantz
1994 Data Collection Procedures for Forensic Skeletal Materials. Knoxville: The University of Tennessee.

Nyati, Lukhanyo H., Shane A. Norris, Noel Cameron, and John M. Pettifor
2006 Effect of Ethnicity and Sex on the Growth of the Axial and Appendicular Skeleton of Children Living in a Developing Country. American Journal of Physical Anthropology 130:135-141.

Phenice, TW
1967 A Newly Developed Visual Method of Sexing the Os Pubis. American Journal of Physical Anthropology 30:297-302.

Pomeroy, E., and S.R. Zakrzewski
2009 Sexual Dimorphism in Diaphyseal Cross-sectional Shape in the Medieval Muslim Population of Ecija, Spain, and Anglo-Saxon Great Chesterford, UK. International Journal of Osteoarchaeology 19:50-65.

Rickland, D.E., and P.V. Tobias
1986 Unusually Low Sexual Dimorphism of Endocranial Capacity in a Zulu Cranial Series. American Journal of Physical Anthropology 71:285-293.

Rios-Frutos, Luis
2005 Metric Determination of Sex from the Humerus in a Guatemalan Forensic Sample. Forensic Science International 147:153-157.

Ruff, CB, and CS Larsen
2001 Reconstructing behavior in Spanish Florida: The Biomechanical Evidence. *In* Bioarchaeology of Spanish Florida: The Impact of Colonialism. C. Larsen, ed. Pp. 113-145. Gainsville: University Press of Florida.

Ruff, Christopher
1988 Sexual Dimorphism in Human Lower Limb Bone Structure: Relationships to Subsistence Strategy and Sexual Division of Labor. Journal of Human Evolution 16:391-416.

Singer, Audrey, and Douglas S. Massey
1998 The Social Process of Undocumented Border Crossing among Mexican Migrants. International Migration Review 32(3):561-592.

Spradley, M. Katherine, and Richard L. Jantz
2011 Sex Estimation in Forensic Anthropology: Skull versus Postcranial Elements. Journal of Forensic Science 56(2):289-296.

Spradley, M. Katherine, Richard L. Jantz, Alan Robinson, and Fredy Peccerelli
2008 Demographic Change and Forensic Identification: Problems in Metric Indentification of Hispanic Skeletons. Journal of Forensic Science 53(1):21-28.

Steckel, Richard H.
2005 Young Adult Mortality Following Severe Physiological Stress in Childhood: Skeletal Evidence. Economics and Human Biology 3:314-328.

Steyn, Maryna, and M. Yasar Iscan
1999 Osteometric Variation in the Humerus: Sexual Dimorphism in South Africans. Forensic Science International 106:77-85.

Stini, William A.
1969 Nutritional Stress and Growth: Sex Difference in Adaptive Response. American Journal of Physical Anthropology 31:417-426.

—
1972 Reduced Sexual Dimorphism in Upper Arm Muscle Circumference Associated with Protein-deficient Diet in a South American Population. American Journal of Physical Anthropology 36:341-352.

—
1975 Adaptive Strategies of Human Populations under Nutritional Stress. *In* Biosocial Interrelations in Population Adaptation. E.S. Watts, F.E. Johnston, and G.W. Lasker, eds. Pp. 19-42. Paris: Mouton Publishers.

Stinson, Sara
1985 Sex Differences in Environmental Sensitivity During Growth and Development. Yearbook of Physical Anthropology 28:123-147.

Tise, Meredith L., M. Katherine Spradley, and Bruce E. Anderson
forthcoming Postcranial Sex Estimation of Individuals Considered Hispanic. Journal of Forensic Science.

Tobias, Phillip V.
1962 On the Increasing Stature of the Bushmen. Anthropos 57(3/6):801-810.

Ubelaker, DH, and CG Volk
2002 A Test of the Phenice Method for the Estimation of Sex. Journal of Forensic Science 4(1):19-24.

Urcid, J
1992 Manual for Postcranial Measurements.

Wolfe, Linda W., and J. Patrick Gray
1982 A Cross-Cultural Investigation into the Sexual Dimorphism *In* Sexual Dimorphism in Homo Sapiens: A Question of Size. R.L. Hall, ed. Pp. 197-228. New York: Praeger.

Zobeck, TS
1983 Postcraniometric Variation Among the Arikara. Dissertation, The University of Tennessee.

VITA

Cristina Figueroa-Soto was born and raised in Lares, Puerto Rico. She attended the University of Puerto Rico where she earned her Bachelor of Science degree in General Science in May of 2008. In the fall of 2010, she began working on her Master’s degree in anthropology at Texas State University-San Marcos. Her research interests include human biological variation, forensic anthropology, and variation of human skeletal remains in the areas of Mexico, Central America, and the Caribbean.

Permanent Address: HC 01 4226

Lares, Puerto Rico 00669

This thesis was typed by Cristina Figueroa-Soto