# CHAPTER 5

# RESULTS of NON-METRIC ANALYSIS

Based on published and known sexually dimorphic visual traits found on the postcranial skeleton (Bass 1995; Rogers 1999; Wanek 2002), two skeletal elements, the distal humerus and pelvis, were used in the attempt to successfully categorize skeletal sex. Subsequently, these visual assessments were subjected to statistical analysis to determine if the predictive value of each feature changed with the onset of age. If a change in accuracy was observed, the location and implications were addressed. The results of analyses of non-metric data from features present on the distal humerus are summarized in Section 5.1. The possibility of improving classification accuracy by removing one non-metric humeral trait is discussed in Section 5.2. Sections 5.3 and 5.4 summarize the analyses of non-metric data of the distal humerus in different male and female populations with the onset of age. Changes in non-metric data related to the pelvis in males and females with the onset of age is arranged in Sections 5.5, 5.6 and 5.7.

## 5.1

## Results of non-metric data from the humerus

Four traits of the distal humerus, namely medial epicondylar symmetry, trochlear extension, olecranon fossa shape, and medial epicondylar angle were used as characteristics for sex determination of the humerus, and comprised an amalgamated score that resulted in the estimation of sex for each specimen. "Estimated sex" was then obtained based on a combination of all four visual traits.

Classic Pearson's chi square statistical analyses were performed on the total sample in order to determine the efficacy of humeral traits as a predictor of sex. Each humeral trait was individually analyzed to determine the relative efficacy of the characteristic in its predictive value for accurately classifying sex. Scoring for each trait was completed with a [1] through [5] determination method to gauge the degree of sexual dimorphism in the individual characteristic. The allocation of a [1] represented the most typical male morphology, whereas [5] represented the most typical female morphology. Subsequently, [2] represented intermediate male morphology, [3] was considered ambiguous morphology, and [4] represented intermediate female morphology (see Chapter 3, section 3.2.1, "data collection for non-metric information" for a more detailed description of these features). Tables in this chapter display the number of specimens that exhibited each "grade" under each score of [1] through [5]. Based on chi square values observed for each trait, males and females appeared significantly different from each other on a statistical level.

### 5.1.1

### Sex determination from epicondylar symmetry (all males and females)

Although the chi square test indicated significant differences between the male and female morphology, the placement of the medial epicondyle within the circular profile of the trochlea (epicondylar symmetry) was not considered an accurate predictor of sex in males; only 40% of males (168/420) were correctly identified from this trait (classified as [1] or [2], Table 5.1). This characteristic accurately placed more females in the correct category than males (classified as [4] or [5], 71%, 134/188). In addition, 14% of the total sample could not be classified as either male or female, meaning the individual element exhibited ambiguous morphology (classified as [3], Figure 5.1). In addition, a large number of male medial epicondyles and their symmetry patterns exhibited intermediate female/ [4] morphology.

### 5.1.2

### Sex determination from trochlear extension (all males and females)

Trochlear extension was also a relatively inaccurate classification trait when observed in isolation. Only 45% of males were correctly classified, in contrast to 56% of females (Table 5.2). This trait was still considered sexually dimorphic based on the distribution of correctly assigned cases and the subsequent Pearson's chi square analysis, which showed statistically significant differences between the sexes (Figure 5.2).

### 5.1.3

### Sex determination from olecranon fossa shape (all males and females)

Olecranon fossa shape was observed to be one of the better traits of the distal and posterior humerus to correctly classify skeletal sex. As seen in Table 5.3, 57% of males were correctly classified when combining the assignment of a [1] (male trait) and a [2] (intermediate male trait). The olecranon fossa shape as a female predictor was 60% accurate in isolation. Nineteen percent (113/ 608) of all specimens were ambiguous in their olecranon fossa morphology (Figure 5.3).

Pearson's chi square value determined that this characteristic was sexually dimorphic on a statistically significant level. The olecranon fossa shape was considered to be distinguishable between males and females.

### 5.1.4

### Sex determination from the angle of the medial epicondyle (all males and females)

The angle of the medial epicondyle was also considered sexually dimorphic based on Pearson's chi square value and its significance level (Table 5.4). The angle of the medial epicondyle classified 71% of all males correctly, and 55% of females.

The angle of the medial epicondyle exhibited classification accuracies for males and females that indicated distinct sexual dimorphism in the feature, and produced a minimal number of ambiguous cases (6%, Figure 5.4). As seen in the bar graph for classification accuracy, the angle of the medial epicondyle appeared sexually dimorphic on a statistically significant level. This isolated trait of the distal humerus proved to be one of the better predictors of sex.

### 5.1.5

### Final estimated sex from the distal humerus (all males and females)

Based on chi square values, a significant difference was observed between males and females for the ultimate determination of "estimated sex". Estimated sex was the final determination of sex classification when the four characteristics previously discussed were combined. To determine estimated sex, scores for each of the four humeral traits were combined, and a final value was placed on the specimen (4 through 11 for males, 12 for ambiguous, 13 through 20 for females). This value determined the final classification of the specimen as either a [1] male, [3] ambiguous, or [5] female (see Table 5.5). Final classification accuracies for sex estimation were 62% for male specimens and 72% for female specimens. Based on the chi square significance of estimated sex from the humerus, each characteristic was established as sexually dimorphic, as was the final determination of estimated sex from the distal humerus.

Distributions of final male and female classifications appear in Figure 5.5. Allocation based on the percentage of correct assignments showed the delineation between male and female morphology in the distal humerus. From these results it can be seen that each humeral characteristic, when used in isolation, was not necessarily an accurate predictor of sex. However, when taking a combined, total score based on a [1] through [5] determination from each trait, the deduction of estimated sex was moderately accurate for both males and females.

Based on chi square values, a statistically significant difference was observed between males and females and the characteristic morphology of medial epicondylar symmetry, trochlear symmetry, olecranon fossa shape, and medial epicondylar angle. In Table 5.6, under each column heading the number of specimens which were observed to exhibit each "grade" of morphology (and their resulting percentage of classification accuracy), is shown. Estimated sex in Table 5.6 (and all other subsequent tables) is *not* a column total for each value; it is a final amalgamation of the total scores of all humeral characteristics. Specimens exhibiting a majority of male characteristics were categorized as male under "estimated sex". Thus, humeral traits exhibiting a [1] and [2] were combined in the table under 1 (M), because both represented male morphology. Specimens exhibiting a majority of female characteristics were categorized as female under estimated sex, and placed in the table under 5 (F). Humeral traits exhibiting a [4] and [5] were combined because both represented female morphology. Some specimens exhibited an equal number of male and female characteristics, and were ultimately categorized under "estimated sex" as [3], or ambiguous. Estimated sex in each table should thus be viewed as the ultimate classification score (with the resulting percentage of accuracy noted in parentheses).

## 5.2

## Removal of inaccurate trait (s) and the improvement in classification accuracy for the distal humerus

Because the non-metric analysis of traits from the distal humerus relied on features with fluctuating statistical significance, the trait that performed most poorly was discarded in an attempt to more accurately classify "estimated sex" and improve the classification accuracy of the sample. Medial epicondylar symmetry had a lower association with sex than the other three characteristics and did not associate strongly with sex when analyzing data. Sex determination by medial epicondylar symmetry was removed from the data, and statistical analyses were then performed on the "estimated sex" determination based on a condensed suite of three morphological traits (trochlear symmetry, olecranon fossa shape, and medial epicondylar angle). The distribution of re-classification efforts is summarized in Table 5.7. A total of 97 cases were still misclassified after removing medial epicondylar symmetry. Twenty-four specimens in total were reclassified incorrectly with the removal of this trait, and a total of 60 specimens improved their classification accuracy from "misclassified" or "ambiguous" to being correctly classified. Seventeen cases were re-classified as ambiguous instead of being patently misclassified as the incorrect sex.

The removal of medial epicondylar symmetry from the data allowed for the correct assignment of a total of 60 otherwise ambiguous or misclassified cases. As seen in Table 5.8 and the corresponding bar graph in Figure 5.6, the classification accuracies for both males and females increased. Males were now classified with an increased accuracy rate of 74% (in contrast to 62% with four characteristics), and female estimated sex determination increased 5% in accuracy (from 72% to 77%). The removal of medial epicondylar symmetry allowed the remaining characteristics to classify skeletal sex equivalent to other anthropological methods used for non-metric sex determination (Albanese *et al.* 2005; Allen *et al.* 1987; Rogers 1999; Ubelaker and Volk 2002; Walrath *et al.* 2003; Wanek 2002).

## 5.3

## Comparison of non-metric data from the humerus: females

After determining the degree of sexual dimorphism in the distal and posterior humerus, the variation between populations within the categories of "male" and "female" were examined. An assessment was done in order to establish whether significant differences existed between the biological affiliations. If not, the results would be documented but groups would otherwise be combined in future analyses. Based on the separation of groups in Chapter 4: Results of Metric Analysis, the sample was separated into "black" and "white" categories, and the results tested to determine if sex classification was dependent on these biological groups for males and females. The categories of "black female", "white female", "black male", and "white male" were utilized. The non-metric classification accuracies of black females were therefore compared to that of white females by means of Pearson's chi square statistics, and differences noted where applicable. Similarly, black and white males were compared.

Non-metric traits of the humerus were categorized into populations to observe specific differences between "black females" and "white females". Populations were considered discrete in these initial analyses and each population data set was examined for classification accuracy fluctuations with the onset of age. A change in the predictive quality of each feature and a change in the classification accuracy for the ultimate determination of sex were noted when applicable.

### 5.3.1

### Classification accuracy for black females vs. white females

A comparison of the categories "black female" and "white female" was performed to reveal the differences, if any, between the two groups (Table 5.9). When observing the specific traits in isolation, the shape of the olecranon fossa was observed to classify better in black than white females (73% and 45%, respectively). This difference in classification accuracy resulted in a statistically significant outcome between female groups. When sex was estimated from the amalgamation of the three humeral traits, this estimation was found to be different depending on the biological affiliation on a statistically significant level. Sex was estimated correctly in 84% of all black females, and 68% in all white females (Figure 5.7). Based on the

Pearson's chi square value (7.015, df=2, 0.030<0.05), estimated sex was dependent on the biological affiliation in females. Females from both populations were correctly classified on an accurate level. Characteristics of the distal humerus proved to be valid criteria for sex determination for both black and white females, although sex was predicted at a higher accuracy rate with black females. Based on Figure 5.7, it was interesting to note that 26% of the total white female sample was misclassified as male. A minimum number of females were deemed ambiguous between populations (5% for black females and 6% for white females).

### 5.3.2

### Classification accuracy for young black females vs. old black females

Females were then separated and statistical analyses were performed to view changes with age in each biological group. Black females and their classification accuracy did not change significantly with age when observing any of the traits from the distal humerus (Table 5.10; 88% for young, 78% for old). Figure 5.8 illustrates the percentages of accuracy between young and old samples in this biological group when all variables were combined to observe "estimated sex".

### 5.3.3

### Classification accuracy for young white females vs. old white females

In white females, the classification accuracy of two isolated humeral characteristics (olecranon fossa shape and medial epicondylar angle) changed on a significant level with the onset of age (Table 5.11). These significant changes increased the classification accuracy of the angle of the medial epicondyle from 36% accurate in young females to 56% accurate in old females, while decreasing the classification accuracy of the olecranon fossa shape from 79% accurate in young females to 38% accurate in old females.

Estimated sex is the final incorporation of isolated humeral trait scores used to predict skeletal sex. As seen in Figure 5.9, the percentage of white females correctly classified by distal humeral traits decreased from 93% to 63% with the onset of age, which indicated a marked decrease in the classification accuracy of the feature. However, the 30% decrease in accuracy was statistically insignificant. The fact that this marked decrease in predictive value was statistically non-significant may be the result of the small sample size (n = 13) of the young white females.

The ultimate result of "estimated sex" is similar in both black females and white females. Changes in non-metric morphology were occurring that decreased the classification accuracy of the sex determination in all females. Thus, young female individuals were classified more accurately than older female individuals when utilizing characteristics from the distal humerus. In general, therefore, the results of the black and white females were congruent, as accuracies of both decreased (although not significantly on a statistical level) with age.

## 5.4

## Comparison of non-metric data from the humerus: males

All data from males were observed in the same way as female non-metric data. Non-metric traits of the humerus were categorized into populations to observe specific differences between "black males" and "white males". Populations were considered discrete and each population data set was examined for classification accuracy fluctuations with the onset of age. A change in the predictive quality of each feature and a change in the classification accuracy for the ultimate determination of sex were noted where applicable.

### 5.4.1

### Classification accuracy for black males vs. white males

A comparison of the categories "black male" and "white male" was performed to reveal the relative diversity between the two groups (Table 5.12).

The olecranon fossa shape exhibited statistically significant differences between male populations. This same trait also differed between the female populations. The remainder of the male traits, including the final estimated skeletal sex, were independent of the biological affiliation for their correct classification. Based on the Pearson's chi square value (0.606>0.05), estimated sex was not population-specific; the male sample was categorized with sufficient accuracy regardless of the biological affiliation of males (72% for black males, 78% for white males). The percentages of correct classification between the two male groups can be observed in Figure 5.10.

### 5.4.2

### Classification accuracy for young black males vs. old black males

Young black males differed only slightly in morphology of the distal humerus from old black males (Table 5.13). The classification accuracy of the suite of 3 traits was accurate at 71% for young individuals of this group, and improved with the onset of age to a classification accuracy of 74%. This increase in accuracy was not statistically significant, however. The only trait that changed in a statistically significant manner was the shape of the olecranon fossa, in which accuracy decreased slightly with advanced age. These results indicated a slight general increase in accuracy with the onset of age in the black male humerus (Figure 5.11).

### 5.4.3

### Classification accuracy for young white males vs. old white males

White males were predicted with more accuracy in general than their black male counterparts, but their classification accuracy decreased with age (black males 71% - 74%, white males 86% - 75%). This result was not statistically significant. Trochlear extension as an isolated element, however, was statistically different between young and old white males in its classification accuracy; correct categorization of white males decreased with age in this humeral characteristic from

64% accuracy to 46% accuracy (Table 5.14). The classification accuracy of sex determination with this suite of traits decreased with age, although not significantly (Figure 5.12). When age increased, more male samples were misclassified as female, which indicated a general change in morphology based on the lower classification accuracy of the features. In addition, more males were deemed ambiguous in their morphology as age increased. This is in direct contrast to the black male sample, where accuracy increased with the onset of advanced age. However, both differences in classification accuracy were considered statistically non-significant.

The pattern for a decrease in classification accuracy with the onset of age in white males was congruent with the female sample in both white and black populations.

### 5.4.4

### Classification accuracy from the distal humerus: summary

In summary, physical traits from the distal and posterior humerus predicted sex at variable rates for different populations and sexes. Males and females across ancestral groups were quite similar comparatively in their morphology; black and white females exhibited similar morphology while black and white males also showed parallels in the anatomy of the distal humerus. When divided into population affinities and scrutinized between age groups (young=50 years old and younger, old=older than 50 years old), only black male classification accuracy increased with the onset of age. All others (black females, white females, and white males) were observed to decrease in their classification accuracy with age. In general, younger individuals were classified more accurately than older individuals in each of these population categories. Ultimately, although these changes were occurring, they could not be directly associated with age on a statistically significant level.

## 5.5

## Results of non-metric data from the pelvis

Characteristics of the os coxae have been shown to be sexually dimorphic. Four non-metric visual traits (subpubic concavity, subpubic angle, ischio-pubic ramus width and greater sciatic notch width) were used to estimate sex. Based on an amalgamation of the first four visual traits, a final trait, "estimated sex" was determined for each specimen. Scoring of these traits was the same as with the distal humerus; [1] denoted the typical male morphology, [2] an intermediate male, [3] was ambiguous, [4] categorized an intermediate female and [5] denoted typical female morphology. Each pelvic trait was initially analyzed to determine the relative efficacy of the characteristic in its classification accuracy for correctly predicting sex.

### 5.5.1

### Sex determination from the subpubic concavity (all males and females)

The subpubic concavity was an accurate predictor of sex as an isolated pelvic trait. If both categories [1] and [2] were deemed as an accurate diagnosis of a male, and both [4] and [5] deemed accurate as female, 76% of all male specimens and 88% of all female specimens were correctly classified when employing this trait (Table 5.15). Twenty-nine percent of all individuals could not be classified, and were assigned a score of [3] / ambiguous; only 3% of females and 6% of males were incorrectly classified. Males were predicted at a lower rate of accuracy than females, and more males exhibited "ambiguous" morphology with this trait than did females (18% and 10% respectively).

The subpubic concavity of individuals within this sample was sexually dimorphic on a statistically significant level. The results are graphically illustrated in Fig. 5.13, where it can also be seen that the overlap was quite small.

### 5.5.2

### Sex determination from the subpubic angle (all males and females)

As expected, the subpubic angle of the os coxae predicted sex with a high rate of accuracy (Table 5.16). Males were correctly classified with this trait in isolation 67% of the time; in contrast, females were accurately predicted 95% of the time. Males appeared to exhibit more ambiguous morphology with the subpubic angle, while females virtually never exhibited ambiguous morphology (23% and 2%, Figure 5.14). Males exhibited both a wide and narrow subpubic angle based on the results. Females, however, exhibit subpubic angle morphology that is distinctly wide and unambiguous.

### 5.5.3

### Sex determination from the ischio-pubic ramus width (all males and females)

The ischio-pubic ramus width in isolation was considered statistically significant in determining sex ($p = 0.000 < 0.05$). Males once again exhibited less defined morphology than females (Table 5.17).

The classification accuracy of this feature was much more robust with females than males, correctly predicting female skeletal sex 84% of the time, in contrast to only 48% of the time for male specimens. There were also numerous ambiguous cases in the male sample (Figure 5.15). This indicated that the width of the ischio-pubic index tends to be variable in males, yet quite consistently thin and gracile in its morphology in females. These results also imply that if a ramus is robust, it is almost definitively a male, while a thin and gracile morphology may indicate a male or female. The ischio-pubic index was observed to be the least-reliable trait in isolation of the four characteristics of the os coxae.

### 5.5.4

### Sex determination from the width of the greater sciatic notch (all males and females)

Based on Pearson's chi square statistical analysis, this trait in isolation was considered sexually dimorphic on a statistically significant level (Table 5.18). Once again, females were correctly categorized with the use of this trait at a highly accurate rate (88%). Males were categorized at an accuracy rate of 70%. Figure 5.16 illustrates the classification accuracy of the greater sciatic notch in regards to sexual dimorphism. More males (13%) exhibited ambiguous morphology in this feature than did females (6%).

The number of ambiguous cases assigned to male specimens indicated again that male morphology was quite variable in this region with regard to greater sciatic notch width. Males exhibited a range of narrow and wide notch widths, while females appeared to remain constant in their characteristic wide morphology. This implies that an individual with a narrow greater sciatic notch is almost certainly a male, while an individual with a wide notch could possibly be male or female. More males exhibited female morphology than females exhibited male morphology.

### 5.5.5

### Estimated sex (all males and females)

Sex was then estimated from incorporating all characteristics and establishing an ultimate determination of sex. As seen in Table 5.19, sex was predicted at a highly accurate rate, confirming that the non-metric pelvic morphology is sexually dimorphic. Table 5.20 indicates the delineation of trait accuracies with all males and females included within the sample, with 83% of the male sample and 94% of the female sample classified correctly (Figure 5.17).

## 5.6

## Comparison of non-metric data from the pelvis: females

A comparison of the categories "black female" and "white female" was performed to reveal the relative diversity between the two groups. Populations were considered discrete and each population data set was examined for classification accuracy fluctuations with the onset of age. A change in the predictive quality of each feature and a change in the classification accuracy for the ultimate determination of sex were noted where applicable.

### 5.6.1

### Classification accuracy for black females vs. white females

Females were first observed together to define similarities and differences in morphology based on classification accuracies of four characteristics of the pelvis. As seen in Table 5.21, all females regardless of their biological affiliation were classified with a high rate of accuracy with all pelvic traits utilized.

Accuracy rates between populations were congruent, and the ability to correctly categorize sex was independent of biological affiliation with every pelvic trait studied in the female sample. None of the p-values were significant. In other words, the characteristics of the female os coxae were non-population-specific; the population affinity was not needed in order to categorize female sex correctly. Both black and white females were categorized at a high rate of accuracy (Final estimated sex; Fig. 5.18, 93% and 96%, respectively). Black females were observed to be misclassified as males more often than white females; however, this was not statistically significant. The pelvis continued to be a highly accurate predictor of female sex in both populations studied.

### 5.6.2

### Classification accuracy for young black females vs. old black females

The female sample was then divided into "black" and "white" and "young" and "old" groups to observe possible changes in accuracy rates within the groups. As seen in Table 5.22, the ability to determine sex from the pelves of black females is independent of age; sexual dimorphism remained high in black females with the onset of age.

Young females were classified more accurately than old females, although the difference between age groups was minimal (94% and 92%, respectively). This indicated that no considerable morphological changes were observed in visual traits of the os coxae with the onset of age, as seen with the high accuracy in which females were categorized regardless of age group (Figure 5.19).

### 5.6.3

### Classification accuracy for young white females vs. old white females

White females performed much in the same manner as black females in their pelvic morphology, with accuracy in sex determination decreasing with the onset of age on a statistically non-significant level (Table 5.23). Although the accuracy rate decreased as age increased (final estimated sex; 100% for young white females, 94% for old white females), white female pelves were still categorized successfully regardless of the age; predictive values were independent of age (Figure 5.20).

As seen with the black female population, white females were also misclassified as males more often than being deemed ambiguous with the onset of advanced age. These numbers were not large, but indicated that when variation occurred, it occurred as an explicit departure in morphology for white females and not an "ambiguous" one. In general, sexual dimorphism remained constant with this biological group with the onset of age, and age was not considered a negative factor in determining skeletal sex from the os coxae.

## 5.7

## Comparison of non-metric data from the pelvis: males

After confirmation of pelvic sexual dimorphism utilizing four non-metric visual traits and then a final estimate of sex based on these four traits, a comparison of the categories "black male" and "white male" was performed to reveal the relative range of variation between the two biological affiliations as was the case in the previous sections.

### 5.7.1

### Classification accuracy for black males vs. white males

The two male groups were compared to observe any differences or contrasts in the morphology of the pelvis (Table 5.24). The subpubic concavity, the subpubic angle, and the greater sciatic notch width in black males differed significantly in morphology from their white male counterparts. Males from each group, however, were classified at a high rate of accuracy (85% for black males and 79% for white males). This indicated that although three morphological characteristics of the os coxae in males differed between populations in their predictive quality when observing each in isolation, the final determination of sex was not affected by these differences.

It was interesting to note that non-metric morphology in the greater sciatic notch exhibited a statistically significant divergence within biological groups. Greater sciatic notch width was dependent upon population in order to correctly classify skeletal sex in males divided between "black" and "white" groupings. Black males were categorized correctly with greater sciatic notch width morphology 73% of the time, while white males were assigned correctly with this pelvic trait 63% of the time. The greater sciatic notch width appeared to be far more variable in whites than in blacks. Not only are white males assigned to the correct sex less often than black males, but that they are also misclassified as females more often than black males when observing the greater sciatic notch width in isolation.

When all of the traits were considered together and an estimated sex was obtained, however, this determination was independent of population on a statistically significant level. In other words, black males and white males were congruent with each other, and the population of a specimen was not needed in order to successfully assign it to the correct sex (Figure 5.21). The determination of sex was accurate in 85% of the black male sample when taking the suite of four pelvic traits into consideration, while the white male sample produced an accuracy of 79%.

This result indicated that although some non-metric visual techniques work better on some populations, the final determination of male sex from the pelvis is quite accurate across population affiliations.

### 5.7.2

### Classification accuracy for young black males vs. old black males

As Table 5.25 illustrates, black males increased in their accuracy rates as their age increased. The subpubic angles as well as the greater sciatic notch width were significantly different in their classification accuracies with the onset of age; more characteristic male morphology was seen in older males. Both the greater sciatic notch and the final estimated sex differed significantly on a statistical level between the younger and older groups (Figure 5.22). This indicated that sexual dimorphism in the black male pelvis is significant for young individuals (79% accurate), but becomes even more pronounced with the onset of age (88% accurate).

### 5.7.3

### Classification accuracy for young white males vs. old white males

The onset of age in the white male pelvis was significant when observing the subpubic concavity. When determining the final assessment of skeletal sex, age did not appear to play a role in the successful determination of sex (Table 5.26). In addition, male pelvic traits were independent of age in the majority of features; age did not play a role in the successful determination of sex from the subpubic angle, the ischio-pubic ramus width, or the greater sciatic notch width.

As seen in Figure 5.23, correct classification of white male sex decreased with the onset of age; younger white males were classified with more accuracy than older white males (93% and 74%, respectively). This was a statistically significant result. Older white males were found to have more ambiguous morphology than their younger counterparts and were misclassified as females more often than young males.

## 5.8

## Repeatability for non-metric characteristics of the humerus and pelvis

An independent observer was utilized to determine if the non-metric characteristics of the distal humerus and the pelvis were apparent enough to reproduce accurate statistical results. This observer could not accurately predict sex with the first two humeral traits (trochlear extension and the olecranon fossa shape), but the angle of the medial epicondyle was categorized accurately as sexually dimorphic on a statistically significant level. When asked to ascertain a final determination of sex from the distal humerus, the independent observer was 91% accurate with male humeri and 75% accurate with female humeri (Appendix K). The distal humerus, therefore, appeared to show some ambiguity in the sexually dimorphic features chosen for this study. As with any non-metric visual trait, experience in observing the characteristic may have played a role in determining sex from this element. Although the observer did not accurately categorize two of the three independent traits, ultimately the correct sex was determined accurately.

Non-metric pelvic features were assigned accurately by the independent observer for all four characteristics. Pelvic morphology as defined in this study was deemed to be reproducible, well-defined, and robust in its sexual dimorphism (Appendix L).

**Table 5.1: Distribution of classification, all males and females, medial epicondylar symmetry. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 41 (10%) | 127 (30%) | 63 (15%) | 140 (33%) | 49 (12%) | 420 |
| Female | 10 (5%) | 24 (12%) | 20 (11%) | 70 (37%) | 64 (34%) | 188 |
| Total | 51 | 151 | 83 | 210 | 113 | *N* = 608 |

***Pearson's chi square value=56.387, df=4, p=0.00<0.05***

**Table 5.2: Distribution of classification, all males and females, trochlear extension. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 55 (13%) | 135 (32%) | 77 (18%) | 137 (33%) | 16 (4%) | 420 |
| Female | 12 (6%) | 40 (21%) | 31 (17%) | 79 (42%) | 26 (14%) | 188 |
| Total | 67 | 175 | 108 | 216 | 42 | *N* = 608 |

***Pearson's chi square value=31.951, df=4, p=0.00<0.05***

**Table 5.3: Distribution of classification, all males and females, olecranon fossa shape. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 70 (17%) | 170 (40%) | 79 (19%) | 86 (21%) | 15 (4%) | 420 |
| Female | 4 (2%) | 36 (19%) | 34 (18%) | 67 (36%) | 47 (24%) | 188 |
| Total | 74 | 206 | 113 | 153 | 62 | *N* = 608 |

***Pearson's chi square value=110.370, df=4, p=0.00<0.05***

**Table 5.4: Distribution of classification, all males and females, medial epicondylar angle. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 153 (37%) | 144 (34%) | 22 (5%) | 76 (18%) | 25 (6%) | 420 |
| Female | 24 (13%) | 49 (26%) | 12 (6%) | 64 (34%) | 39 (21%) | 188 |
| Total | 177 | 193 | 34 | 140 | 64 | *N* = 608 |

***Pearson's chi square value=73.6673, df=4, p=0.00<0.05***

**Table 5.5: Distribution of classification, all males and females, estimated sex. 1=Male, 3=Ambiguous, 5=Female**

| | 1 | 3 | 5 | Total |
|---|---|---|---|---|
| Male | **261 (62%)** | 56 (13%) | 103 (25%) | 420 |
| Female | 30 (16%) | 22 (12%) | **136 (72%)** | 188 |
| Total | 291 | 78 | 239 | *N*= 608 |

***Pearson's chi square value=133.687, df=2, p=0.00<0.05***

**Table 5.6: Distribution of classification and chi square significance, all males and females (total *N* = 608). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations for males, and [4] and [5] "estimated sex" determinations for females.**

| | **Males (*n*=420)** | | | | | **Females (*n*=188)** | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Epicondylar symmetry | 41 | 127 | 63 | 140 | 49 | 10 | 24 | 20 | 70 | 64 | 56.387 | 4 | **0.000*** |
| | (10%) | (30%) | (15%) | (33%) | (12%) | (5%) | (13%) | (11%) | (37%) | (34%) | | | |
| Trochlear extension | 55 | 135 | 77 | 137 | 16 | 12 | 40 | 31 | 79 | 26 | 32.994 | 4 | **0.000*** |
| | (13%) | (32%) | (18%) | (32%) | (4%) | (6%) | (21%) | (16%) | (42%) | (14%) | | | |
| Olecranon fossa shape | 70 | 170 | 79 | 86 | 15 | 4 | 36 | 34 | 67 | 47 | 110.370 | 4 | **0.000*** |
| | (17%) | (40%) | (19%) | (20%) | (4%) | (2%) | (19%) | (18%) | (36%) | (25%) | | | |
| Epicondyle angle | 153 | 144 | 22 | 76 | 25 | 24 | 49 | 12 | 64 | 39 | 69.388 | 4 | **0.000*** |
| | (36%) | (34%) | (5%) | (18%) | (6%) | (13%) | (26%) | (6%) | (34%) | (21%) | | | |
| Estimated sex | 261 | | 56 | | 103 | 30 | | 22 | | 136 | 133.687 | 2 | **0.000*** |
| | **(62%)** | | (13%) | | (25%) | (16%) | | (12%) | | **(72%)** | | | |

***Significant at <0 .05**

**Table 5.7: Distribution and classification changes with "medial epicondylar symmetry" trait removed.**

| | YBF | YWF | OBF | OWF | YBM | YWM | OBM | OWM | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| Misclassified originally to still misclassified | 5 | 1 | 6 | 10 | 23 | 2 | 31 | 19 | **97** |
| Ambiguous or correct to misclassified | 1 | 0 | 0 | 10 | 7 | 0 | 6 | 0 | **24** |
| Ambiguous or misclassified **to correct classification** | 3 | 0 | 4 | 3 | 9 | 3 | 20 | 18 | **60** |
| Misclassified to ambiguous | 0 | 0 | 2 | 3 | 1 | 0 | 10 | 1 | **17** |

*YBF = young black female, YWF = young white female, OBF = old black female, OWF = old white female, YBM = young black male, YWM = young white male, OBM = old black male, OWM = old white male.*

**Table 5.8: Distribution of classification, all males and females, estimated sex with the removal of epicondylar symmetry. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 3 | 5 | Total |
|---|---|---|---|---|
| Male | **310 (74%)** | 56 (6%) | 86 (20%) | 420 |
| Female | 33 (17%) | 10 (5%) | **145 (77%)** | 188 |
| Total | 343 | 34 | 231 | *N*= 608 |

***Pearson's chi square value=182.593, df=2, p=0.00<0.05***

**Table 5.9: Distribution of classification and chi square significance, black females and white females (total *n* = 188). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Black Females (*n*=106) | | | | | White Females (*n*=82) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Trochlear extension | 6 | 19 | 18 | 42 | 21 | 6 | 21 | 13 | 37 | 5 | 8.138 | 4 | 0.087 |
| | (5%) | (18%) | (17%) | (40%) | (20%) | (7%) | (26%) | (16%) | (45%) | (6%) | | | |
| Olecranon fossa shape | 1 | 13 | 15 | 39 | 38 | 3 | 23 | 19 | 28 | 9 | 21.230 | 4 | **0.000*** |
| | (1%) | (12%) | (14%) | (37%) | (36%) | (4%) | (28%) | (23%) | (34%) | (11%) | | | |
| Epicondyle angle | 11 | 27 | 8 | 42 | 18 | 13 | 22 | 4 | 22 | 21 | 5.517 | 4 | 0.238 |
| | (10%) | (25%) | (8%) | (40%) | (17%) | (16%) | (26%) | (5%) | (27%) | (26%) | | | |
| Estimated sex | 12 | | 5 | | 89 | 21 | | 5 | | 56 | 7.015 | 2 | **0.030*** |
| | (11%) | | (5%) | | **(84%)** | (26%) | | (6%) | | **(68%)** | | | |

***Significant at <0 .05**

**Table 5.10: Distribution of classification and chi square significance for young black females vs. old black females (total *n* = 106). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Young Black Females (*n*=65) | | | | | Old Black Females (*n*=41) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Trochlear extension | 4 | 9 | 9 | 30 | 13 | 2 | 10 | 9 | 12 | 8 | 4.417 | 4 | 0.353 |
| | (6%) | (14%) | (14%) | (46%) | (20%) | (5%) | (24%) | (22%) | (29%) | (20%) | | | |
| Olecranon fossa shape | 0 | 7 | 10 | 19 | 29 | 1 | 6 | 5 | 20 | 9 | 8.286 | 4 | 0.082 |
| | (0%) | (11%) | (15%) | (29%) | (45%) | (2%) | (15%) | (12%) | (49%) | (22%) | | | |
| Epicondyle angle | 5 | 15 | 6 | 30 | 9 | 6 | 12 | 2 | 12 | 9 | 4.959 | 4 | 0.292 |
| | (8%) | (23%) | (9%) | (46%) | (14%) | (15%) | (29%) | (5%) | (29%) | (22%) | | | |
| Estimated sex | 5 | | 3 | | 57 | 7 | | 2 | | 32 | 2.236 | 2 | 0.327 |
| | (7%) | | (5%) | | **(88%)** | (17%) | | (5%) | | **(78%)** | | | |

***Significant at <0 .05**

**Table 5.11: Distribution of classification and chi square significance for young white females vs. old white females (total *n* = 82). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Young White Females (*n*=14) | | | | | Old White Females (*n*=68) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Trochlear extension | 0 | 3 | 1 | 9 | 1 | 6 | 18 | 12 | 28 | 4 | 3.563 | 4 | 0.468 |
| | (0%) | (21%) | (7%) | (65%) | (7%) | (9%) | (26%) | (18%) | (41%) | (6%) | | | |
| Olecranon fossa shape | 0 | 0 | 3 | 7 | 4 | 3 | 23 | 16 | 21 | 5 | 11.380 | 4 | **0.023*** |
| | (0%) | (0%) | (21%) | (50%) | (29%) | (4%) | (34%) | (24%) | (31%) | (7%) | | | |
| Epicondyle angle | 4 | 2 | 3 | 4 | 1 | 9 | 20 | 1 | 18 | 20 | 14.460 | 4 | **0.006*** |
| | (29%) | (14%) | (21%) | (29%) | (7%) | (13%) | (30%) | (1%) | (26%) | (30%) | | | |
| Estimated sex | 1 | | 0 | | 13 | 20 | | 5 | | 43 | 4.769 | 2 | 0.092 |
| | (7%) | | (0%) | | **(93%)** | (30%) | | (7%) | | **(63%)** | | | |

***Significant at <0.05***

**Table 5.12: Distribution of classification and chi square significance for black males vs. white males (total *N* = 420). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Black Males (*n*=312) | | | | | White Males (*n*=108) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Trochlear extension | 35 | 101 | 60 | 104 | 12 | 20 | 34 | 17 | 33 | 4 | 4.012 | 4 | 0.404 |
| | (11%) | (33%) | (19%) | (33%) | (4%) | (19%) | (32%) | (16%) | (30%) | (3%) | | | |
| Olecranon fossa shape | 37 | 128 | 57 | 75 | 15 | 33 | 42 | 22 | 11 | 0 | 29.817 | 4 | **0.000*** |
| | (12%) | (41%) | (18%) | (24%) | (5%) | (30%) | (39%) | (21%) | (10%) | (0%) | | | |
| Epicondyle angle | 117 | 109 | 19 | 50 | 17 | 36 | 35 | 3 | 26 | 8 | 5.601 | 4 | 0.231 |
| | (38%) | (35%) | (6%) | (16%) | (5%) | (33%) | (33%) | (3%) | (24%) | (7%) | | | |
| Estimated sex | 226 | | 19 | | 67 | 84 | | 5 | | 19 | 1.200 | 2 | 0.549 |
| | **(72%)** | | (6%) | | (22%) | **(78%)** | | (4%) | | (18%) | | | |

***Significant at <0.05***

**Table 5.13: Distribution of classification and chi square significance for young black males vs. old black males (total $n$ = 312). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | **Young Black Males (*n*=127)** | | | | | **Old Black Males (*n*=185)** | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Trochlear extension | 18 | 46 | 19 | 38 | 6 | 17 | 55 | 41 | 66 | 6 | 5.856 | 4 | 0.210 |
| | (14%) | (36%) | (15%) | (30%) | (5%) | (9%) | (30%) | (22%) | (36%) | (3%) | | | |
| Olecranon fossa shape | 21 | 47 | 16 | 31 | 12 | 16 | 81 | 41 | 44 | 3 | 18.171 | 4 | **0.001*** |
| | (17%) | (37%) | (12%) | (24%) | (10%) | (9%) | (43%) | (22%) | (24%) | (2%) | | | |
| Epicondyle angle | 45 | 43 | 11 | 20 | 8 | 72 | 66 | 8 | 30 | 9 | 2.936 | 4 | 0.569 |
| | (35%) | (34%) | (9%) | (16%) | (6%) | (39%) | (36%) | (4%) | (16%) | (5%) | | | |
| Estimated sex | 90 | | 5 | | 32 | 136 | | 14 | | 35 | 3.085 | 2 | 0.214 |
| | **(71%)** | | (4%) | | (25%) | **(74%)** | | (7%) | | (19%) | | | |

***Significant at 0.05***

**Table 5.14: Distribution of classification and chi square significance for young white males vs. old white males (total $n$ = 108). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | **Young White Males (*n*=28)** | | | | | **Old White Males (*n*=80)** | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Trochlear extension | 6 | 12 | 7 | 3 | 0 | 14 | 22 | 10 | 30 | 4 | 10.056 | 4 | **0.040*** |
| | (21%) | (43%) | (25%) | (11%) | (5%) | (18%) | (28%) | (12%) | (37%) | (5%) | | | |
| Olecranon fossa shape | 11 | 10 | 4 | 3 | 0 | 22 | 32 | 18 | 8 | 0 | 1.738 | 4 | 0.628 |
| | (39%) | (36%) | (14%) | (11%) | (0%) | (28%) | (40%) | (22%) | (10%) | (0%) | | | |
| Epicondyle angle | 11 | 10 | 1 | 5 | 1 | 25 | 25 | 2 | 21 | 7 | 1.973 | 4 | 0.741 |
| | (39%) | (36%) | (4%) | (17%) | (4%) | (31%) | (31%) | (3%) | (26%) | (9%) | | | |
| Estimated sex | 24 | | 1 | | 3 | 60 | | 4 | | 16 | 1.414 | 2 | 0.493 |
| | **(86%)** | | (3%) | | (11%) | **(75%)** | | (5%) | | (20%) | | | |

***Significant at 0.05***

**Table 5.15: Distribution of classifi subpubic concavity. 1=M, 2=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 105 (25%) | 214 (51%) | 76 (18%) | 15 (4%) | 8 (2%) | 418 |
| Female | 3 (2%) | 2 (1%) | 17 (9%) | 56 (32%) | 99 (56%) | 177 |
| Total | 108 | 216 | 93 | 71 | 107 | *N*= 595 |

***Pearson's chi square value = 413.057, df = 4, p= 0.00<0.05***

**Table 5.16: Distribution of classification for all males and females, subpubic angle. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 108 (26%) | 173 (41%) | 96 (23%) | 26 (6%) | 15 (4%) | 418 |
| Female | 2 (1%) | 4 (2%) | 4 (2%) | 43 (25%) | 124 (70%) | 177 |
| Total | 108 | 177 | 100 | 69 | 139 | *N*= 595 |

***Pearson's chi square value = 406.961, df = 4, p= 0.00<0.05***

**Table 5.17: Distribution of classification for all males and females, ischio-pubic ramus width. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 91 (22%) | 108 (26%) | 110 (26%) | 86 (20%) | 23 (6%) | 418 |
| Female | 3 (2%) | 6 (3%) | 20 (11%) | 51 (29%) | 97 (55%) | 177 |
| Total | 94 | 114 | 130 | 137 | 120 | *N*= 595 |

***Pearson's Chi Square value = 230.774, df = 4, p = 0.00<0.05***

**Table 5.18: Distribution of classification for all males and females, greater sciatic notch width. 1=M, 2=Intermediate M. 3=Ambiguous, 4=Intermediate F, 5=F**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Male | 143 (34%) | 152 (36%) | 54 (13%) | 48 (12%) | 21 (5%) | 418 |
| Female | 5 (3%) | 5 (3%) | 11 (6%) | 41 (23%) | 115 (65%) | 177 |
| Total | 148 | 157 | 65 | 89 | 136 | *N*= 595 |

***Pearson's Chi Square Value = 314.215, df = 4, p= 0.00<0.05***

**Table 5.19: Distribution of classification for all males and females, estimated sex for the pelvis. 1=Male, 3=Ambiguous, 5=Female**

| | 1 | 3 | 5 | Total |
|---|---|---|---|---|
| Male | 347 (83%) | 24 (6%) | 47 (11%) | 418 |
| Female | 8 (4%) | 3 (2%) | 166 (94%) | 177 |
| Total | 355 | 27 | 213 | *N*= 595 |

***Pearson's Chi Square Value = 369.551, df = 2, p = 0.00<0.05***

**Table 5.20: Distribution of classification and chi square significance, all males and females (total *N* = 595). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations for males and [4] and [5] "estimated sex" determinations for females.**

| | **Males (*n*=418)** | | | | | **Females (*n*=177)** | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 105 | 214 | 76 | 15 | 8 | 3 | 2 | 17 | 56 | 99 | 413.057 | 4 | **0.000*** |
| | (25%) | (51%) | (18%) | (4%) | (2%) | (2%) | (1%) | (8%) | (32%) | (56%) | | | |
| Subpubic angle | 108 | 173 | 96 | 26 | 15 | 2 | 4 | 4 | 43 | 124 | 406.961 | 4 | **0.000*** |
| | (26%) | (41%) | (23%) | (6%) | (4%) | (1%) | (2%) | (2%) | (25%) | (70%) | | | |
| Ischio-pubic ramus | 91 | 108 | 110 | 86 | 23 | 3 | 6 | 20 | 51 | 97 | 230.774 | 4 | **0.000*** |
| | (22%) | (26%) | (26%) | (20%) | (6%) | (2%) | (3%) | (11%) | (29%) | (55%) | | | |
| Greater sciatic notch | 143 | 152 | 54 | 48 | 21 | 5 | 5 | 11 | 41 | 115 | 314.215 | 4 | **0.000*** |
| | (34%) | (36%) | (13%) | (12%) | (5%) | (3%) | (3%) | (6%) | (23%) | (65%) | | | |
| Estimated sex | 347 | | 24 | | 47 | 8 | | 3 | | 166 | 369.551 | 2 | **0.000*** |
| | (83%) | | (6%) | | (11%) | (4%) | | (2%) | | (94%) | | | |

****Significant at 0.05***

**Table 5.21: Distribution of classification and chi square significance, all black females and white females (total *n* = 177). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Black Females (*n*=95) | | | | | White Females (*n*=82) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 1 | 2 | 9 | 31 | 52 | 2 | 0 | 8 | 25 | 47 | 2.345 | 4 | 0.673 |
| | (1%) | (2%) | (9%) | (33%) | (55%) | (2%) | (0%) | (10%) | (31%) | (57%) | | | |
| Subpubic angle | 1 | 3 | 3 | 20 | 68 | 1 | 1 | 1 | 23 | 56 | 2.429 | 4 | 0.657 |
| | (1%) | (3%) | (3%) | (21%) | (72%) | (1%) | (1%) | (1%) | (28%) | (69%) | | | |
| Ischio-pubic ramus | 2 | 5 | 13 | 22 | 53 | 1 | 1 | 7 | 29 | 44 | 5.672 | 4 | 0.225 |
| | (2%) | (5%) | (14%) | (23%) | (56%) | (1%) | (1%) | (9%) | (35%) | (54%) | | | |
| Greater sciatic notch | 4 | 3 | 6 | 27 | 55 | 1 | 2 | 5 | 14 | 60 | 5.505 | 4 | 0.239 |
| | (4%) | (3%) | (6%) | (29%) | (58%) | (1%) | (3%) | (6%) | (17%) | (73%) | | | |
| Estimated sex | 5 | | 2 | | 88 | 3 | | 1 | | 78 | 0.484 | 2 | 0.785 |
| | (5%) | | (2%) | | **(93%)** | (3%) | | (1%) | | **(96%)** | | | |

**Table 5.22: Distribution of classification and chi square significance, young black females (50 years and younger) and old black females (over 50 years) (total *n* = 95). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Young Black Females (*n*=58) | | | | | Old Black Females (*n*=37) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 1 | 1 | 6 | 23 | 27 | 0 | 1 | 3 | 8 | 25 | 4.934 | 4 | 0.294 |
| | (1%) | (1%) | (11%) | (40%) | (47%) | (0%) | (3%) | (8%) | (21%) | (68%) | | | |
| Subpubic angle | 1 | 2 | 2 | 10 | 43 | 0 | 1 | 1 | 10 | 25 | 1.881 | 4 | 0.758 |
| | (1%) | (4%) | (4%) | (17%) | (74%) | (0%) | (3%) | (3%) | (27%) | (67%) | | | |
| Ischio-pubic ramus | 1 | 3 | 9 | 13 | 32 | 1 | 2 | 4 | 9 | 21 | 0.517 | 4 | 0.972 |
| | (1%) | (5%) | (16%) | (23%) | (55%) | (3%) | (5%) | (11%) | (24%) | (57%) | | | |
| Greater sciatic notch | 3 | 2 | 4 | 17 | 32 | 1 | 1 | 2 | 10 | 23 | 0.679 | 4 | 0.954 |
| | (5%) | (4%) | (6%) | (29%) | (55%) | (3%) | (3%) | (5%) | (27%) | (62%) | | | |
| Estimated sex | 3 | | 1 | | 54 | 2 | | 1 | | 34 | 0.109 | 2 | 0.947 |
| | (5%) | | (1%) | | **(94%)** | (5%) | | (3%) | | **(92%)** | | | |

**Table 5.23: Distribution of classification and chi square significance, young white females and old white females (total *n* = 82). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Young White Females (*n*=14) | | | | | Old White Females (*n*=68) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 0 (0%) | 0 (0%) | 3 (21%) | 4 (29%) | 7 (50%) | 2 (3%) | 0 (0%) | 5 (7%) | 21 (31%) | 40 (59%) | 2.947 | 4 | 0.400 |
| Subpubic angle | 0 (0%) | 0 (0%) | 0 (0%) | 4 (29%) | 10 (71%) | 1 (1%) | 1 (1%) | 1 (1%) | 19 (28%) | 46 (68%) | 0.644 | 4 | 0.958 |
| Ischio-pubic ramus | 0 (0%) | 0 (0%) | 1 (7%) | 6 (43%) | 7 (50%) | 1 (1%) | 1 (1%) | 6 (9%) | 23 (34%) | 37 (55%) | 0.760 | 4 | 0.944 |
| Greater sciatic notch | 0 (0%) | 0 (0%) | 2 (14%) | 3 (22%) | 9 (64%) | 1 (1%) | 2 (3%) | 3 (5%) | 11 (16%) | 51 (75%) | 2.844 | 4 | 0.584 |
| Estimated sex | 0 (0%) | | 0 (0%) | | 14 **(100%)** | 3 (5%) | | 1 (1%) | | 64 **(94%)** | 0.866 | 2 | 0.649 |

**Table 5.24: Distribution of classification and chi square significance, black males and white males (total *N* = 418). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Black Males (*n*=311) | | | | | White Males (*n*=107) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 72 (23%) | 161 (52%) | 65 (21%) | 7 (2%) | 6 (2%) | 33 (31%) | 53 (50%) | 11 (10%) | 8 (7%) | 2 (2%) | 12.95C | 4 | **0.012*** |
| Subpubic angle | 74 (24%) | 124 (40%) | 85 (27%) | 17 (5%) | 11 (4%) | 34 (32%) | 49 (46%) | 11 (10%) | 9 (8%) | 4 (4%) | 13.834 | 4 | **0.008*** |
| Ischio-pubic ramus | 71 (23%) | 81 (26%) | 84 (27%) | 57 (18%) | 18 (6%) | 20 (19%) | 27 (25%) | 26 (24%) | 29 (27%) | 5 (5%) | 4.028 | 4 | 0.402 |
| Greater sciatic notch | 121 (39%) | 107 (34%) | 36 (12%) | 39 (13%) | 8 (2%) | 22 (21%) | 45 (42%) | 18 (17%) | 9 (8%) | 13 (12%) | 26.527 | 4 | **0.000*** |
| Estimated sex | 263 **(85%)** | | 17 (5%) | | 31 (10%) | 84 **(79%)** | | 7 (7%) | | 16 (14%) | 2.273 | 2 | 0.321 |

***Significant at 0.05***

**Table 5.25: Distribution of classification and chi square significance, young black males and old black males (total $n$ = 311). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Young Black Males ($n$=126) | | | | | Old Black Males ($n$=185) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 29 | 59 | 30 | 5 | 3 | 43 | 102 | 35 | 2 | 3 | 4.859 | 4 | 0.302 |
| | (23%) | (47%) | (24%) | (4%) | (2%) | (23%) | (55%) | (19%) | (1%) | (2%) | | | |
| Subpubic angle | 22 | 55 | 33 | 8 | 8 | 52 | 69 | 52 | 9 | 3 | 9.469 | 4 | **0.050*** |
| | (18%) | (44%) | (26%) | (6%) | (6%) | (28%) | (37%) | (28%) | (5%) | (2%) | | | |
| Ischio-pubic ramus | 25 | 33 | 31 | 31 | 6 | 46 | 48 | 53 | 26 | 12 | 6.220 | 4 | 0.183 |
| | (20%) | (26%) | (24%) | (25%) | (5%) | (25%) | (26%) | (29%) | (14%) | (6%) | | | |
| Greater sciatic notch | 53 | 39 | 9 | 19 | 6 | 68 | 68 | 27 | 20 | 2 | 9.909 | 4 | **0.042*** |
| | (42%) | (31%) | (7%) | (15%) | (5%) | (37%) | (37%) | (14%) | (11%) | (1%) | | | |
| Estimated sex | 100 | | 6 | | 20 | 163 | | 11 | | 11 | 8.280 | 2 | **0.016*** |
| | **(79%)** | | (5%) | | (16%) | **(88%)** | | (6%) | | (6%) | | | |

***Significant at 0.05***

**Table 5.26: Distribution of classification and chi square significance, young white males and old white males (total $n$ = 107). Estimated sex under "1 (M)" and "5 (F)" represents a total of the [1] and [2] "estimated sex" determinations and [4] and [5] "estimated sex" determinations.**

| | Young White Males ($n$=27) | | | | | Old White Males ($n$=80) | | | | | Pearson's Chi Square | df | Sign. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 (M) | 2 | 3 | 4 | 5 (F) | 1 (M) | 2 | 3 | 4 | 5 (F) | | | |
| Subpubic concavity | 14 | 11 | 0 | 2 | 0 | 19 | 42 | 11 | 6 | 2 | 10.12C | 4 | **0.038*** |
| | (52%) | (41%) | (0%) | (7%) | (0%) | (24%) | (53%) | (14%) | (7%) | (2%) | | | |
| Subpubic angle | 12 | 13 | 1 | 0 | 1 | 22 | 36 | 10 | 9 | 3 | 6.425 | 4 | 0.170 |
| | (44%) | (48%) | (4%) | (0%) | (4%) | (28%) | (45%) | (13%) | (11%) | (3%) | | | |
| Ischio-pubic ramus | 3 | 10 | 5 | 8 | 1 | 17 | 17 | 21 | 21 | 4 | 3.758 | 4 | 0.440 |
| | (11%) | (37%) | (19%) | (29%) | (4%) | (21%) | (21%) | (26%) | (26%) | (6%) | | | |
| Greater sciatic notch | 6 | 10 | 8 | 2 | 1 | 16 | 35 | 10 | 7 | 12 | 5.949 | 4 | 0.203 |
| | (22%) | (37%) | (30%) | (7%) | (4%) | (20%) | (44%) | (13%) | (8%) | (15%) | | | |
| Estimated sex | 25 | | 0 | | 2 | 59 | | 7 | | 14 | 8.541 | 2 | **0.049*** |
| | **(93%)** | | (%) | | (7%) | **(74%)** | | (9%) | | (17%) | | | |

***Significant at 0.05***

**Figure 5.1: Classification accuracy for all males and females, epicondylar symmetry (total *N* = 595; males *n* = 420, females *n* = 188).**

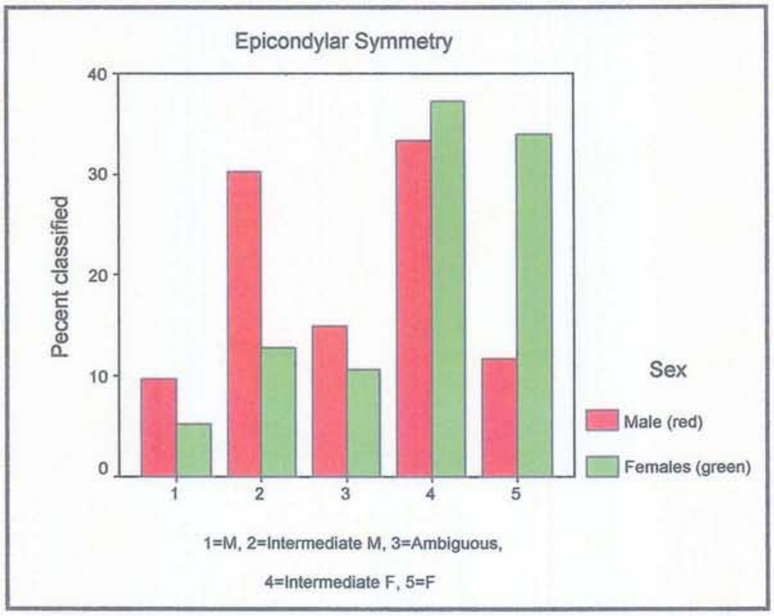


**Figure 5.2: Classification accuracy for all males and females, trochlear extension (total *N* = 608; *n* = 420 males, *n* = 188 females).**

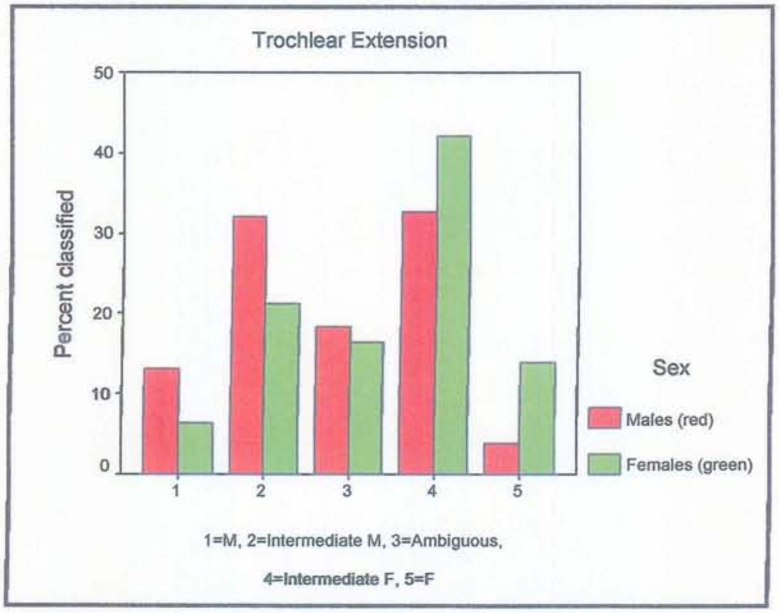

**Figure 5.3: Classification accuracy for all males and females, olecranon fossa shape (total *N* = 608; *n* = 420 males, *n* = 188 females).**

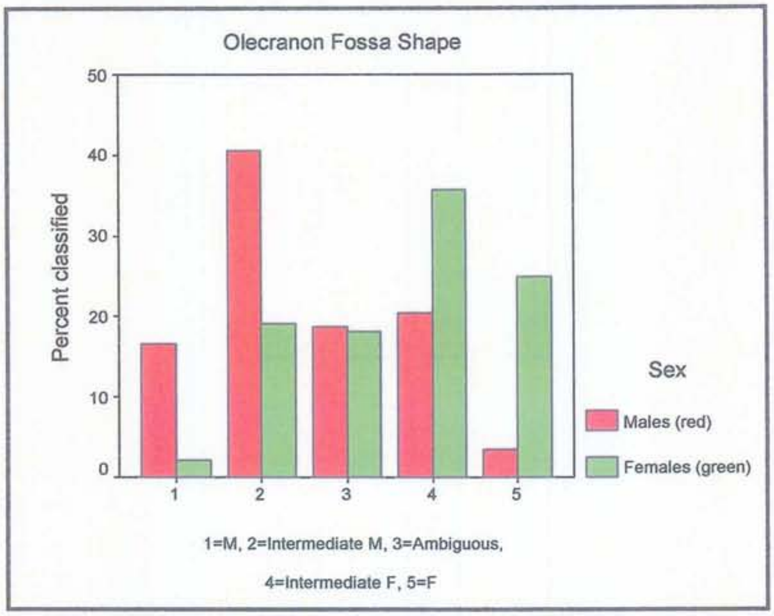


**Figure 5.4: Classification accuracy for all males and females, angle of the medial epicondyle (total *N* = 595; *n* = 420 males, *n* = 188 females).**

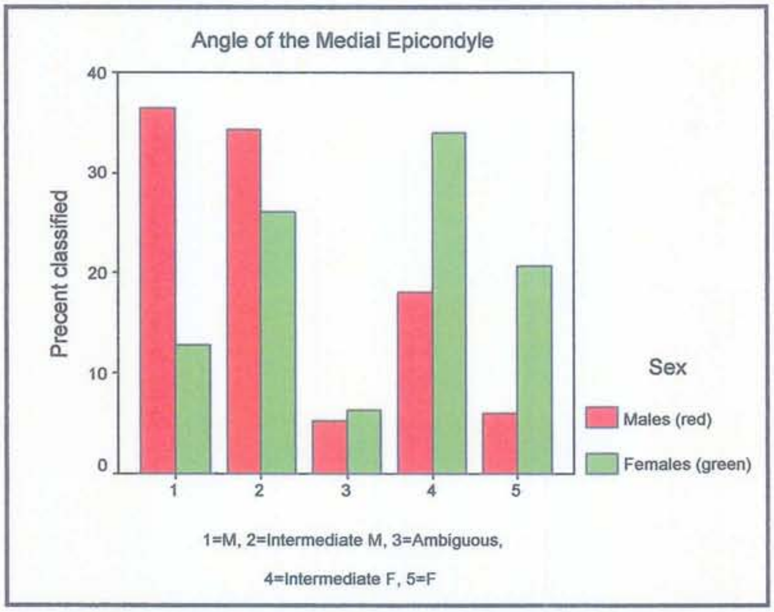

**Figure 5.5: Classification accuracy for males and females, estimated sex (total *N* = 595; *n* = 420 males, *n* = 188 females).**

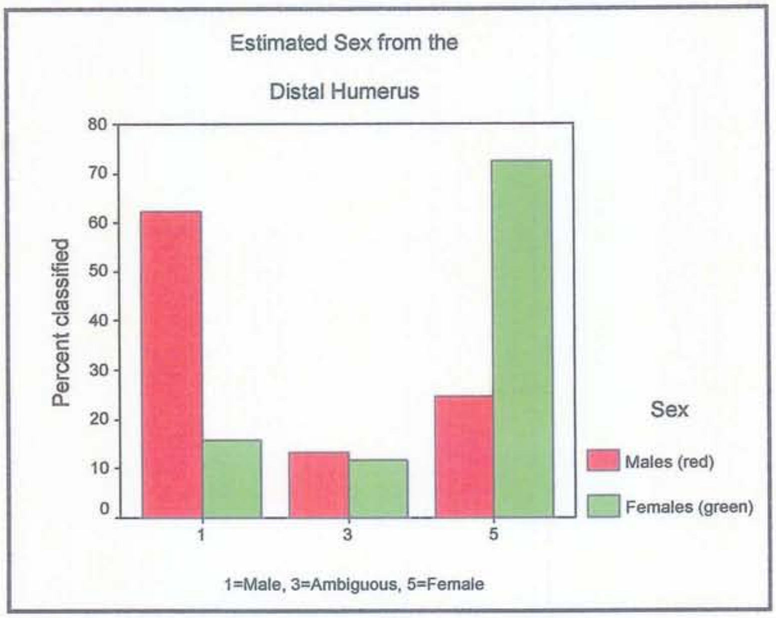


**Figure 5.6: Classification accuracy for males and females with the three-trait combination of features, estimated sex (total *N* = 595; *n* = 420 males, *n* = 188 females).**

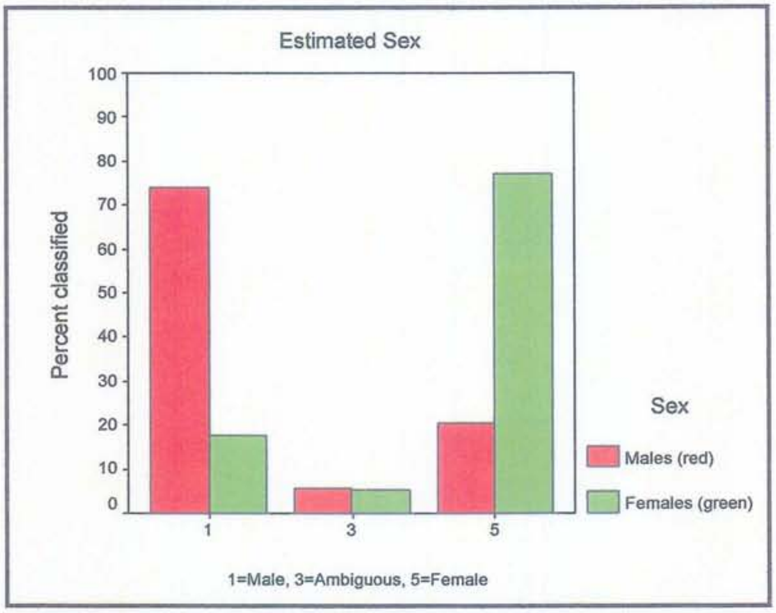

**Figure 5.7: Classification accuracy for black females vs. white females, estimated sex (total *N*=188, black females *n*=106, white females *n*= 82).**

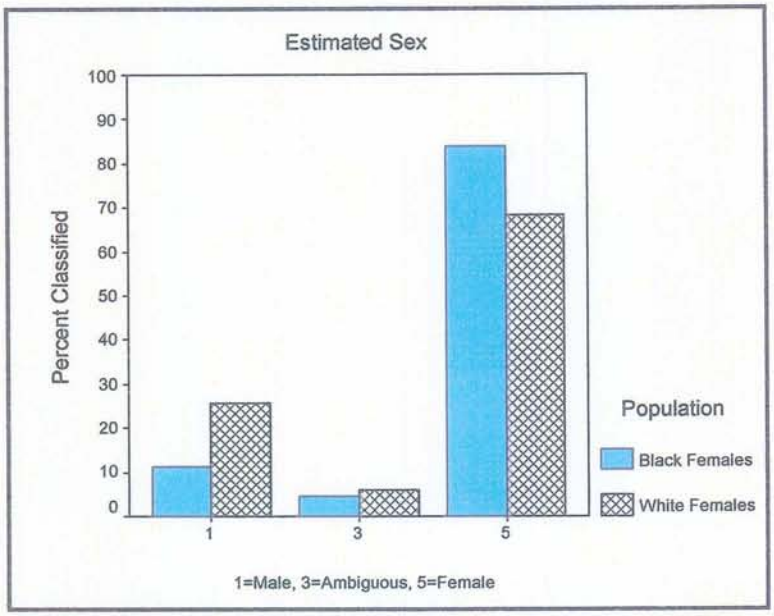


**Figure 5.8: Classification accuracy for young black females vs. old black females, estimated sex (total *N*= 106, young black females *n*=65, old black females *n*=41).**

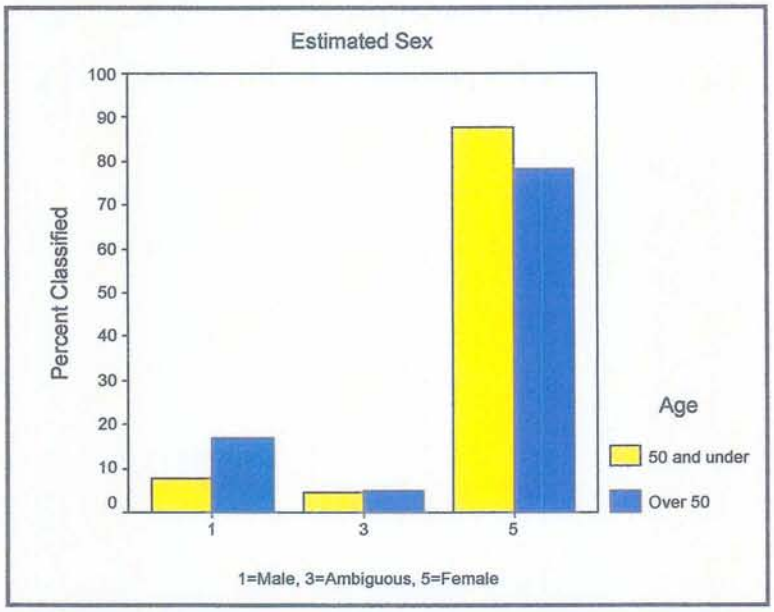

**Figure 5.9: Classification accuracy for young white females vs. old white females, estimated sex (total *N*= 82, young white females *n*=14, old black females *n*=68).**

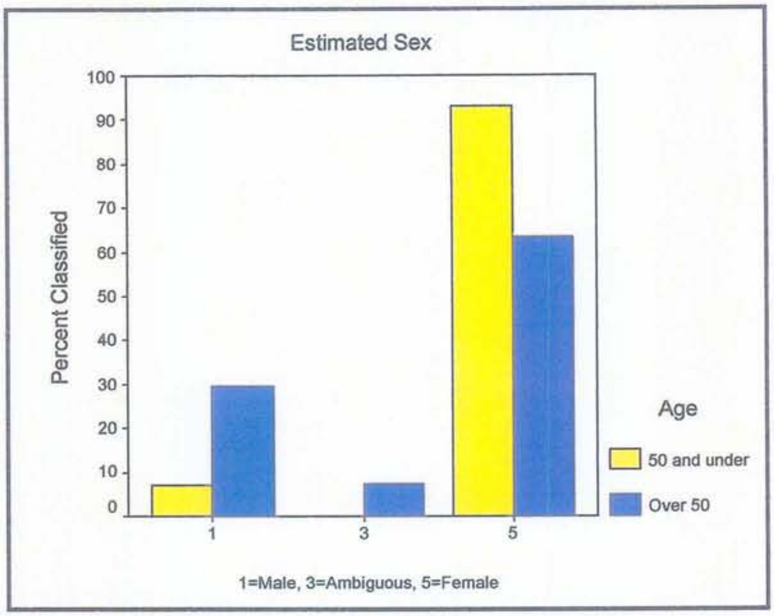


**Figure 5.10: Classification accuracy for black males vs. white males, estimated sex (*N*=420, black males *n*=312, white males *n*=108).**

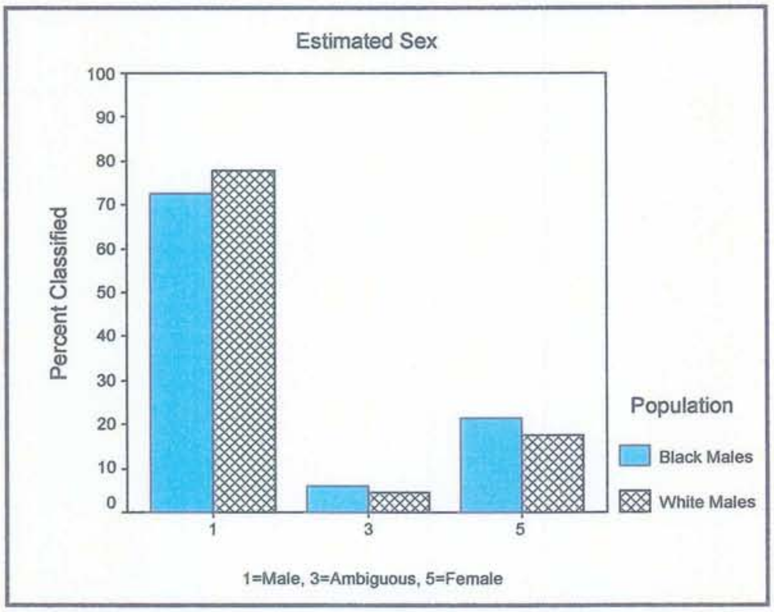

**Figure 5.11: Classification accuracy for young black males vs. old black males, estimated sex (*N*=312, young black males *n*=125, old black males *n*=185).**

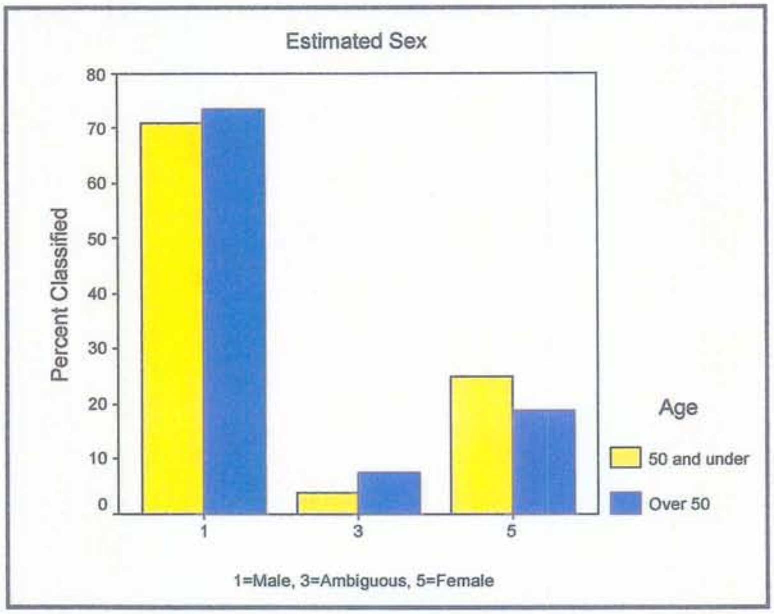


**Figure 5.12: Classification accuracy for young white males vs. old white males, estimated sex (*N*=108, young white males *n*=28, old white males *n*=80).**

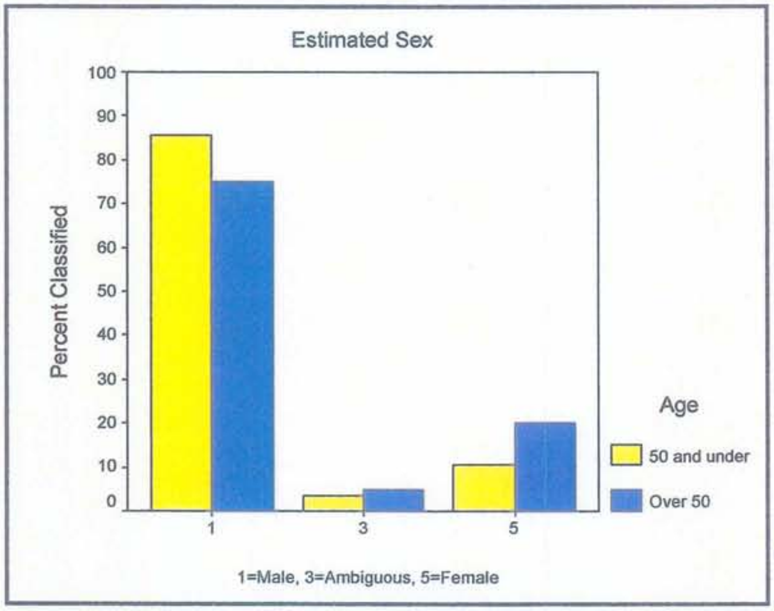

**Figure 5.13: Classification accuracy for all males and females, subpubic concavity (total *N*=595, males *n*=418, females *n*=177).**

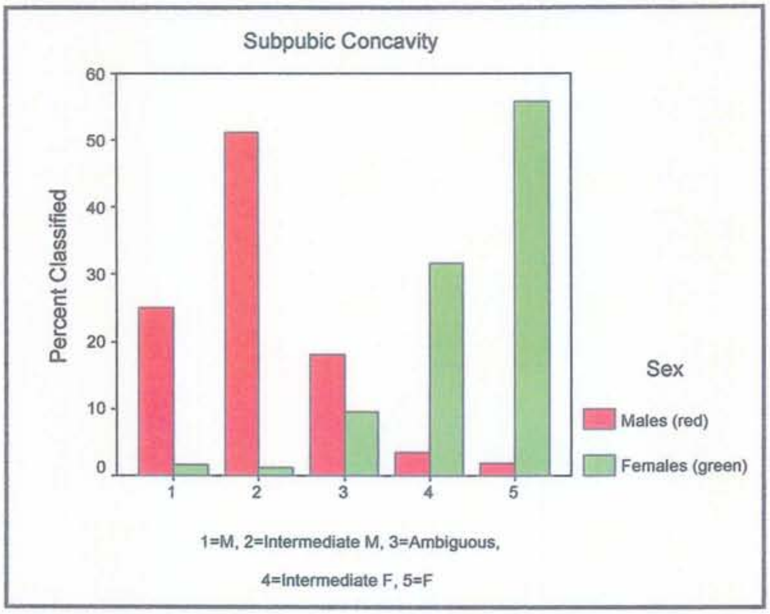


**Figure 5.14: Classification accuracy for all males and females, subpubic angle (total *N*=595, males *n*=418, females *n*=177).**

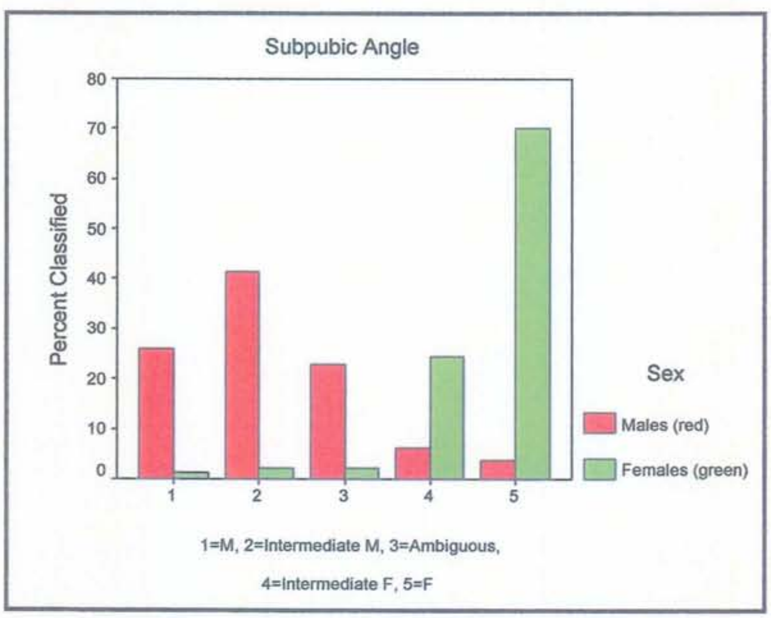

**Figure 5.15: Classification accuracy for all males and females, ischio-pubic ramus width (total *N*=595, males *n*=418, females *n*=177).**

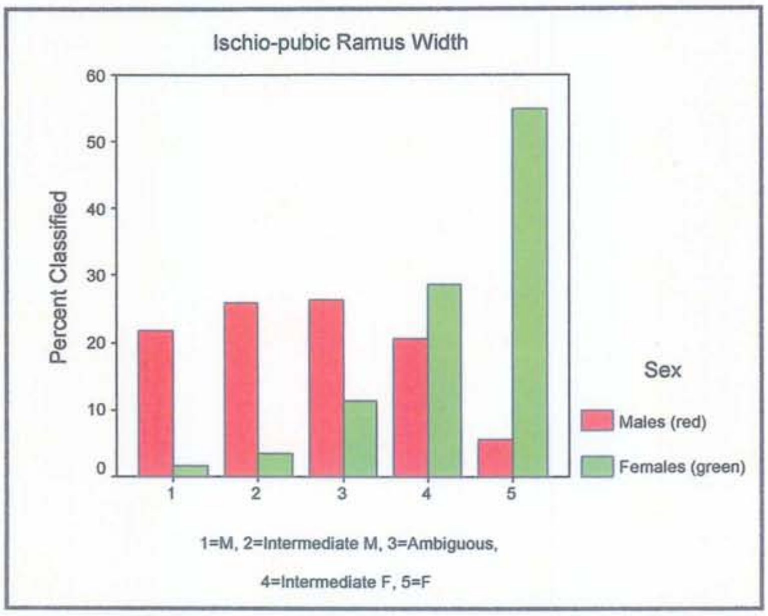


**Figure 5.16: Classification accuracy for all males and females, greater sciatic notch width (total *N*=595, males *n*=418, females *n*=177).**

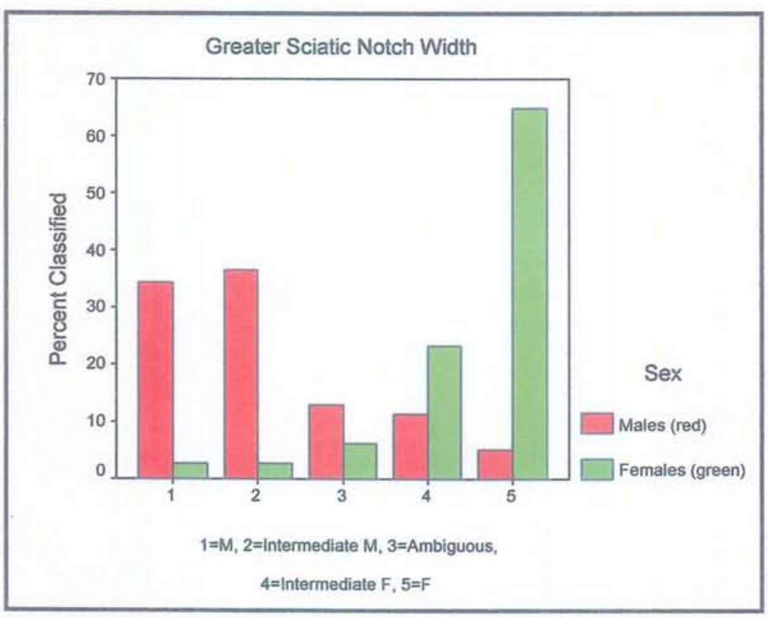

**Figure 5.17: Classification accuracy for all males and females, estimated sex (total *N*=595, males *n*=418, females *n*=177).**

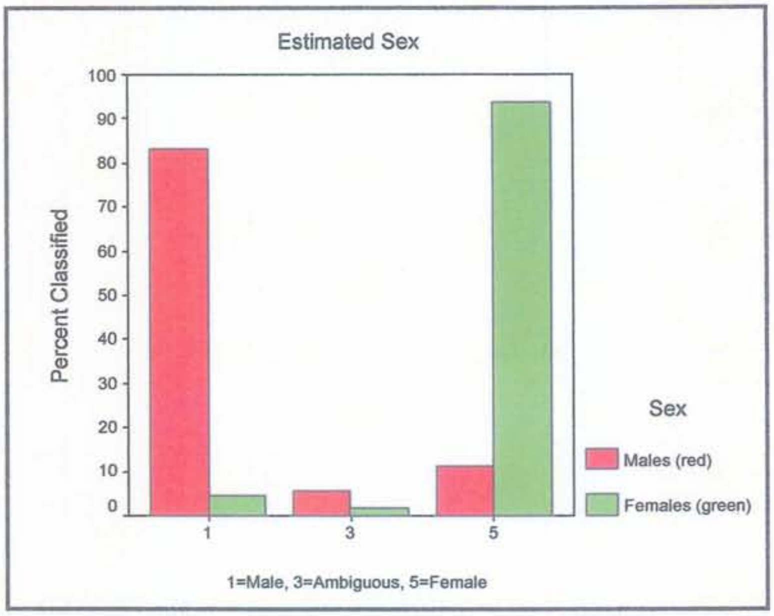


**Figure 5.18: Classification accuracy for black females and white females, estimated sex (total *N*=177, black females *n*=95, white females *n*=82).**

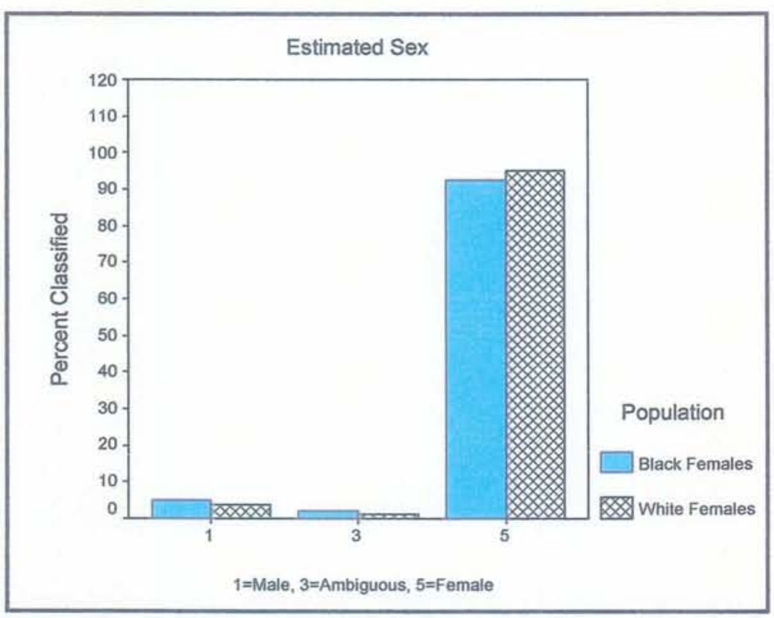

**Figure 5.19: Classification accuracy for young black females and old black females, estimated sex (total *N*=95, young black females *n*=58, old black females *n*=37).**

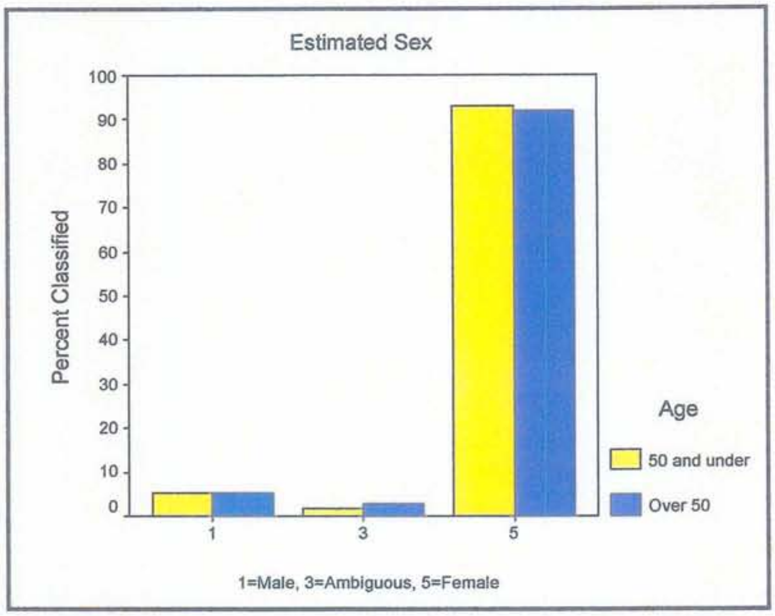


**Figure 5.20: Classification accuracy for young white females and old white females, estimated sex (total *N*= 82, young white females *n*=14, old white females *n*=68).**

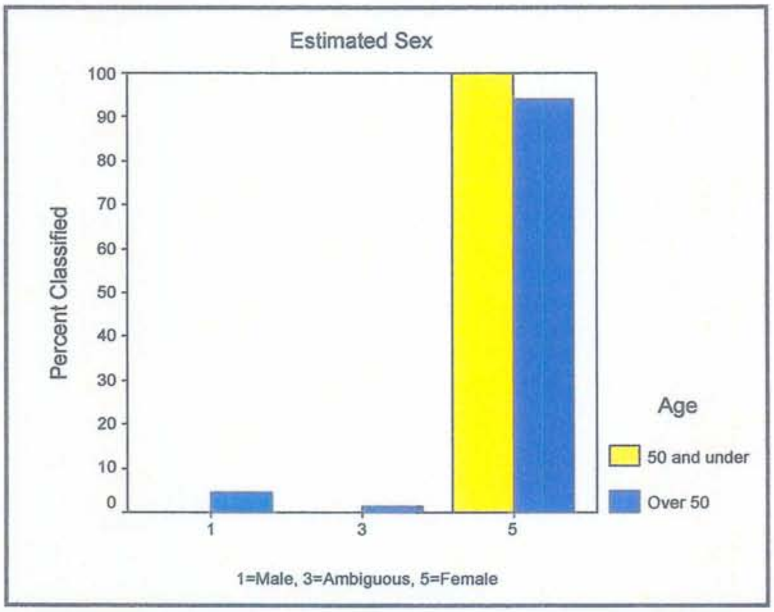

**Figure 5.21: Classification accuracy for black males and white males, estimated sex (total *N*= 418, black males *n*=311, white males *n*=107).**

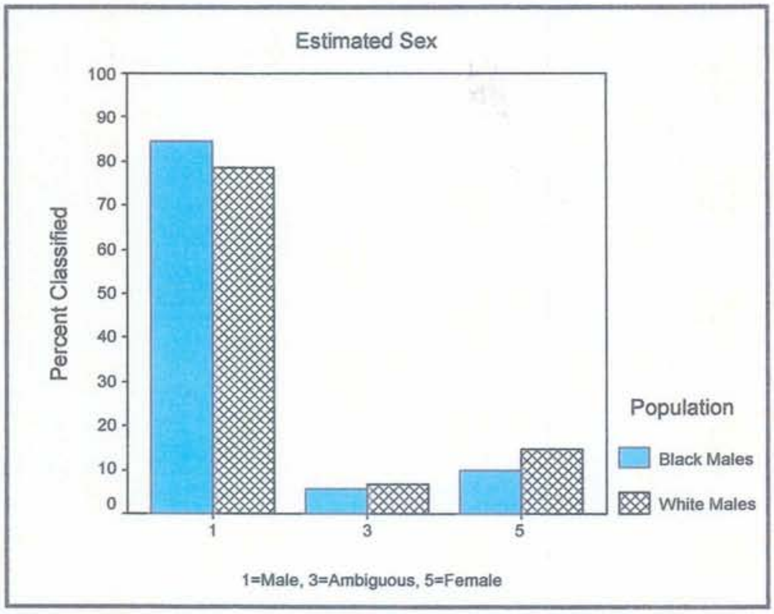


**Figure 5.22: Classification accuracy for young black males and old black males, estimated sex (total *N*= 311, young black males *n*=126, old black males *n*=185).**

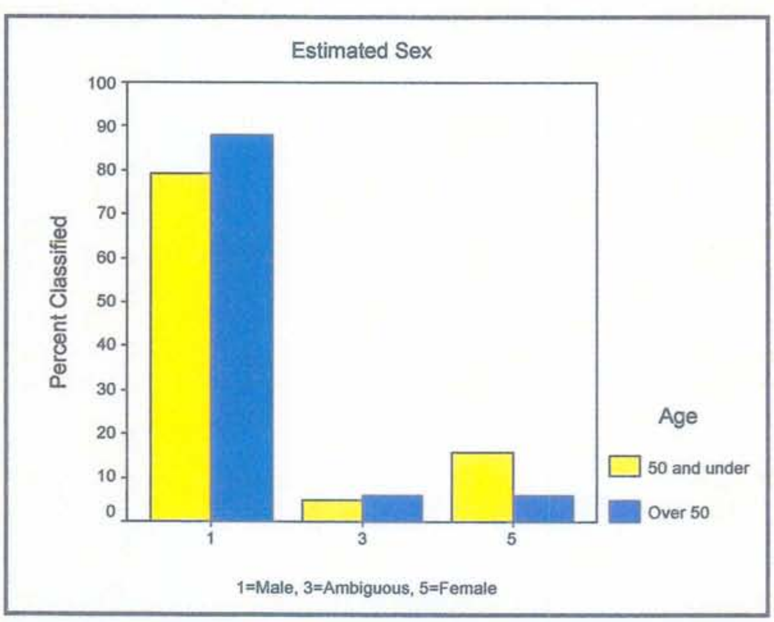

**Figure 5.23: Classification accuracy for young white males and old white males, estimated sex (total *N*= 107, young white males *n*=27, old white males *n*=80).**