VARIATION IN NON-METRIC TRAITS OF THE PELVIS

BETWEEN WHITES, BLACKS, AND HISPANICS

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VARIATION IN NON-METRIC TRAITS OF THE PELVIS

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ABSTRACT

VARIATION IN NON-METRIC TRAITS OF THE PELVIS

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The pelvis has been shown to be the most accurate bone used for assessing the sex of an unknown individual. Assessing the sexually diagnostic traits of the pelvis can be achieved through metric or nonmetric analysis. However, it has been suggested that the male pelvis may exhibit more variation then the female pelvis and that sexually dimorphic nonmetric traits change with increasing age by becoming exhibiting more masculine traits. Few studies have evaluated the patterns of sexually dimorphic non-metric traits between different reference groups or examined the effect of age on these traits. Therefore, this study examined how accurately nonmetric traits of the pelvis can be used to assess sex in three populations: Blacks, Whites, and Hispanics. In addition, variation between males and females in each reference group was analyzed to determine if age was associated with the scoring of the traits. Ordinal level scores were taken on five traits of the os coxa, the ventral arc, subpubic concavity, ischiopubic ramus ridge, greater sciatic notch, and preauricular surface. These scores were recorded on White, Black, and Hispanic individuals from the William Bass Donated Skeletal Collection at the University of Tennessee (n=197). Scores were also taken from Black and Hispanic individuals from the Documented Skeletal Collection at the University of New Mexico (n=12). Results showed that there are some significant differences by reference group in the non-metric traits of the pelvis. In addition, significant differences were not found between the age ranges of most traits in either males or females, with the exception of male the ischiopubic ramus ridge. The differences in the growth patterns of the pelvis between males and females could account for the consistency of the traits between each reference group. Understanding these differences can help more accurately assess the sex of individuals.

CHAPTER I

INTRODUCTION

Statement of Purpose and Problem

Most of the current methods used by researches to assess the sex of unknown individuals were developed from Black and White samples. In the United States, there remains a need to incorporate other biological population groups, such as Hispanics, into the methods to obtain more accurate results. In addition, many researchers do not address differences in trait variation between references groups.

It is the purpose of this study to test for significant differences between three reference groups, Blacks, Whites, and Hispanics, to better understand non-metric trait variation in the pelvis between reference groups. Understanding the variation found in non-metric traits is important when scoring them to assess the sex of unknown individuals, especially between different reference groups.

Background

One of the basic goals in forensic anthropology is the assessment of the biological profile, which includes the assessment of sex of a given individual. Researchers often identify the pelvis as the most accurate element of the skeleton used to assess sex due to the many morphological changes it undergoes during puberty. The assessment of the pelvis is made through metric measurements as well as through the visual analysis of nonmetric traits; both important aspects of the analysis. However, there is a need for accurate population specific criteria for sex assessment using nonmetric traits. In addition, sexually dimorphic traits may vary by population, age, and other factors. This study focuses on nonmetric traits that are visually observable and can be systematically scored and examines population and age effects on these traits.

Previous studies instead focused on the application of methods that assess the sex of individuals through examining the pelvis via metric measurements or visual morphological assessment techniques. Walker (2005) studied the use of the greater sciatic notch to assess the sex of an individual, and developed a new, five-stage method for scoring the greater sciatic notch. Walker (2005) found that the greater sciatic notch of males was more variable than that of females, and therefore may have a greater range of scores. Walker (2005) also noted that age may be correlated to the depth and width of the greater sciatic notch. He found it to "shift in a masculine direction" with increasing age (Walker 2005: 388).

Figure 1: Example of female pelvis; A) preauricular sulcus B) greater sciatic notch C) subpubic concavity D) ventral arc

Figure 2: Example of male pelvis; A) preauricular sulcus B) greater sciatic notch C) subpubic concavity D) ventral arc

Phenice (1969) analyzed the ventral arc, subpubic concavity, and the ischiopubic ramus ridge. He describes the most accurate way to score these traits based on his methods for males and females, which provide accurate results even for less experienced researchers (Phenice 1969). Phenice (1969) notes that results might differ when a researcher is unfamiliar with a biological population group and that biological population differences might occur. However, he does not describe these differences (Phenice 1969).

Both Phenice (1969) and Walker (2005) studied pelvises from White and Black individuals and found no significant differences between the scores in the reference groups (Phenice, 1969; Walker, 2005). Since current methods are based mostly on White and Black samples from the United States, there remains a need to incorporate other groups into the methods.

Coleman (1969) and LaVelle (1995) examined growth of the pelvis in White individuals, which limits the study to understanding the pelvis of different reference groups. Coleman (1969) focused on specific regions of the pelvis, and he found that females show greater overall growth especially in a lateral dimension. Also, he found that males can have more variation than females in certain traits. LaVelle (1995) studied how the changes occur in the pelvis by studying annual radiographs for 10 years to understand the growth of the pelvis. She found that males are more variable than females even at an early age. She notes that age and reference groups may account for this variability (LaVelle, 1995). Understanding how the pelvis develops is important to understanding the nonmetric traits used in assessing sex.

Though the morphology of the pelvis is impacted by growth patterns in both males and females, pregnancy in females also affects certain traits of the pelvis. Houghton (1974) studied the relationship between the preauricular surface and pregnancy. To do this, he first scored the preauricular surface by the presence or absence of a preauricular sulcus. Houghton (1974) assigned his own scores to the trait based on the characteristic of the sulcus, allowing each characteristic to stand out from the others. One type of sulcus is that seen from pregnancy, which can cause pitting. There is also a category for the lack of a sulcus. This method helps offer an explanation of the different variations found between the sexes. The reference groups used in his sample are most likely from European or Asian descent; however, he notes that he is not certain of their biological population group since they are from the Maori and Moriori collection of the Department of Anatomy at the University of Otago. He found that a sulcus can be present in both males and females. However, during pregnancy, changes occur to this sulcus making it deeper and more pitted, which makes it stand apart from the sulci of males and other females (Houghton, 1974).

Listi (2010) studied how to assess the sex of an individual from the pelvis using nonmetric traits and their relationship to the metric variation between biological population groups. She analyzed Whites and Blacks, testing if the size of the pelvis influenced the nonmetric traits. She found that assessing sex from the pelvis using nonmetric traits is consistent between biological population groups. She also found that there is no significant change in the nonmetric traits due to the size of the pelvis. In addition, she found that White males were misclassified more often than Black males, and Black females more often misclassified than White females. She notes that these groups may be misclassified more often because they are more variable than Black males and White females (Listi 2010).

SWGANTH (2013) notes the importance of using biological population -specific samples when assessing the sex of an individual, stating that the different genetic markers of different biological population groups could cause differences in traits of the pelvis. Metric and nonmetric bone traits are polygenetic, and bone morphology is an attribute of gene expression, which shapes the nonmetric traits seen in the pelvis (Gosman et al., 2011). These expressions affect the development of bone during puberty, where the pelvis begins to become distinctive in males and females (Gosman et al., 2011).

Though, many authors have studied the nonmetric traits of the pelvis, most authors do not note if differences occur between biological population groups (Hoyme, 1952; Tague, 1989; Weiss, 1972). It is the purpose of this study to analyze nonmetric traits used to assess the sex of individuals from the pelvis between different reference groups, including Hispanics, and to examine if age effects the variation in trait expression.

Research Questions

1) Are nonmetric traits used in assessing the sex of individuals from the pelvis expressed significantly different in Whites, Blacks, and Hispanics? Based on the results of previous studies, the expectation for this study is that the nonmetric traits used for assessing sex will be consistently the same between reference groups when all the traits are pooled together. It is also expected, however, that some differences may occur when assessing sex based on the individual traits themselves.

2) Do males have greater variation in non-metric traits than females? Previous studies have produced mixed results, some show that male pelvises do exhibit more variation than the females when assessing the nonmetric traits of the pelvis (Coleman, 1969; Meindl et al., 1985; Walker, 2005), while others, (Tague 1989) found that males were not more varied than females. The expectation of this study is that males will show more variation than females within each reference groups.
3) Does the expression of sexually dimorphic nonmetric traits change with age in adults? Walker (2005) found adult age was correlated with the greater sciatic notch width, and Tague (1989) found the subpubic angle began to narrow with increasing age. It is expected that the older individuals would appear to have more masculine traits while the younger individuals exhibited more feminine traits. This study will systematically evaluate this hypothesis on multiple traits and in each reference population.

CHAPTER II

METHODS

Samples

Data were collected for a total of 203 adult individuals identified as White, Black, and Hispanic (Table 1). Left coxa were preferentially scored but the right was used in cases where the left was damaged or unavailable. The data for this research were collected primarily from the William M. Bass Donated Skeletal Collection at the University of Tennessee, Knoxville. . Individuals scored from the Bass Collection were randomly selected from the entire sample while ensuring a representative sample from each ancestral group. To do this, a spreadsheet containing the demographic information from all of the skeletons in the Bass Collection was sorted by ancestry and age. From these lists, I randomly selected 191 individuals using a random number generator (Math Goodies, 2012). The sample from the William Bass Donated Skeletal Collection included 77 White males, 61 White females, 34 Black males, 6 Black females, 12 Hispanic males, and 1 Hispanic female.

Data were also collected from the Documented Skeletal Collection from the University of New Mexico, Albuquerque. I used only their Black and Hispanic reference groups for my sample. Only 12 individuals were available: 4 Black males, 1 Black female, 4 Hispanic males, and 3 Hispanic females. The samples from both collections were pooled together to make three reference groups.

Table 1: Total Data Sample.

Reference groups	# of Males	# of Females	Total #
White	77	61	138
Black	38	7	46
Hispanic	16	4	21
Total	131	72	203

Age categories were divided by ranges of 10 years, except for the first age range which has an 11 year range (10-20). The following age ranges include: 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, and 91-100.

Traits

Subpubic concavity

Subpubic concavity refers to the space lateral to the pubic symphysis on the ischiopubic ramus (Buikstra and Ubelaker 1994). Females are characterized by having a more concave ischiopubic ramus, creating a longer distance between the pubis and the ischium. Males, on the other hand, tend to exhibit a more convex ischiopubic ramus, creating a sharp slope inferiorly lateral to the pubic symphysis. Following Phenice (1969), this trait was scored on a scale of 1-3 using the data sheet found in “Standards for Data Collection from Human Skeletal Remains” (Buikstra and Ubelaker, 1994) (Figure 3).

The score of 1, usually indicative of females, indicated the subpubic area is wide and concave. From the pubic symphysis, the ischiopubic ramus begins more laterally before continuing inferiorly (Figure 3A). The score of 2 had more variety. There was less concavity than in score 1, extended less laterally before sloping inferiorly (Figure 3B). The score of 3, usually characteristic of males, indicated the subpubic area lateral to the pubic symphysis began to slope inferiorly immediately. The area had a convex appearance (Figure 3C).

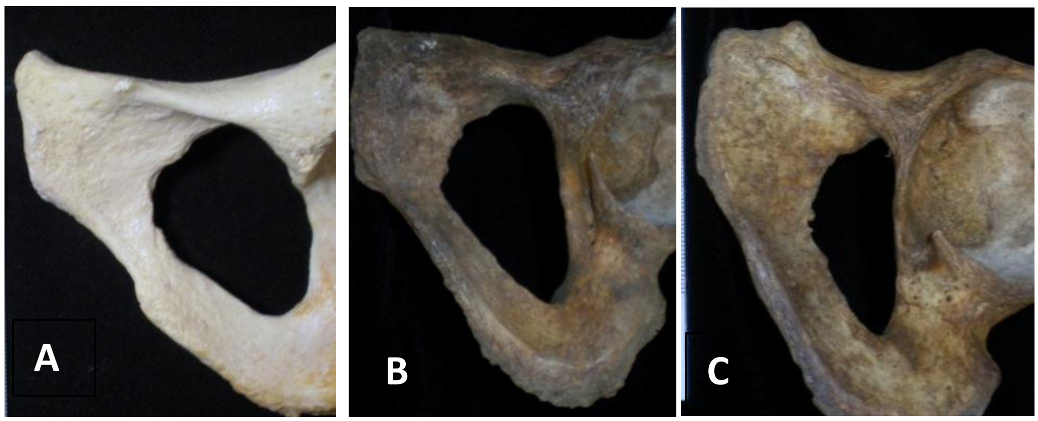

Figure 3: Subpubic concavity; A) score of 1 B) score of 2 C) score of 3.

Ischiopubic ramus ridge

The ischiopubic ramus is the surface inferior to the pubic symphysis. This morphology in this area exhibits a continuum from flat to a distinct ridge. Following Phenice (1969), the trait was scored on a scale of 1-3 (Buikstra and Ubelaker, 1994).

The score of 1, characteristic of females, indicated the ischiopubic ramus was narrow and had a sharp ridge. This score indicated most of the surface formed this ridge (Figure 4A). A score of 2 was more variable but characterized by a flat surface on either side of a less distinct ridge on the ischiopubic ramus (Figure 4B). The ischiopubic ramus itself was also broader than it was in score 1. Score 3, indicative of males, indicated a broad flat surface inferior to the pubic symphysis (Figure 4C).

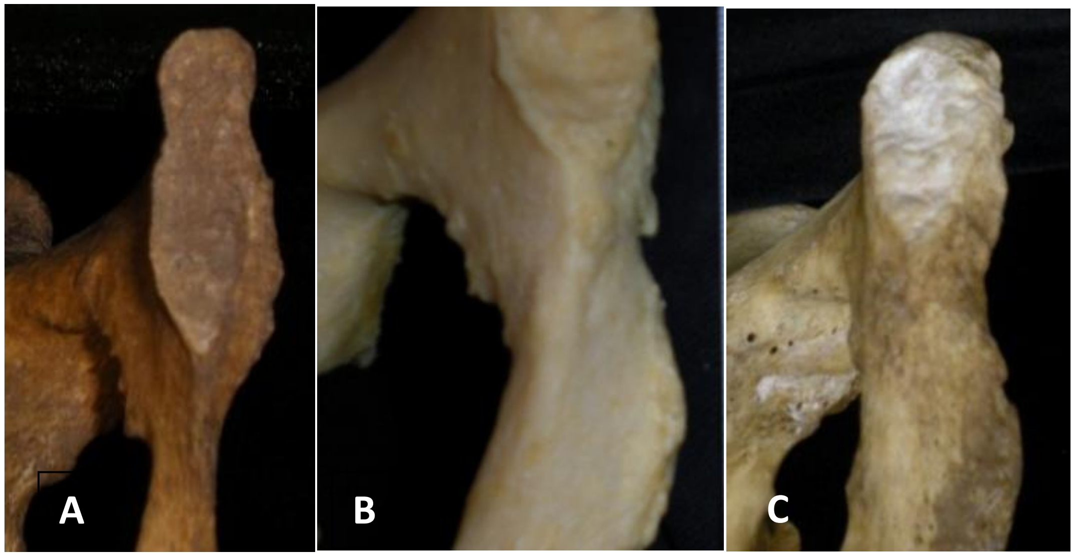

Figure 4: Ischiopubic ramus; A) score of 1 B) score of 2 C) score of 3.

Ventral arc

The ventral arc is located on the ventral side of the pubis. In some individuals, a ridge of bone forms across this surface, known as the ventral arc. Following Phenice (1969), this trait was scored on a scale of 1-3 (Buikstra and Ubelaker, 1994).

The score of 1, usually characteristic of females, indicated the ventral arc was clearly present. There was an obvious ridge present and it appeared over most of the ventral surface of the pubis (Figure 5A). If the arc was present, but it was not as obvious as in score 1, it was designated with the score of 2. In these cases the arc often appeared more medially and was narrower (Figure 5B). A score of 3, usually indicative of males, indicated there was no ventral arc present. This was usually clear because of the lack of a ridge (Figure 5C).

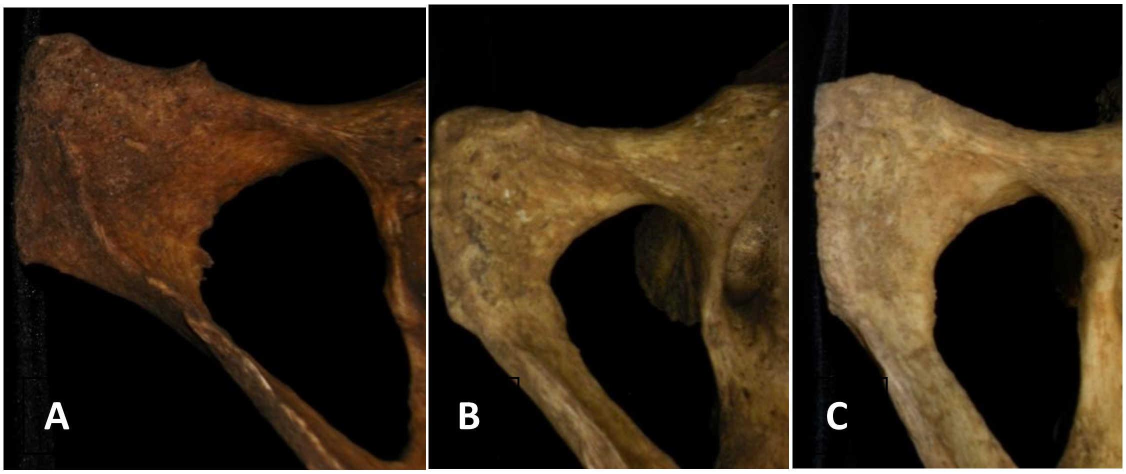

Figure 5: Ventral arc; A) score of 1 B) score of 2 C) score of 3.

Preauricular surface

The preauricular surface is found below the auricular surface of the ilium. There is often a groove in this area called the preauricular sulcus; however, it is variable is size and shape. The preauricular sulcus was also scored from 1 to 3. If the sulcus was absent it was given a score of 3. If present, then the preauricular sulcus was scored a 1 or 2 based on its form following Houghton (1974) (Figure 6).

The score of GP (1), groove of pregnancy, is assigned when the groove appears to have been formed by many pits, and often it is elongated. These pits are characteristic in that they have many ridges forming the pits, although the floor of each pit is smooth (Houghton, 1974) (Figure 6A). This indicates the individual is female. The score of GL (2) indicates there is a groove present, but it can be shallow or deep, narrow or wide with no distinct pits (Figure 6B). In addition, the score of GL will produce either a flat bottom groove, or rough pitting (Houghton, 1974). Houghton (1974), states if it is not clearly GP, then it is GL. The score of No Groove (3) indicates there was no groove present in the preauricular surface, but rather the area was flat (Figure 6C). This score is usually indicative of males (Houghton, 1974).

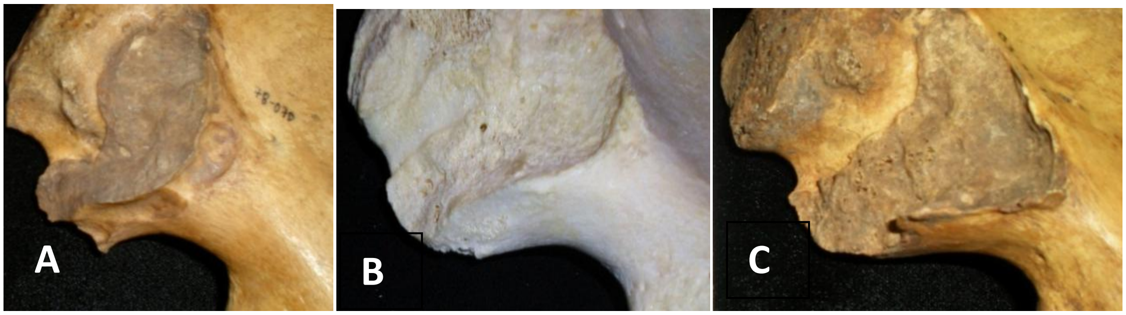

Figure 6: Preauricular sulcus; A) score of GP (1) B) score of GL (2) C) Score of No Groove (3).

Greater sciatic notch

The greater sciatic notch is located on the dorsal end of the os coxa. The shape takes on many variations from broad to narrow. Following Walker (2005), the shape of the sciatic notch was scored from 1-5 (Buikstra and Ubelaker, 1994).

The score of 1, characteristic of females, indicated a wide, often v-shaped notch. Often, the wide notch appears to disappear behind the auricular surface (Figure 7A). The score of 2, also characteristic of females, indicated a somewhat wide notch with a more rounded or U-shape (Figure 7B). The score of 3 had more variety than the other scores. The superior portion came straight across medially, or it began to curve more inferiorly. In both cases the curve was narrower than the previous scores (Figure 7C). The score of 4, characteristic of males, indicated a narrower, u-shaped curve. The medial end clearly curved inferiorly (Figure 7D). The score of 5, characteristic of males, was a narrow curve. This curve was tight and it curved inferiorly more than the other scores (Figure 7E).

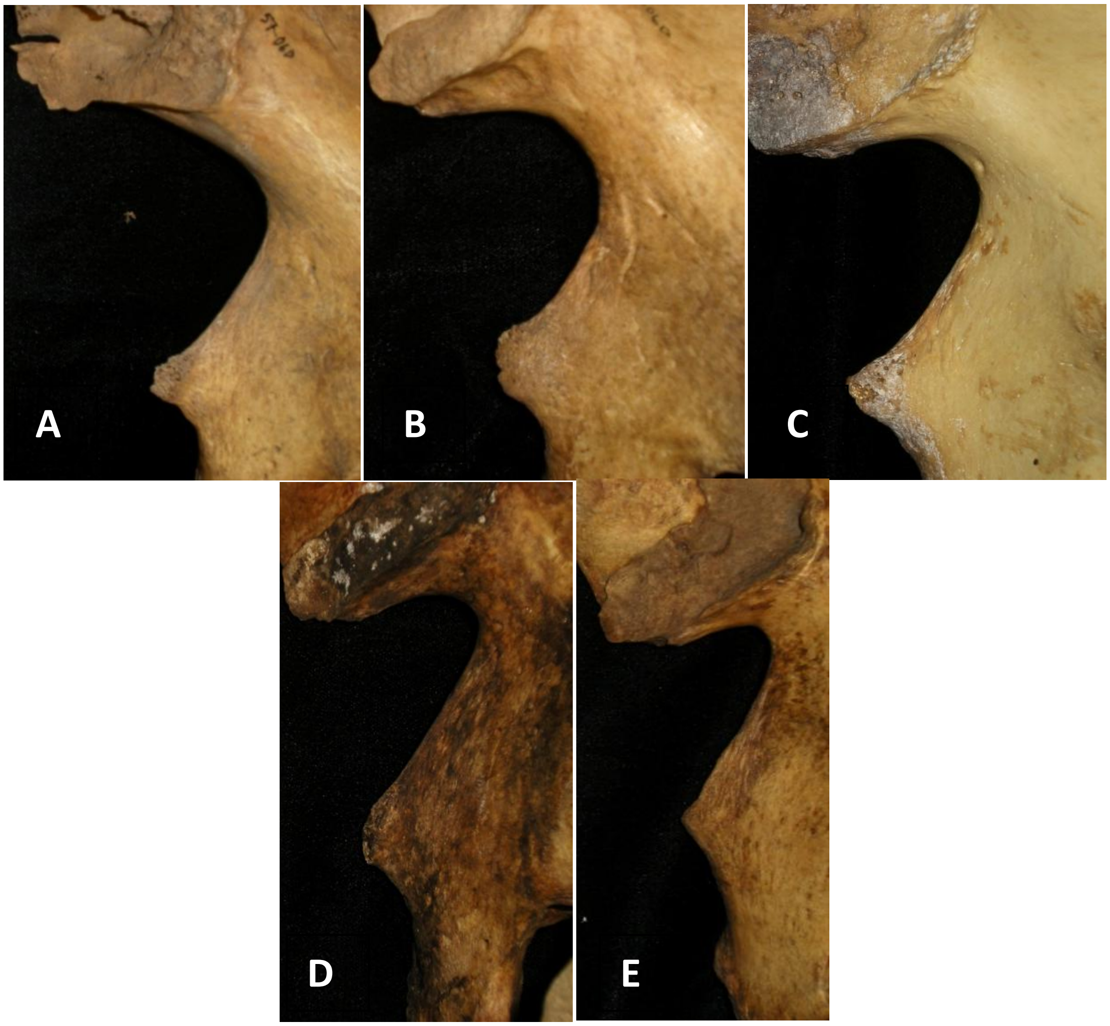

Figure 7: Greater sciatic notch; A) score of 1 B) score of 2 C) score of 3 D) score of 4 E) score of 5.

Procedure

To collect my data I chose to conduct the study without knowing the biological population group, age, or sex of the individuals I was analyzing. Not knowing these variables took away any bias of scoring a trait toward certain sex. The missing information was provided only after I had assessed the sex for each individual. Another way I chose to limit any bias was to cover each trait on each os coxa, uncovering only the trait I was analyzing. This method limited any bias that could exist after scoring one trait on an os coxa toward one sex and then scoring another trait. To do this properly, I assigned each os coxa a number and only identified it by the number assigned.

To achieve the blind study affectively, I analyzed five to seven os coxae at a time and covered each trait in aluminum foil. I marked each piece of foil with the assigned number and took the score of one trait at a time on each os coxa. To erase any further bias, I shuffled the os coxae in a new order after each trait was scored. I also recorded each trait on a different data collection sheet to avoid looking at other trait's scores. While scoring a trait, I compared the score not only to other os coxae with the same score, but also to a score below and above it to account for accuracy. Once I scored and analyzed each individual, I collected the biological profile data of each individual which included actual sex, biological population group and age. After all the data were collected from each collection, I photographed each trait with each score.

Statistics

Intraobserver error

To account for intra-observer error I rescored 20% of the individuals from each collection. I chose the individuals by random selection using a random number generator (Math Goodies, 2012). I rescored 40 individuals from the William Bass Donated Skeletal Collection and 3 from the Documented Skeletal Collection at the University of New Mexico. My procedure was the same as before, conducting a blind study. A sign test was conducted to test the differences between the original scores and those from the 20% sample.

Frequency of traits

To analyze the differences between males and females, I calculated the total frequency of females and males scored in each category in each trait. I also calculated the frequency of each score for each reference group for both males and females for each trait. Finding the frequencies of each score for every trait was used to compare how each reference group scored in each trait. Also calculated were the frequency scores in each age range. It should be noted four of the individuals were of unknown ages and therefore were not included in this calculation.

Chi square tests

Chi square tests were used to assess if there are significant differences between the sexes, the reference groups, and the age ranges in both males and females. Adjusted residuals were also calculated to find the points of significance for each trait in both males and females.

CHAPTER III

RESULTS

Intraobserver Error

The sign test for subpubic concavity came out to p=1.0 from three negatives and four positives. The sign test for ischiopubic ramus ridge came out to p= 0.45 from five negative scores and two positive scores. The results of the sign test for the ventral arc was p= 1.0 from two negative scores and three positive scores. The sign test for preauricular surface came to p= 1.0 from two negative and three positive scores. The results for greater sciatic notch was p= 0.22 from one negative and five positive scores. These high p values indicate there were no significant differences found between the individuals of any traits.

Male and Female Differences

When males and females from all reference groups were pooled together each trait exhibited significant differences between males and females (Tables 2-6).

Table 2: Subpubic concavity observed and expected scores for pooled males and females.

	Observed		Expected	
x-axis	Males	Female	Males	Females
1	0	69	44.23923	24.76077
2	55	5	38.4689	21.5311
3	79	1	51.29187	28.70813

Significant difference found at the 0.05 level of confidence (χ^2= 184.78; df =2; p<0.0001).

Table 3: Ischiopubic ramus ridge observed and expected scores for pooled males and females.

	Observed		Expected	
x-axis	Males	Female	Males	Females
1	4	55	37.8	21.2
2	92	18	70.5	39.5
3	38	2	25.6	14.4

χ^2= 119.102; df =2; p<0.0001

Table 4: Ventral arc observed and expected scores for pooled males and females.

	Observed		Expected	
x-axis	Males	Female	Males	Females
1	0	35	22.4	12.6
2	49	37	55.1	30.9
3	85	3	56.4	31.6

χ^2= 104.78; df =2; p<0.0001

Table 5: Preauricular surface observed and expected scores for pooled males and females.

	Observed		Expected	
x-axis	Males	Female	Males	Females
1	0	26	16.7	9.3
2	118	48	106.4	59.6
3	16	1	10.9	6.1

χ^2= 56.61; df =2; p<0.0001

Table 6: Greater sciatic notch observed and expected scores for pooled males and females.

	Observed		Expected	
x-axis	Males	Female	Males	Females
1	0	17	10.9	6.1
2	5	43	30.8	17.2
3	59	14	46.8	26.2
4	54	1	35.3	19.7
5	16	0	10.3	5.7

χ^2= 136.085; df =5; p<0.0001

Frequencies of Traits and Significant Tests

Subpubic concavity

When each reference group was compared to the others, the Black and Hispanic frequencies increased in number from score 1 to 3, whereas in the White reference group

42.75% (n=59) scored a 1 and only 29.0% (n=40) score a 3. Males showed no significant differences found at the 0.05 level ($\chi^2 = 5.12$; df= 2; p= 0.077) between reference groups. However, significant differences were found between reference groups in females at the 0.05 level ($\chi^2 = 14.12$; df= 2; p= 0.007). The adjusted residuals showed significance in all scores of Whites, and almost all scores of Blacks (Table 7).

When the reference groups were analyzed separately (Table 7), the Black females appeared in every score. However, 71.4% (n=5) of Black females scored the expected feminine score of 1. Black males only scored 2s and 3s;, 63.2% (n=24) scored a 3 as expected for males. The White females almost all scored a 1 with 96.7% (n=59) as expected with the remainder scoring a 2. White males scored 2s and 3s with only 52.0% (n=40) males scoring a 3 as expected. The majority of Hispanic females also scored a 1 as expected with 75.0% (n=3) and the remainder scoring a 2. The majority of Hispanic males scored the expected 3 with 81.3% (n=13) and the remainder scoring a 2.

Table 7: Frequencies of subpubic concavity scores in three reference groups with adjusted residuals (AR); yellow high adjusted residual, green low adjusted residual.

	White Males (n=77)		Black Males (n=38)		Hispanic Males (n=16)		White Females (n=61)		Black Females (n=7)		Hispanic Females (n=4)	
Subpubic concavity	N	AR	N	AR	N	AR	N	AR	N	AR	N	AR
1	0	0	0	0	0	0	59	2.88	5	-2.37	3	-1.46
2	37	1.90	14	-0.65	3	-1.95	2	-1.99	1	1.06	1	1.75
3	40	-1.90	24	0.65	13	1.95	0	-2.37	1	3.07	0	-0.24

Ischiopubic ramus ridge

When each reference group was compared to the others, it became apparent that the majority of individuals in all reference groups received a score of 2. Males showed no significant differences found at the 0.05 level (χ^2 = 4.635; df =2; p= 0.327) between reference groups. However, females showed significant differences found the 0.05 level (χ^2 = 9.75; df =2; p= 0.045). The adjusted residuals showed significance in the score of 1 in Whites, and almost all scores of Hispanics (Table 8).

When the reference groups were analyzed separately (Table 8), the majority of males in each reference group scored a 2 rather than the expected score of 3. No Black or Hispanic males scored a 1, however 5.2% of White males did score a 1 (n=4). The majority of White and Black females scored the expected 1, however only 25.0% of Hispanic females scored a 1 (n=1). Hispanic females were also the only ones not to have scored a 3.

Table 8: Ischiopubic ramus ridge frequencies between three reference groups with adjusted residuals (AR); yellow high adjusted residual, green low adjusted residual.

	White Males (n=77)		Black Males (n=38)		Hispanic Males (n=16)		White Females (n=61)		Black Females (n=7)		Hispanic Females (n=4)	
Ischiopubic Ramus	N	AR	N	AR	N	AR	N	AR	N	AR	N	AR
1	4	1.70	0	-1.3	0	-0.76	47	2.15	4	-0.94	1	-2.17
2	55	0.80	25	-0.46	10	-0.57	13	-1.70	2	0.23	3	2.38
3	18	-1.48	13	0.97	6	0.88	1	-1.38	1	1.95	0	-0.35

Ventral arc

When each reference group was compared to the others, the majority of Blacks and Hispanics scored a 3, with 64.4% (n=29) of Blacks and 60.0% (n=12) of Hispanics. The White reference group had the majority score a 2 with 47.1% (n=65). Males showed significant differences found at the 0.05 level (χ^2 = 6.25; df =2; p= 0.044) between reference groups. Adjusted residuals showed significance in White and Black males in the scores of 2 and 3 (Table 9). However, females showed no significant differences found at the 0.05 level (χ^2 = 1.695; df =2; p= 0.792).

When the reference groups were analyzed separately (Table 9), no males in any reference group scored a 1, and the majority of all males in each reference group scored the expected 3. White females were the only females to score a 3, with 4.92% (n=3). Black females were the only females whose majority scored the expected 1, with 57.1% (n=4). The majority of White and Hispanic females scored a 2.

Table 9: Ventral arc frequencies in three reference groups with adjusted residuals (AR); yellow high adjusted residual, green low adjusted residual.

	White Males (n=77)		Black Males (n=38)		Hispanic Males (n=16)		White Females (n=61)		Black Females (n=7)		Hispanic Females (n=4)	
Ventral Arc	N	AR	N	AR	N	AR	N	AR	N	AR	N	AR
1	0	0	0	0	0	0	28	0.03	4	0.63	1	-0.86
2	35	2.5	9	-1.97	4	-1.03	30	-0.33	3	-0.4	3	1.03
3	42	-2.5	29	1.97	12	1.03	3	0.75	0	-0.58	0	-0.43

Preauricular surface

When each reference group was compared to the others, the majority of each reference group scored a 2. Males showed no significant differences at the 0.05 level ($\chi^2 = 0.605$; df = 2; p = 0.739) between reference groups. In addition, females showed no significant differences at the 0.05 level ($\chi^2 = 3.15$; df = 2; p = 0.532). Adjusted residuals shown in table 10.

When the reference groups were analyzed separately, (Table 10) the majority of all males scored a 2. Only 13.0% of White males scored a 3 (n=10), 13.2% (n=5) of Black males, and 6.3% (n=1) of Hispanic males scored a 3. Hispanic females were the only group to score the majority of the expected score of 1 with 75.0% (n=3). White and Black females were closer in the score of 1 and 2 with 32.8% (n=20) of White females scoring a 1, and 42.9% (n=3) of Black females scoring a 1. White females were the only females to appear in score 3 with 1.6% (n=1).

Table 10: Preauricular surface frequencies in three reference groups with adjusted residuals (AR); yellow high adjusted residual, green low adjusted residual.

	White Males (n=77)		Black Males (n=38)		Hispanic Males (n=16)		White Females (n=61)		Black Females (n=7)		Hispanic Females (n=4)	
Preauricular Surface	N	AR	N	AR	N	AR	N	AR	N	AR	N	AR
1	0	0	0	0	0	0	20	-1.38	3	0.39	3	1.67
2	67	-0.32	33	-0.21	15	0.78	40	1.27	4	-0.31	1	-1.59
3	10	0.32	5	0.21	1	-0.78	1	0.43	0	-0.33	0	-0.24

Greater sciatic notch

When each reference group was compared to the others, the majority of each reference group scored a 3. Significant differences were not found in females of different reference groups at the 0.05 level (χ^2= 10.21; df =4; p = 0.116). In addition, no significant differences were found at the 0.05 level (χ^2= 2.25; df =4; p = 0.895) between males of different reference groups. Adjusted residuals shown in table 11.

When each reference group was analyzed separately (Table 11) no males in any group scored a 1, and no females in any group scored a 4. Hispanic males were the only males not to have scored a 2. White females were the only group to score a 4 with 1.64% (n=1). The majority of males in each reference group scored a 3, followed by the score of 4. Hispanic females were the only females where the majority scored the expected 1 with 75% (n=3). The majority of White females scored a 2 with 62.3% (n=38), with the score of 1 and 3 following each with 18.0% (n=11). The majority of Black females scored either a 2 or a 3, each with 42.9% (n=3).

Table 11: Greater sciatic notch frequencies in three reference groups with adjusted residuals (AR); yellow high adjusted residual, green low adjusted residual.

	White Males (n=77)		Black Males (n=38)		Hispanic Males (n=16)		White Females (n=61)		Black Females (n=7)		Hispanic Females (n=4)	
Sciatic Notch	N	AR	N	AR	N	AR	N	AR	N	AR	N	AR
1	0	0	0	0	0	0	11	-1.38	1	-0.45	3	2.74
2	4	0.98	1	-0.45	0	-0.85	38	1.61	3	-0.87	1	-1.39
3	34	-0.03	16	-0.32	8	0.49	11	-0.71	3	1.65	0	-1.01
4	30	-0.20	15	-0.03	7	0.35	1	0.43	0	-0.33	0	-0.24
5	9	-0.22	6	0.80	1	-0.78	0	0	0	0	0	0

Age

Subpubic concavity

When males and females were analyzed separately (Figure 8 and Figure 9), with reference groups pooled, no significant difference were found at the 0.05 level (χ^2=13.62; df=2; p=0.4788) between females of different age ranges of ten years. Adjusted residuals are shown in table 12. There were also no significant differences found at the 0.05 level (χ^2=9.16; df= 2; p=0.3291) for males of different age ranges. Adjusted residuals are shown in table 13.

When the reference groups were analyzed separately, Black females displayed the masculine score of 3 in the oldest age range (91-100), with the majority yielding a score of 1 throughout the age ranges. White females showed no pattern of age ranges and scores, with the majority of the score 1 being present in all age ranges. Hispanic females showed the score of 2 in the higher age range with score of 1 in the lower age ranges. Black males showed the majority of the score 2 in the lower age ranges, whereas the score of 3 was present in all age ranges. White males showed scores of 2 and 3 in all age ranges except the youngest, which scored a 3. Hispanic males showed the score of 3 in all age categories, with the score of 2 in the younger age ranges.

Table 12: Adjusted residuals of the subpubic concavity between different age ranges of females; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	0.3	-1.02	-0.37	1.44	0.04	0.04	-0.37	-0.64
2	0	-0.27	1.24	0.57	-1.3	0.16	0.16	0.57	-0.74
3	0	-0.12	-0.27	-0.37	-0.57	-0.46	-0.46	-0.37	3.14

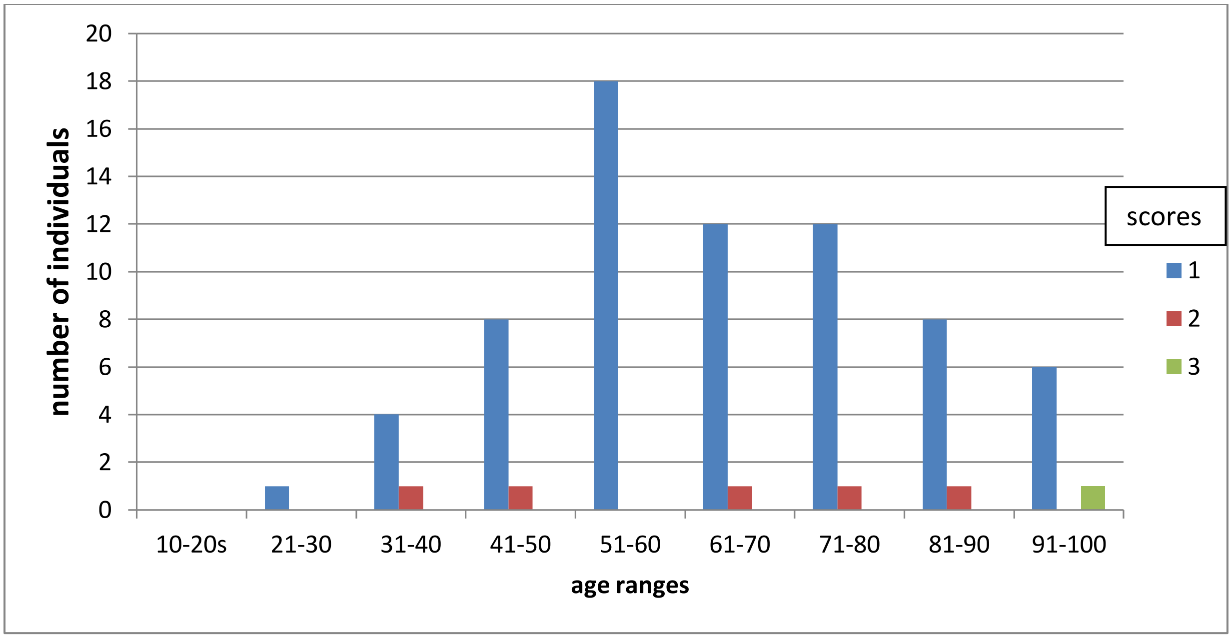

Figure 8: Female distribution of subpubic concavity in age ranges; results not significant.

Table 13: Adjusted residuals of the subpubic concavity between different age ranges of males; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	0	0	0	0	0	0	0	0
2	-1.22	0.57	-0.96	1.54	0.19	0.8	-2.07	-0.42	0.32
3	1.22	-0.57	0.96	-1.54	-0.19	-0.8	2.07	0.42	-0.32

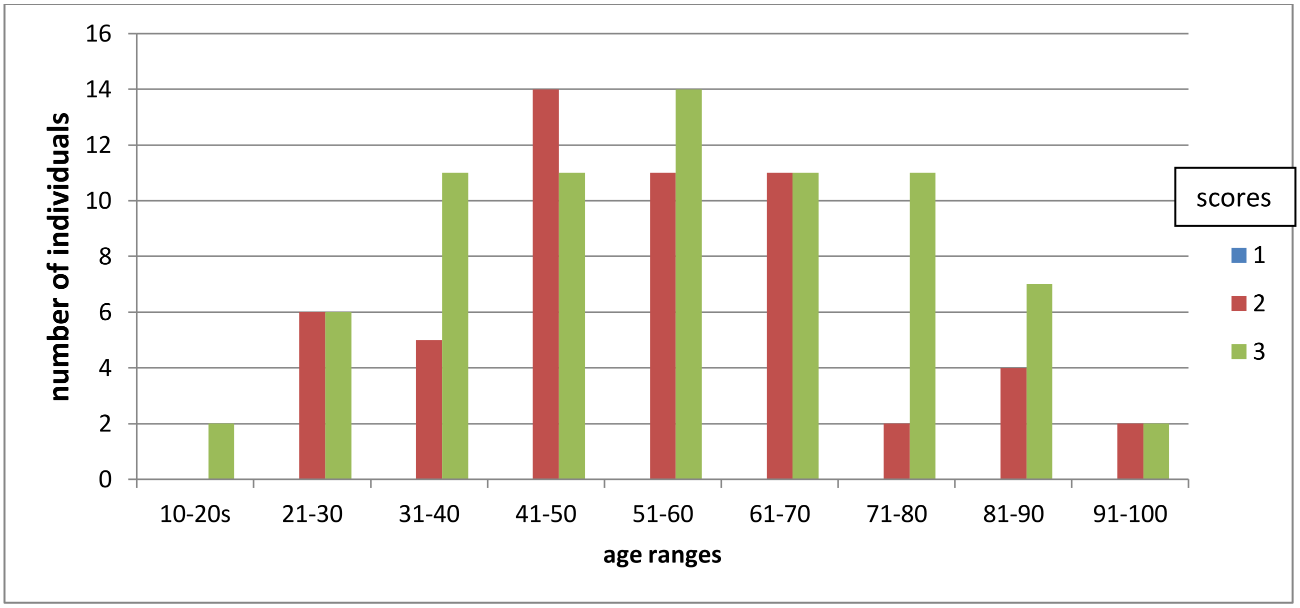

Figure 9: Male distribution of subpubic concavity in age ranges; results not significant.

Ischiopubic ramus ridge

When males and females were analyzed separately, with reference groups pooled, (Figure 10 and Figure 11) no significant difference were found at the 0.05 level (χ^2=23.43; df=2; p=0.0536) between females of different age ranges. Adjusted residuals shown in table 14. However, there was significance difference found at the 0.05 level (χ^2=36.811; df= 2; p=0.0002) for males of different age ranges. Adjusted residuals show significant differences were found in females in the age range 81-90 in the scores of 1 and 2, whereas significant differences were found in males in half the age ranges and in every score (Table 15).

When the reference groups were analyzed separately Black females showed the masculine score of 3 in a younger age range and the feminine score of 1 in older and younger age ranges. White females showed the score of 3 in an older age range, in addition the score of 2 was present in the older age ranges. The score of 1 was found in every age range. Hispanic females mostly scored 2, the only score of 1 was found in a middle age range. Black and White males showed the score of 3 in almost every age range, whereas the score of 2 was present in the middle and younger age ranges. Hispanic males, however, mostly scored 2s in the younger age ranges, whereas the score of 3 was found in almost every age range.

Table 14: Adjusted residuals of the ischiopubic ramus ridge between different age ranges of females; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	0.61	0.35	1.12	-0.12	1.01	1.01	-2.89	-1.02
2	0	-0.57	-1.3	-0.97	0.43	-0.8	-1.51	3.19	1.23
3	0	-0.17	2.49	-0.53	-0.81	-0.66	1.24	-0.53	-0.46

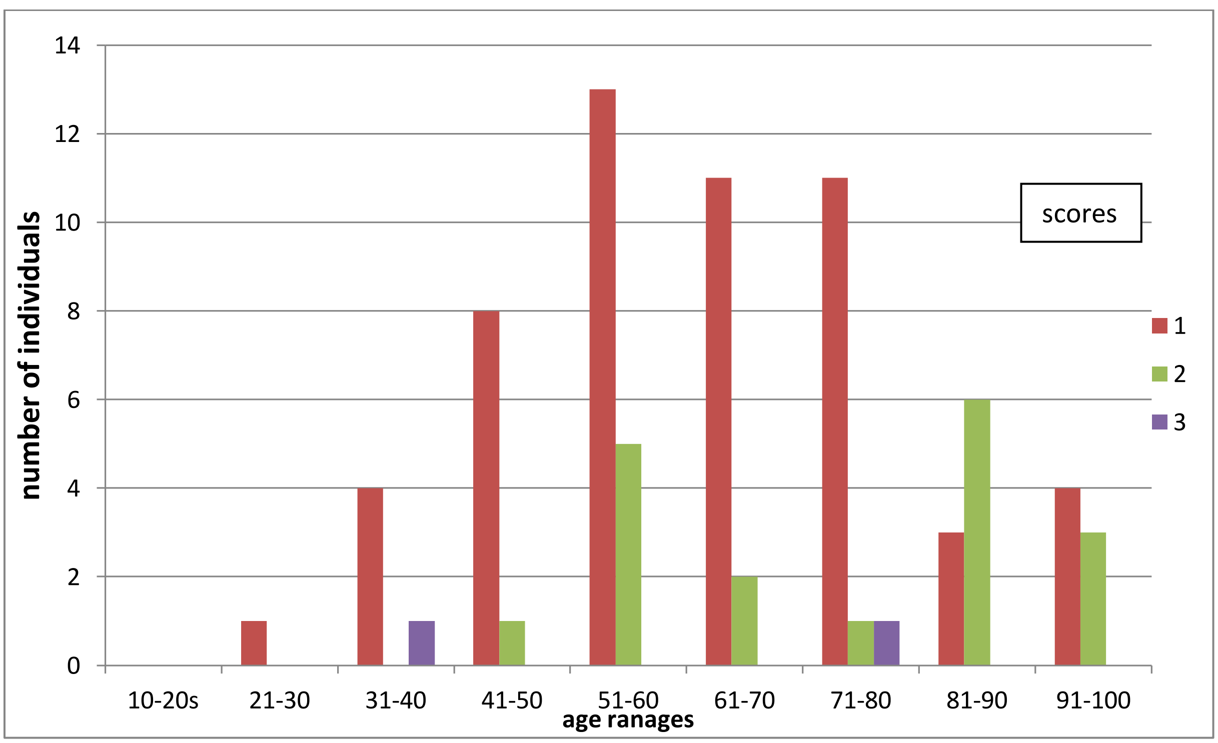

Figure 10: Female distribution of ischiopubic ramus ridge in age ranges; results not significant.

Table 15: Adjusted residuals of the ischiopubic ramus ridge between different age ranges of males; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	-0.25	2.86	-0.76	-0.99	-0.99	0.44	-0.68	-0.62	2.58
2	-2.06	-2.02	-0.47	0.04	1.94	2.05	0.75	-2.32	-0.77
3	2.22	0.99	0.78	0.34	-1.62	-2.28	-0.51	2.62	-0.19

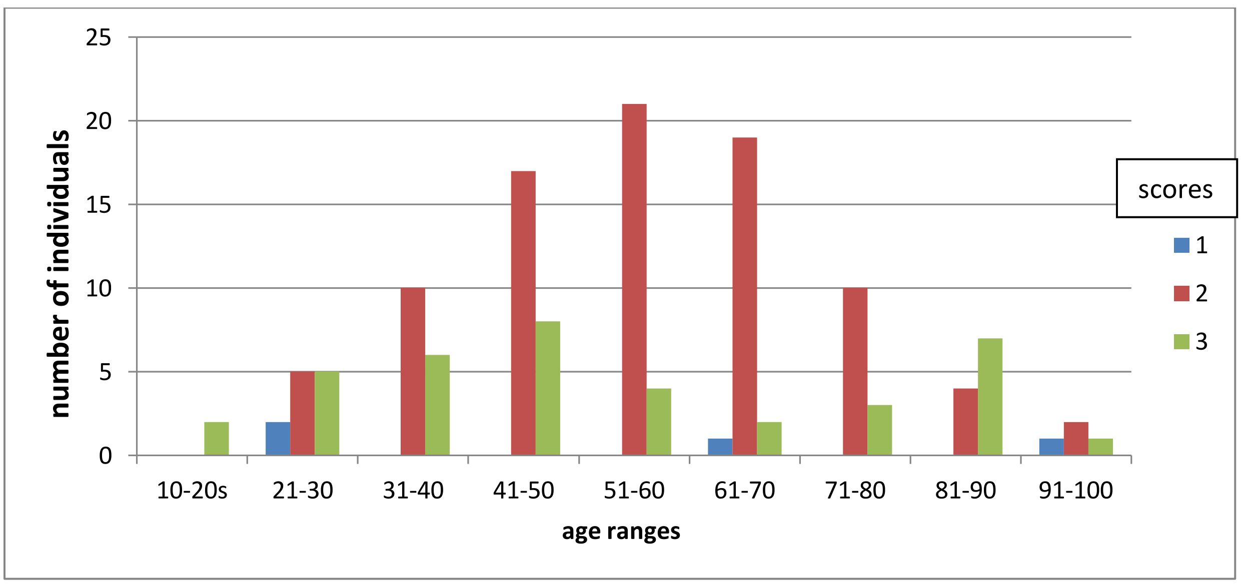

Figure 11: Male distribution of ischiopubic ramus ridge in age ranges; significant results at the 0.05 level of confidence.

Ventral arc

When males and females were analyzed separately, with reference groups pooled together, (Figure 12 and Figure 13) no significant differences were found at the 0.05 level (x^2=11.539; df=2; p=0.1763) between females of different age ranges. Adjusted residuals shown in table 16. There were also no significance differences found at the 0.05 level (x^2=6.603; df= 2; p=0.6006) for males of different age ranges. Adjusted residuals shown in table 17.

When the reference groups were analyzed separately, Black females scored more 2s in the older age ranges, although the score of 1 was present in most age ranges. White females scored more 2s and 3s in the older age ranges, although the score of 1 was present in every age range. Hispanic females scored 2 in the older age ranges and 1 in the younger age range. Black males exhibited the score of 3 in every age range, whereas the majority of the score of 2 was in the lower age ranges. White males scored 2s and 3s in every age category. Hispanic males scored 2s younger and older age ranges, whereas the majority of score 3 was found in the younger age ranges.

Table 16: Adjusted residuals of the ventral arc between different age ranges of females; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	1.08	0.62	-1.57	1.41	-1.88	0.57	-0.14	0.58
2	0	-0.99	-0.43	1.82	-1.02	1.58	-0.25	-1.02	-0.36
3	0	-0.21	-0.47	-0.65	-0.99	0.75	-0.81	2.97	-0.57

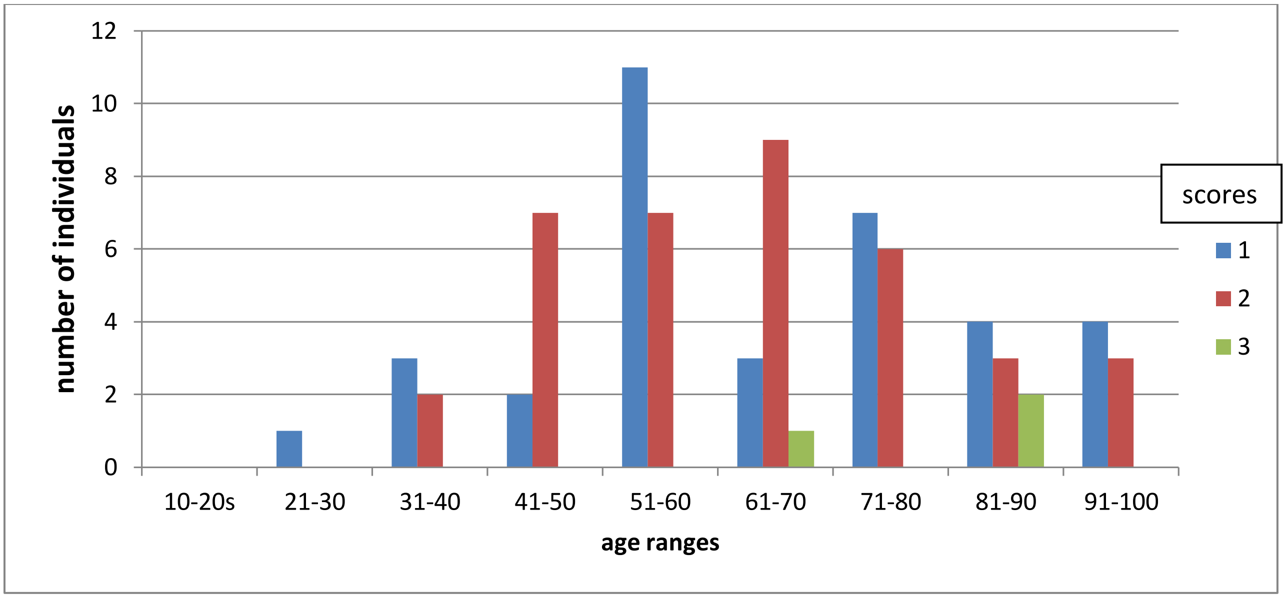

Figure 12: Female distribution of ventral arc in age ranges; results not significant.

Table 17: Adjusted residuals of the ventral arc between different age ranges of males; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	0	0	0	0	0	0	0	0
2	-1.11	-0.33	-0.57	0.26	0.26	1.31	-1.75	0.56	0.52
3	1.11	0.33	0.57	-0.26	-0.26	-1.31	1.75	-0.56	-0.52

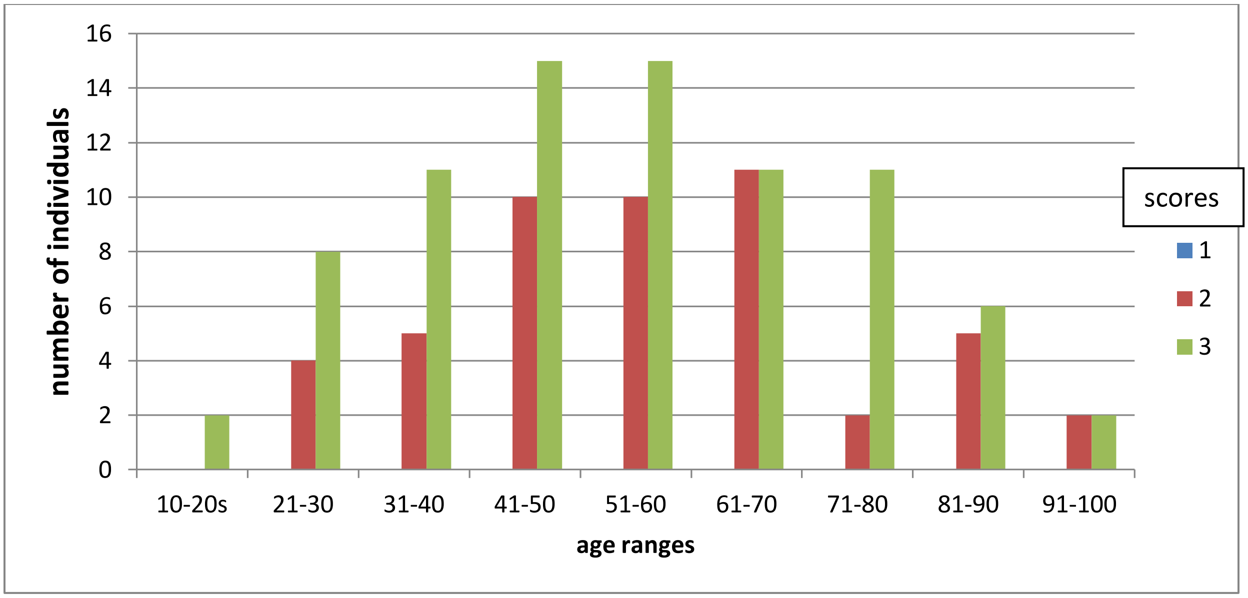

Figure 13: Male distribution of ventral arc in age ranges; results not significant.

Preauricular surface

When males and females were analyzed separately with reference groups pooled together, (Figure 14 and Figure 15) no significant differences were found at the 0.05 level (x^2=12.15; df =2; p=0.5945) between females of different age ranges. Adjusted residuals shown in table 18. There were also no significant differences found at the 0.05 level (x^2=6.46; df= 2; p=0.5958) for males of different age ranges. Adjusted residuals shown in table 19.

When the reference groups were analyzed separately, Black females showed the score of 2 throughout the age ranges, whereas the score of 1 appeared in the younger age ranges. White females scored 1s and 2s throughout the age ranges; however the score of 3 was only present in the middle age range. Hispanic females showed the score of 2 in the older age range, whereas the score of 1 appeared in the younger age ranges. Black males showed the score of 2 in every age range whereas the score of 3 appeared in the middle and older age ranges. White males scored 2s in all age ranges, whereas the majority of score 3 was found in the older age ranges. Hispanic males scored 2 in every age range, whereas the score of 3 was found in a middle age range.

Table 18: Adjusted residuals of the preauricular surface between different age ranges of females; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	1.38	-0.71	2.15	-0.7	-0.97	0.96	-0.84	-0.36
2	0	-1.34	0.77	-2.04	0.27	1.07	-0.84	0.92	0.43
3	0	-0.12	-0.27	-0.37	1.79	-0.46	-0.46	-0.37	-0.32

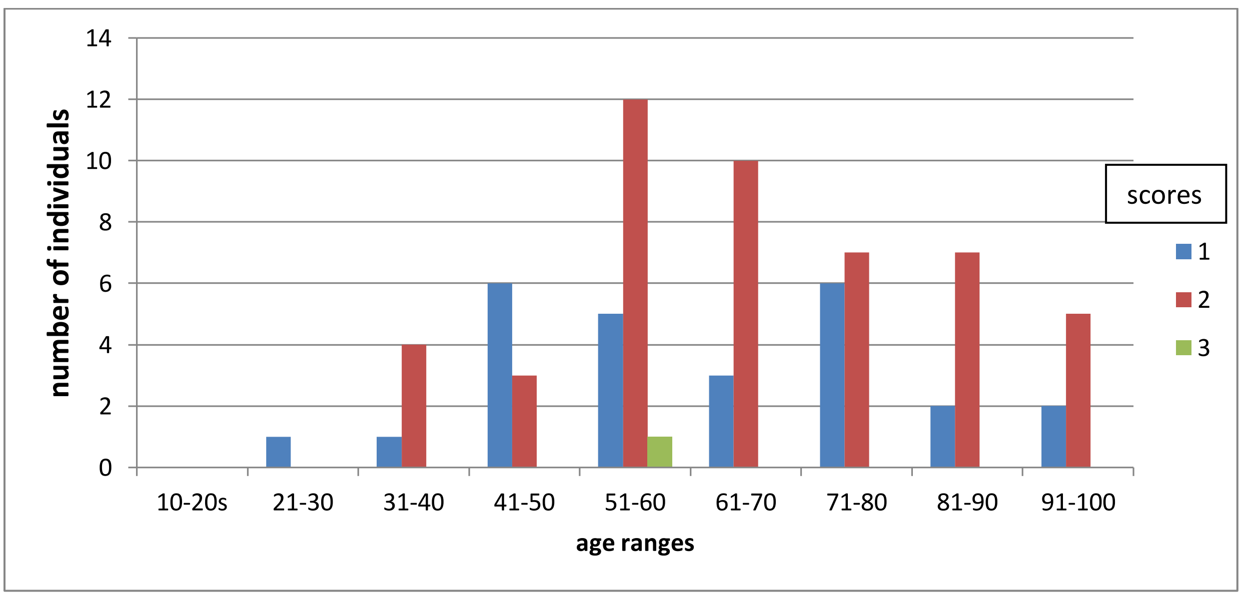

Figure 14: Female distribution of preauricular surface in age ranges; results not significant.

Table 19: Adjusted residuals of the preauricular surface between different age ranges of males.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	0	0	0	0	0	0	0	0
2	0.51	1.31	0.71	-0.08	0.62	-1.8	-0.46	-0.72	0.73
3	-0.51	-1.31	-0.71	0.08	-0.62	1.8	0.46	0.72	-0.73

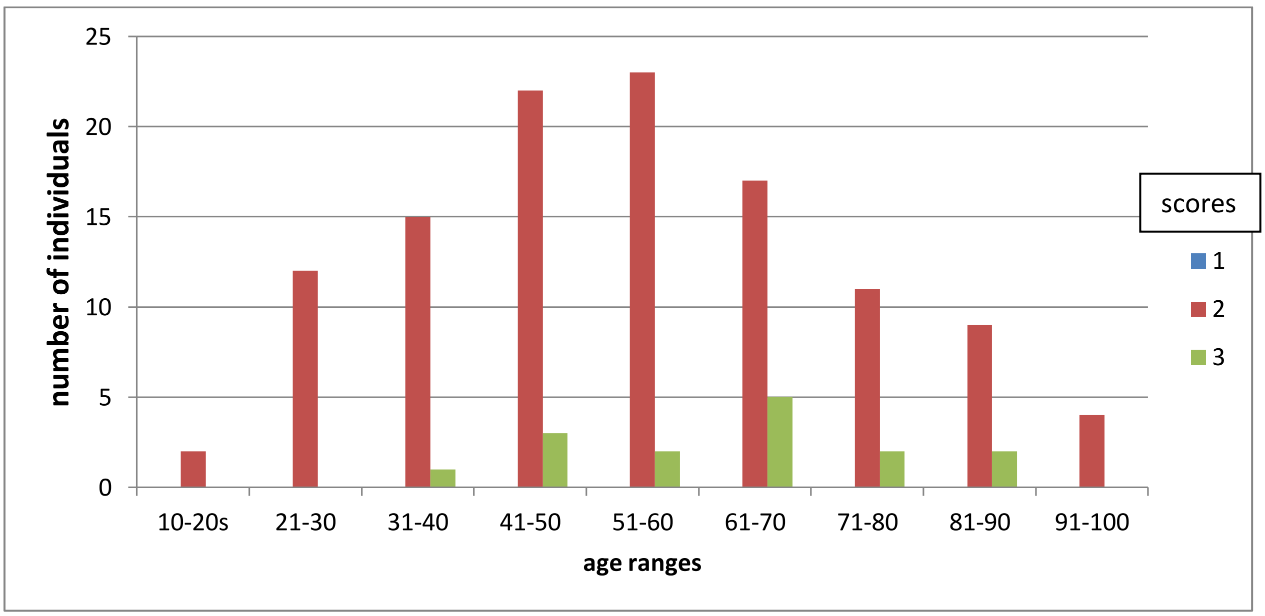

Figure 15: Male distribution of preauricular surface in age ranges; results not significant.

Greater sciatic notch

When males and females were analyzed separately, with reference groups pooled together, (Figure 16 and Figure 17) no significant differences were found at the 0.05 level (x^2=25.94; df=2; p=0.2086) between females of different age ranges. Adjusted residuals shown in table 20. In addition, no significant differences were found at the 0.05 level

(x^2=24.002; df= 2; p=0.4615) for males of different age ranges. Adjusted residuals shown in table 21.

When the reference groups were analyzed separately, Black females showed the lower score of 1 in an older age range, and the scores 2 and 3 in younger and older age ranges. White females showed the higher score of 4 in an older age range; however, 1s, 2s, and 3s, were present in the majority of age ranges. Hispanic females showed the score of 2 in the higher age range and the score of 1 in the middle age ranges. Black males showed the majority of scores 3, 4, and 5 in the middle age ranges, and the score of 2 in the older age range. White males showed the majority of the score 5 in the older age range, whereas the majority of scores 3 and 4 were in the middle age ranges. The score of 2 was found mostly in the middle age ranges; however it was also in the lowest age range. Hispanic males showed the score of 5 in the middle age range whereas the scores 3 and 4 were found throughout the age ranges.

Table 20: Adjusted residuals of the greater sciatic notch between different age ranges of females; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	-0.55	-1.25	-0.03	-0.05	2.95	-0.69	-0.03	0.39
2	0	-1.17	1.06	0.6	-0.17	-2.13	1.57	-0.11	-0.01
3	0	2.1	0.08	-0.62	0.44	-0.33	-1.9	0.29	1.73
4	0	-0.12	-0.27	-0.37	-0.57	-0.46	2.2	-0.37	-0.32
5	0	0	0	0	0	0	0	0	0

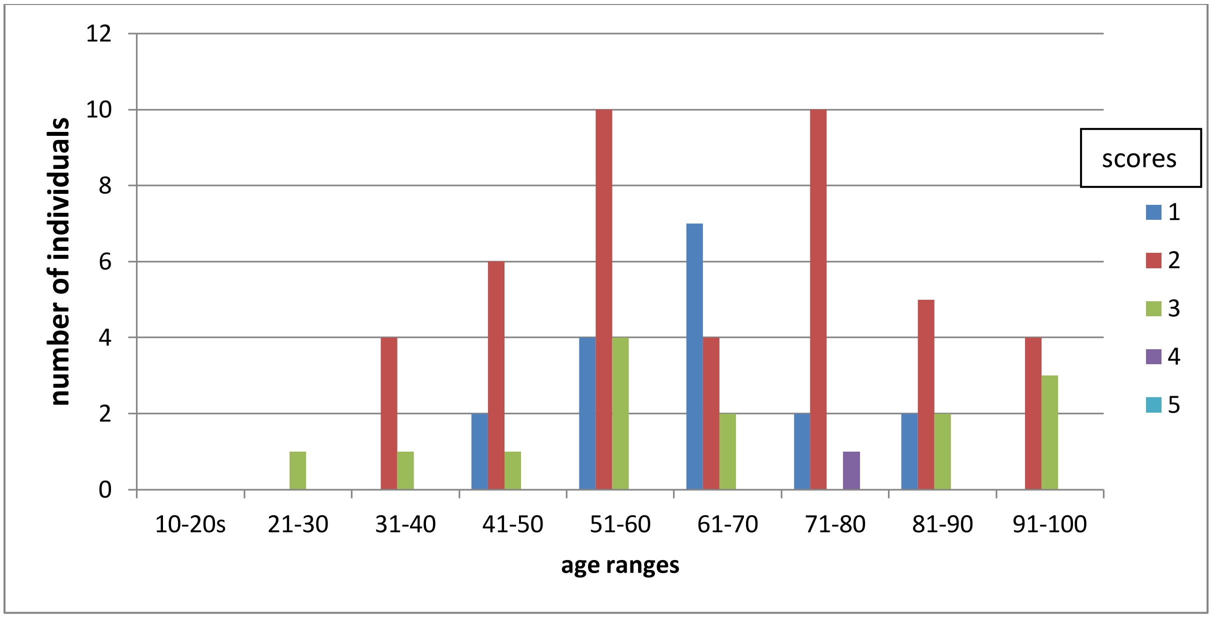

Figure 16: Female distribution of greater sciatic notch in age ranges; results not significant.

Table 21: Adjusted residuals of the greater sciatic notch between different age ranges of males; yellow high adjusted residual, green low adjusted residual.

score	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
1	0	0	0	0	0	0	0	0	0
2	3.42	-0.73	-0.85	0.04	1.2	-1.03	-0.76	0.95	-0.41
3	0.15	1.61	-0.07	-0.96	-0.07	0.56	0.12	-0.58	-0.8
4	-1.15	-0.44	-0.15	1	-0.37	-0.3	-0.06	-0.2	1.49
5	-0.53	-1.36	0.84	-0.05	-0.05	0.21	0.36	0.62	-0.76

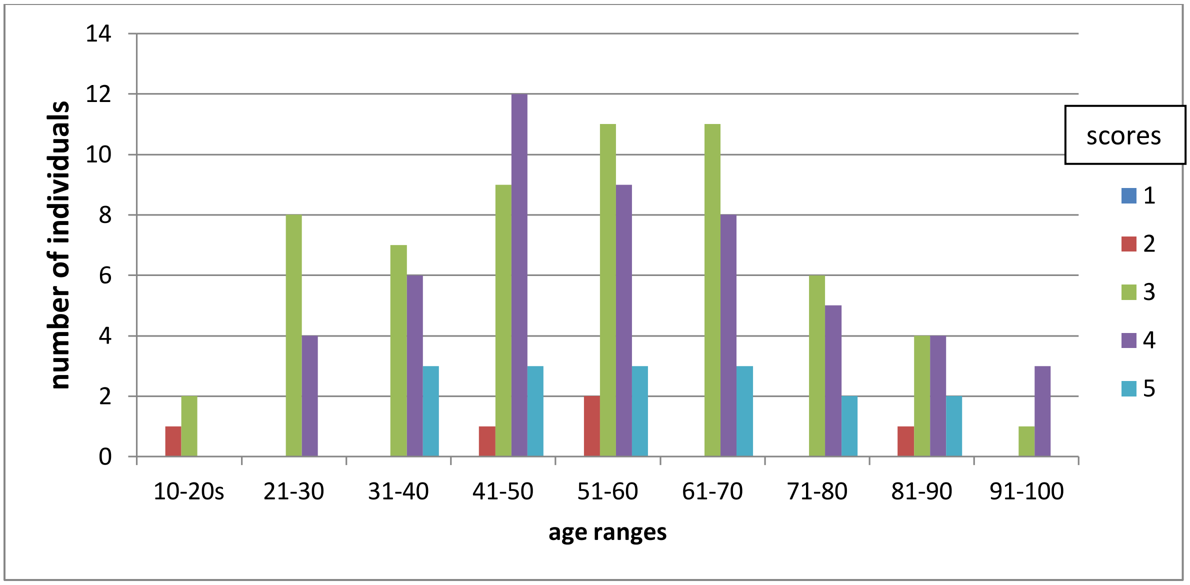

Figure 17: Male distribution of greater sciatic notch in age ranges; results not significant.

Summary

Females yielded significant differences between different reference groups in the subpubic concavity and ischiopubic ramus ridge. No significant differences were found among males in any trait, with the exception of the ventral arc. In addition, no age ranges showed significant differences in any trait for either males or females, with the exception of males in the ischiopubic ramus ridge.

CHAPTER IV

DISCUSSION

This study analyzed the non-metric traits of the pelvis that attribute to the assessment of sex of males and females between American Blacks, Whites, and Hispanics. The main focus of this study postulated that the scoring of the subpubic concavity, ischiopubic ramus ridge, ventral arc, preauricular surface, and greater sciatic notch would be consistent between these reference groups. This research also questioned if the adult age of a given individual would influence the scoring of these traits, where older individuals would appear to have more masculine traits and younger individuals would exhibit more feminine traits. In addition, males were expected to show more variation in these pelvic traits than females. Significant differences were found on the subpubic concavity and ischiopubic ramus ridge, used to assess sex between American Blacks, Whites, and Hispanics in females, as well as in the ventral arc in males. This suggests biological population-specific differences exist for non-metric sex assessment from the pelvis in American female groups.

Non-metric Traits

The results of this study show that in the greater sciatic notch most females score a 2, rather than a 1 as found by Walker (2005). He found that females almost always score a 1, and the score of 2 had the most overlap between males and females (Walker 2005). The current study found that the score of 3 had the most overlap between males and females, with the exception of Hispanic females who only scored 1's and 2's. What is most important to this study is that Walker (2005) found there were significant differences in scores between 20th century Americans and 18th-19th century English. He notes that this difference is likely due to environmental differences, such as diet, between reference groups, rather than biological population differences (Walker 2005). This study only analyzed modern American reference groups; therefore, secular change could not be tested.

Males in this study did not show a wide subpubic angle, which is consistent with the findings of Phenice (1969), who found that most males do not show a wider angle. Phenice (1969) also found that only a small number of males present a slightly wider angle, which would be designated by the score of 2. In this study, few Hispanic males scored a 2 for this trait, whereas almost half of the White males scored a 2 and more than a third of the Black males scored a 2. Phenice (1969) also noted that this slightly wider angle found in males is unique and difficult to confuse with the well-developed wide angle found in females. This study also found that it the slight angle in males is differentiated from that found in females and corroborates with Phenice's (1969) study. This variation in subpubic concavity angle with sexes could be caused by the differences of development patterns that form the subpubic concavity.

Kelley (1978) found that there were fewer intermediate scores of 3 for the ventral arc than any other non-metric pelvic trait developed by Phenice (1969). The results of this study are not consistent with those findings. This study found that females actually scored more 2s in the ventral arc than any other of the Phenice traits. Kelly (1978) also found that the intermediate score of 2 is predominately associated with females.

Although the majority of females did score a 2 in the present study, many of the White males also scored a 2, indicating that assessing the score of 2 to be female will result in many misclassifications.

It is likely that there is mostly consistency between reference groups in males and females because the sex traits themselves develop during puberty (Coleman 1969). Ali and Maclaughlin (1991) found differences in the pelvis between the sexes correlates with differences in body size, and generally males are larger than females.

The pattern of the growth of the pelvis is different between males and females, which could be the cause of the difference between the traits, specifically the presences of the subpubic concavity and the shallowness of the greater sciatic notch in females (Coleman 1969). Coleman (1969) found that the female pelvis grows more laterally whereas the male pelvis grows more inferiorly. This lateral growth in females causes a greater subpubic concavity and a shallower greater sciatic notch whereas the deep, narrow sciatic notch of males can be attributed to the inferior growth of the pelvis which deepens the notch while at the same time retaining a narrow notch shape (Coleman 1969). These differences in growth are likely common between reference groups, allowing for the sex traits to be consistent between groups.

Variation

LaVelle (1995) found that there is greater variation among males in the traits used to assess the sex of the pelvis and this variation could be attributed to group and age differences. She discovered that females throughout their growth span accumulate pelvic growth at moderate levels. She also notes that variation between the male and female pelvis is due to the continuous growth of female pubic bones even after growth in stature has ceased (LaVelle 1995). Significant differences found in this study could have been found among females in certain traits used for sexing due to the longer growth pattern of the pelvis in females.

Hormones also attribute to the morphological differences in the pelvis between males and females. Washburn (1948) relates the differences in pubic length to hormone responses in females. He notes that the reason the subpubic concavity is the best indicator of sex is because it is part of the growth that is most responsive to the action of female hormones (Washburn 1948). Tague (1989) found that it has not actually been significantly proven that females are any less variable in the morphological traits of the pelvis than males. He found that the male hormone, testosterone, modifies the pattern of growth and development. However, it does not affect the range in variation beyond that typical in females. In addition, estrogen also does not influence the pelvic shape (Tague 1989). The present study shows significant differences found between males and females, as expected. However, it also suggests that females are more variable. Females exhibited almost every score in each trait, while males typically only exhibited the masculine or intermediate scores.

Few authors found that when assessing sex from the pelvis, results are more accurate with the combination of traits (Washburn 1948; Listi 2010). This study was consistent with those findings. With the amount of ambiguous scores seen in all traits, it is suggested to pool all traits together when assessing sex. Few authors also found that females are misclassified less often than males (Bruzek 2002; Meindl et al. 1985).

Age

The only trait found to be significant between the different age ranges was the ischiopubic ramus ridge in males. Phenice (1969) states that this trait has a lot of variation in the scoring of the trait, which could explain why there is significant differences between the age ranges.

Walker (2005) also found that the widths of the greater sciatic notch tend to decease with age and that younger individuals tended to have wider greater sciatic notches in both males and females. He found that younger males were more likely to be misclassified as females, and older females were often misclassified as males (Walker 2005). However, Coleman (1969) found that as early as nine years of age, individuals express masculine or feminine sciatic notches, before puberty begins. He notes that it does not yet alter the shape of the pelvis, but it does show that sex differences are present at even a young age (Coleman 1969). The results of this study found no significant differences between males and females of different age ranges, indicating that age does not affect the shape of the greater sciatic notch.

This study is also inconsistent with Tague's (1989) study, who found that in both males and females the subpubic concavity began to narrow with age, becoming more masculine. He attributed this to the growth of osteophytes near the ischiopubic ramus (Tague 1989). In the present study significant differences were not found between the age groups in either males and females. This suggests that the shape of the subpubic concavity does not change with age, which conflicts with Tague's findings.

Limitations of the Study

This study was limited by the small sample size included as well as the uneven distribution of samples between the reference groups. In addition, the sample was also skewed to a higher percentage of males than females of each biological population group. Tague (1989) noted that nutrition and diet could affect the scores of the traits used for assessing sex based on the pelvis, which was not accounted for in this study. As environment and diet play an important role in the development and growth of individuals, it could also affect the traits of the pelvis utilized for assessing sex.

Significant differences were found in three of the non-metric pelvic traits between Blacks, Whites, and Hispanics in females, which indicate that the scoring of these traits could be dependent on group specific samples when assessing sex of American reference groups. This finding did not support the expectation that no changes would be found between reference groups. This study found no significant differences between reference groups of males in any of the traits; however, significant differences between reference groups in females were found, which contradicts the expectation that males were more varied than females. In addition, there were significant differences in the scores between age ranges in both males and females, supporting that expectation that age would affect the scoring of traits. Differences in the scoring of traits for males and females can be attributed to growth development rather than age or biological population differences.

CHAPTER V

CONCLUSION

The pelvis is the best indicator of sex when assessing the biological profile of an unknown individual. The most common method for assessing sex of unknown individuals is to score the non-metric traits of the pelvis found in "Standards for Data Collection from Human Skeletal Remains" (Buikstra and Ubelaker 1994), and were developed by Phenice (1969) and Walker (2005). Many authors have stated that biological population differences could account for differences in the scoring of traits; however, they did not analyze what those differences could be. Few authors have analyzed the differences between reference groups and found that no significant differences existed between Blacks and Whites in the traits of the pelvis (Listi 2010). Hispanics however, were rarely used in these studies, most likely due to limited availability.

The results of this study found significant differences between the scoring of two of the traits in Blacks, Whites, or Hispanics in females which included the subpubic concavity and ischiopubic ramus ridge. In addition the ventral arc showed significant differences between reference groups among males. This finding does not support the expectation that there would be consistency between these reference groups in the non-metric traits of the pelvis. In addition, this study does not provide support for the expectation that age would affect the scoring of the traits. There was no significant difference between the scores in the different age ranges of both females and males, with the exception of males in the ischiopubic ramus ridge. Therefore, the differences in pelvic trait scores between males and females can be attributed exclusively to sex rather than age differences.

The results indicate that the scores of non-metric traits of the pelvis used to assess sex of unknown individuals are not consistent among females of Blacks, Whites, and Hispanics in American reference groups. This implies that the current methods used to sex unknown individuals may need to be taken with caution American reference groups. The results of this study also found that there was overlap between males and females in each of the observed traits. Although overlap was observed in each trait, the best results to assess sex come from the researcher assessing the traits together and analyzing the entire pelvis.

This study has shown that current methods may not always be accurate in assessing sex among American reference groups. Walker (2005) found differences in the scores of the greater sciatic notch among current American reference groups and 18^{th}-19^{th} century English reference groups, but he did not find significant differences between Americans of different biological population groups. This is important because knowing the sex of an individual is often an important part of assessing the biological population group of an individual. Therefore, if sex is not population specific, the researcher can continue to assess sex first. Different reference groups might lead to differences in the non-metric scores of the pelvis.

This study is important to researchers because it incorporates Hispanics into the current methods of assessing sex based on the non-metric traits of the pelvis. In addition, it provides statistical results indicating that most of the traits are consistent between Whites, Blacks, and Hispanics, with the exception of the subpubic concavity and ischiopubic ramus ridge in females. These differences could be related to secular change, which was beyond the scope of this research.

Future studies should analyze different reference groups outside of the United States. This research should also be used to study whether or not environment and diet affect the non-metric scores of the pelvis. Studies could also include analysis of metric variables of the pelvis between Blacks, Whites, and Hispanics in American reference groups, as well as expand into other reference groups. As the current study was limited in the sample size of Blacks and Hispanics, future studies should include a more even distribution among reference groups. Another limitation of this study was the distribution of individuals among the age ranges. To better test if age plays a role in the scoring of non-metric traits utilized in sex estimation, a more even sample between the age ranges is important.

APPENDIX: COMPOSITE DATA

sample	ID	subpubic concav	ischiopubis ridg	ventra ar	preauricu	sciatic notch	estimated s	actual sex	ancestry	age
1	UT03-06D	1	1	1	3	3	F	F	W	52
2	UT57-04D	1	2	1	2	1	F	F	W	81
3	UT01-02D	3	2	3	2	4	M	M	W	96
4	UT27-07D	1	2	2	1	2	F	F	W	45
5	UT15-91D	2	2	2	2	3	I	M	B	51
6	UT24-00D	1	1	1	2	2	F	F	W	73
7	UT12-89D	3	3	2	2	3	M	M	W	63
8	UT105-06D	3	3	3	2	5	M	M	H	44
9	UT46-03D	2	3	3	2	3	M	M	B	23
10	UT57-08D	1	2	1	1	1	F	F	H	58
11	UT28-07D	1	1	1	2	2	F	F	W	77
12	UT49-07D	3	2	2	2	4	M	M	W	73
13	UT35-05D	3	2	2	2	4	M	M	H	43
14	UT06-06D	3	2	2	2	3	I	M	W	43
15	UT92-05D	1	1	2	2	1	F	F	W	47
16	UT01-08D	3	2	3	2	3	M	M	W	77
17	UT63-06D	2	2	2	2	3	I	M	W	43
18	UT11-02D	3	2	3	2	4	M	M	W	76
19	UT40-07D	2	2	3	3	4	M	M	W	69
20	UT44-01D	3	3	3	2	5	M	M	W	72
21	UT78-08D	1	2	1	1	2	F	F	W	92
22	UT10-97D	2	1	2	2	3	I	M	W	94
23	UT97-07D	1	1	2	2	2	F	F	W	66
24	UT25-93D	3	2	3	2	4	M	M	B	
25	UT94-06D	1	1	2	2	2	F	F	W	93
26	UT12-05D	3	2	2	2	3	I	M	B	56
27	UT86-08D	1	1	1	1	1	F	F	W	84
28	UT63-07D	3	2	2	2	4	M	M	W	53
29	UT106-06D	2	3	2	2	3	I	M	W	26
30	UT44-04D	2	2	3	2	4	M	M	W	39
31	UT15-97D	2	3	1	2	2	F	F	B	30's
32	UT74-07D	2	2	3	2	3	I	M	B	55
33	UT101-06D	1	2	2	2	2	F	F	W	60
34	UT15-89D	3	3	3	2	5	M	M	B	56
35	UT34-99D	3	2	3	2	3	M	M	H	24
36	UT29-04D	3	3	2	2	3	M	M	W	34
37	UT40-04D	2	2	3	3	3	I	M	B	49
38	UT83-05D	2	2	3	2	4	M	M	W	54
39	UT11-06D	1	1	1	1	2	F	F	W	60
40	UT23-03D	3	2	3	2	4	M	M	B	68
41	UT18-05D	1	1	1	2	3	F	F	B	99
42	UT17-97D	1	2	1	1	3	F	F	W	84
43	UT41-06D	3	3	3	3	3	M	M	B	71
44	UT27-03D	2	3	2	3	3	I	M	W	46
45	UT27-05D	1	1	2	2	3	F	F	W	59
46	UT17-00D	3	3	3	2	3	M	M	B	35
47	UT25-06D	1	1	1	1	2	F	F	W	44
48	UT48-07D	3	2	2	2	3	I	M	W	60
49	UT30-05D	1	1	2	2	2	F	F	W	69
50	UT04-06D	1	2	1	2	2	F	F	W	58
51	UT18-06D	2	3	2	2	3	M	M	W	81
52	UT48-04D	3	2	3	2	5	M	M	B	46
53	UT112-08D	1	2	2	2	2	F	F	W	97
54	UT19-92D	3	1	3	2	4	M	M	W	27
55	UT30-01D	3	2	3	2	3	M	M	B	64
56	UT34-02D	3	3	2	2	3	M	M	W	58
57	UT19-88D	3	2	2	2	4	M	M	W	46
58	UT13-08D	1	3	2	2	2	F	F	W	75
59	UT07-03D	3	3	3	2	5	M	M	W	87

60	UT81-07D	3	3	2	2	4	M	M	B	49
61	UT100-06D	1	1	2	2	2	F	F	W	57
62	UT27-01D	1	1	2	1	2	F	F	W	73
63	UT68-07D	2	1	2	1	3	I	F	W	42
64	UT18-03D	1	1	2	2	2	F	F	W	47
65	UT10-87D	2	2	3	2	3	I	M	W	76
66	UT47-06D	2	2	3	2	5	M	M	W	39
67	UT78-07D	1	1	1	1	3	F	F	B	24
68	UT53-05D	3	2	3	2	4	M	M	B	43
69	UT19-07D	3	2	3	2	4	M	M	B	53
70	UT59-06D	1	2	2	2	2	F	F	W	88
71	UT71-05D	3	2	3	3	4	M	M	B	72
72	UT80-05D	1	1	1	2	2	F	F	W	59
73	UT49-04D	3	2	2	2	3	I	M	W	64
74	UT36-06D	1	1	2	2	1	F	F	B	73
75	UT33-06D	3	2	3	2	3	M	M	H	33
76	UT02-07D	3	2	2	2	4	M	M	W	80
77	UT72-07D	3	2	3	2	5	M	M	W	79
78	UT65-04D	3	3	3	3	3	M	M	W	82
79	UT42-04D	3	3	3	2	4	M	M	H	42
80	UT14-98D	3	3	3	3	5	M	M	W	61
81	UT34-04D	1	2	2	1	2	F	F	W	80
82	UT82-08D	3	2	3	2	4	M	M	W	26
83	UT73-05D	3	2	2	2	4	M	M	W	63
84	UT05-06D	2	2	3	3	4	M	M	W	63
85	UT66-06D	1	1	2	2	1	F	F	W	62
86	UT90-06D	3	2	2	2	4	M	M	W	49
87	UT13-03D	2	2	3	2	3	I	M	W	48
88	UT17-88D	3	2	3	3	3	M	M	B	
89	UT37-04D	2	2	3	2	3	I	M	H	30's
90	UT79-07D	3	2	3	3	4	M	M	W	68
91	UT32-02D	3	2	2	2	4	M	M	W	64
92	UT21-92D	2	3	3	2	3	M	M	B	25
93	UT15-06D	1	1	1	2	3	F	F	W	59
94	UT28-01D	1	1	2	2	2	F	F	W	61
95	UT53-03D	1	1	1	2	1	F	F	W	60
96	UT81-06D	1	1	1	1	1	F	F	W	61
97	UT26-99D	1	1	2	2	2	F	F	W	74
98	UT20-93D	1	1	2	2	2	F	F	W	89
99	UT08-05D	2	2	3	2	4	M	M	W	55
100	UT62-06D	1	2	2	1	2	F	F	B	54
101	UT19-02D	1	2	3	2	2	F	F	W	85
102	UT46-08D	3	3	3	2	3	M	M	W	82
103	UT18-90D	3	3	3	2	4	M	M	B	27
104	UT17-04D	1	1	1	2	2	F	F	W	91
105	UT18-92D	3	3	3	2	3	M	M	H	20?
106	UT27-99D	3	3	3	2	4	M	M	W	88
107	UT18-97D	3	2	3	2	4	M	M	W	78
108	UT61-05D	1	1	1	2	3	F	F	W	55
109	UT31-00D	2	2	2	2	2	I	M	W	48
110	UT11-00D	3	2	3	2	3	M	M	W	55
111	UT03-08D	1	1	1	2	3	F	F	W	61
112	UT33-99D	1	1	1	1	3	F	F	W	94
113	UT10-99D	3	2	2	2	5	M	M	B	30-40
114	UT39-01D	1	1	1	1	2	F	F	W	36
115	UT20-08D	1	2	2	2	1	F	F	W	62
116	UT05-04D	3	2	3	2	3	M	M	W	72
117	UT12-08D	2	2	3	2	4	M	M	W	89
118	UT48-05D	3	2	2	2	3	I	M	W	61
119	UT11-04D	1	1	2	2	2	F	F	W	54
120	UT54-06D	3	2	3	3	3	M	M	B	43
121	UT05-01D	1	1	1	1	2	F	F	B	59
122	UT104-06D	2	2	3	2	3	I	M	W	56
123	UT33-07D	1	1	3	2	3	F	F	W	70
124	UT97-08D	3	2	3	2	5	M	M	B	36
125	UT100-07D	3	3	3	2	4	M	M	B	59
126	UT64-06D	2	2	3	3	2	M	M	W	57
127	UT13-91D	3	2	3	2	4	M	M	W	34
128	UT15-90D	2	2	2	2	4	I	M	B	54
129	UT11-03D	1	1	1	1	2	F	F	W	47
130	UT65-06D	2	2	2	2	4	I	M	W	31
131	UT27-91D	1	1	2	2	2	F	F	W	38
132	UT14-06D	3	3	3	2	3	M	M	W	38
133	UT11-05D	1	1	1	1	2	F	F	W	76

134	UT11-98D	2	2	2	2	3	I	M	B	49
135	UT06-04D	3	3	3	2	2	M	M	W	16
136	UT93-06D	2	3	3	2	4	M	M	B	50
137	UT75-06D	2	2	3	2	4	M	M	B	47
138	UT20-94D	3	2	3	2	4	M	M	H	
139	UT20-03D	1	1	2	2	2	F	F	W	44
140	UT31-93D	3	2	3	2	5	M	M	B	68
141	UT78-06D	1	1	2	1	1	F	F	W	49
142	UT92-06D	2	3	3	2	3	M	M	W	48
143	UT12-99D	1	1	1	2	4	F	F	W	72
144	UT19-94D	2	2	3	2	5	M	M	B	54
145	UT28-08D	3	3	3	2	3	M	M	W	79
146	UT13-01D	3	2	2	2	4	M	M	W	86
147	UT14-93D	2	2	2	2	4	I	M	W	32
148	UT20-90D	3	2	2	2	3	I	M	W	29
149	UT17-91D	2	1	2	2	3	I	M	W	26
150	UT45-06D	3	3	3	2	3	M	M	B	33
151	UT77-07D	1	1	2	2	2	F	F	W	36
152	UT52-03D	2	2	2	2	5	I	M	W	55
153	UT98-06D	2	3	2	2	4	M	M	B	47
154	UT23-06D	2	2	3	2	3	I	M	B	70
155	UT48-08D	2	2	3	2	4	M	M	H	28
156	UT70-06D	2	2	3	2	5	M	M	W	42
157	UT10-91D	3	3	3	3	3	M	M	W	35
158	UT32-06D	1	1	1	2	3	F	F	W	39
159	UT28-99D	2	2	3	2	4	M	M	H	44
160	UT17-06D	1	1	2	1	2	F	F	W	50
161	UT12-01D	2	2	3	2	4	M	M	W	50
162	UT22-99D	3	3	2	2	3	M	M	H	27
163	UT90-07D	2	1	2	1	2	F	F	W	77
164	UT72-08D	1	1	1	1	2	F	F	W	55
165	UT23-08D	3	2	3	2	4	M	M	H	40
166	UT04-01D	2	2	3	2	4	M	M	W	91
167	UT13-06D	2	2	2	3	5	I	M	W	90
168	UT18-88D	3	2	3	2	4	M	M	B	
169	UT16-99D	1	1	1	2	2	F	F	W	82
170	UT15-93D	3	3	2	2	4	M	M	B	84
171	UT93-05D	2	1	2	2	4	I	M	W	64
172	UT02-08D	1	1	1	2	1	F	F	W	65
173	UT09-02D	3	2	2	2	3	I	M	W	63
174	UT103-07D	2	2	3	2	5	M	M	W	66
175	UT108-07D	1	1	2	2	2	F	F	W	69
176	UT10-96D	2	2	2	2	4	I	M	W	67
177	UT12-87D	2	2	2	2	3	I	M	W	82
178	UT14-01D	1	1	1	1	1	F	F	W	78
179	UT14-05D	2	2	3	3	3	I	M	W	63
180	UT14-08D	2	2	2	2	3	I	M	W	64
181	UT14-87D	3	3	3	2	4	M	M	W	50
182	UT15-98D	1	2	3	2	3	I	F	W	81
183	UT17-01D	3	2	2	2	2	I	M	W	51
184	UT18-91D	2	2	3	2	4	M	M	W	58
185	UT34-05D	2	2	3	2	3	I	M	W	44
186	UT35-03D	2	2	2	2	3	I	M	W	62
187	UT41-01D	1	2	2	2	1	F	F	W	58
188	UT42-07D	2	2	2	2	3	I	M	W	70
189	UT43-02D	2	2	3	2	3	I	M	W	66
190	UT45-07D	1	1	1	1	2	F	F	W	76
191	UT63-03D	1	1	2	2	2	F	F	W	58
192	UNM 3	3	2	3	2	4	M	M	B	55
193	UNM 28	2	2	2	2	3	I	M	B	59
194	UNM 45	3	3	3	2	2	M	M	B	82
195	UNM 94	2	2	3	2	3	I	M	B	74
196	UNM 153	3	3	3	2	3	M	M	H	60
197	UNM 168	2	2	2	2	2	I	F	H	81
198	UNM 194	1	1	2	1	1	F	F	H	68
199	UNM 218	1	2	2	1	1	F	F	H	66
200	UNM 221	3	2	2	2	3	I	F	B	100
201	UNM 234	3	3	2	2	4	M	M	H	91
202	UNM 238	3	2	3	2	3	M	M	H	59
203	UNM 242	3	2	2	3	3	I	M	H	52

REFERENCES

Buikstra J.E., and Ubelaker D.H. 1994. Standards for Data Collection from Human Skeletal Remains. Research series, no. 44.

Coleman W.H. 1969. Sex differences in the growth of the human bony pelvis. American Journal of Physical Anthropology 31(2):125-151.

Gosman J.H, Stout S.D., and Larson C.S. 2011. Skeletal biology over the life span: A view from the surfaces. Yearbook of Physical Anthropolgoy 146(54):86-98.

Houghton P. 1974. The relationship of the pre-auricular groove of the llium to pregnancy. American Journal of Physical Anthropology 41(3):381-389.

Hoyme L.E. 1957. The earliest use of indices for sexing pelves. American Journal of Physical Anthropology 15(4):537-546.

Kelley M.A. 1978. Phenice's visual sexing technique for the os pubis: A critique. American Journal of Physical Anthropology 48(1):121-122.

LaVelle M. 1995. Natural selection and developmental sexual variation in the human pelvis. American Journal of Physical Anthropology 98(1):59-72.

Listi G.A. 2010. The Impact of Racial Metric Variation in the Os Coxae on the Morphological Assessment of Sex*. Journal of Forensic Sciences 55(5):1157-1161.

Meindl R.S., Lovejoy C.O., Mensforth R.P., and Carlos L.D. 1985. Accuracy and direction of error in the sexing of the skeleton: Implications for paleodemography. American Journal of Physical Anthropology 68(1):79-85.

Phenice T.W. 1969. A Newly Developed Visual Method of Sexing Os Pubis. American Journal of Physical Anthropology 30(2):297-&.

SWGANTH: The Scientific Working Group for Forensic Anthropology. 2013. Sex Assessment. http://swganth.startlogic.com/Sex%20Rev0.pdf, accessed Feb. 24, 2013.

Tague R.G. 1989. Variation in pelvic size between males and females. American Journal of Physical Anthropology 80(1):59-71.

Walker P.L. 2005. Greater sciatic notch morphology: Sex, age, and reference groups differences. American Journal of Physical Anthropology 127(4):385-391.

Washburn S.L. 1948. Sex differences in the pubic bone. American Journal of Physical Anthropology 6(2):199-208.

Weiss K.M. 1972. On the systematic bias in skeletal sexing. American Journal of Physical Anthropology 37(2):239-249.

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