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Subadult Sexual Dimorphism in the Luís Lopes Collection

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Presented for the
Master of Arts
Degree
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Dedication

This thesis is dedicated to my parents, Natividad C. Soto and Rita G. Soto, for supporting me throughout my education. I would especially like to dedicate this thesis to my father, who has been my rock throughout this process.

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There are several people I would like to thank for their support during the research and writing of this thesis.

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Abstract

Previous works on subadult sexual dimorphism have focused on the pelvis, cranium, or dentition. The results of these studies have been inconsistent regarding the existence of significant sex differences prior to puberty. For the most part, subadult long bone dimensions have been ignored in previous studies. This study evaluated subadult sexual dimorphism in long bone dimensions using a sample from the Luís Lopes collection. The results of MANCOVA tests and logistic regressions indicate that subadult long bone dimensions are significantly sexually dimorphic and hold some promise for sex determination. Clavicle measurements proved to be fairly accurate sex predictors for subadults. Models constructed from clavicle measurements correctly sexed ~83% of the young subadult sample (≤ 11 years) and ~95% of the older subadult sample (≥ 12 years). Measurements of the humerus, tibia, and ulna were fairly accurate at predicting sex in older subadults. Humerus measurements correctly classified ~94% the older subadult sample. Approximately 92% of the older subadult sample was accurately sexed using age and the minimum diameter of the tibia or circumference of the tibia. Overall, the most accurate models for sexing adults and subadults in this sample were constructed from the measurements of several long bones. Further research should be conducted on sexual dimorphism in subadult long bone dimensions.

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Chapter 1

Introduction

Currently, Forensic and physical anthropologists do not have the ability to sex subadults reliably. Much research has gone into examining areas of the subadult body that are reported to be the most sexually dimorphic in adults. This approach has not produced methods reliable enough for sex determination and has led some investigators to conclude that significant sexual dimorphism is not present until the commencement of puberty. However, growth studies using skeletal remains have reported that significant sexual dimorphism is present prior to puberty and in some cases is present at birth (Humphrey 1998). The main purpose of this study is to investigate sexual dimorphism in subadults using the postcranial measurements that Humphrey (1998) reported to be sexually dimorphic in subadults. The second goal of this research is evaluate the efficacy of those measurements for sex determination. A review of the adult studies of sexual dimorphism and sex determination is necessary to understand the past rationale for focusing on certain traits and areas of the body for investigations into subadult sexual dimorphism and sex determination. Also, a review of the subadult literature will demonstrate how past investigations of sexual dimorphism using traditional approaches have not led to reliable methods for sex determination.

Adult Sexual Dimorphism and Sex Determination

The following is a review of the literature on adult sexual dimorphism and sex determination. The following sections include studies focusing on the pelvis, crania, dentition, long bones, and other miscellaneous bones. The review begins with the pelvis and crania because they are the most important areas for sex determination.

Studies on Sexual Dimorphism of the Pelvis

Anthropological and anatomical literature have reported sex differences in pelvis size and shape since the late 1800s when these observations were first made on dissecting room cadavers (Grulich and Thoms 1939b). Since then, anthropologists have been using pelvis shape to sex individuals. In the literature, males are reported to have a small heart-shaped pelvic inlet, while females are reported to have a much larger inlet shape that is more oval than heart-shaped (Grulich and Thoms 1939b). However, Grulich and Thoms (1939a, 1939b) observed that sex differences in pelvis shape are not as distinct as it is made to seem in the texts. Although there is still a significant sex difference in the shape of the pelvis, male and female pelves display a great deal of variation (Grulich and Thoms 1939a; Grulich and Thoms 1939b). Caldwell and Moloy (1933, 1938) classified female pelves into four types ranging from gynecoid (the typical female type) to android (the typical male type). Of the 215 female pelves examined, as many as 24% were classified into the more masculine categories (Caldwell et al. 1934). After examining 147 pelves, Caldwell and Moloy (1938) made similar observations. Approximately 33% of White female and ~16% of African American female pelves were of the masculine type (Caldwell and Moloy 1938). Only ~40% of White and African American pelves were classified as the typical female (gynecoid) type (Caldwell and Moloy 1938). In contrast, Meindl et al. (1985) did not observe a high degree of variation in a sample of female pelves from the Hamann-Todd collection. However, Meindl et al (1985) examined several characteristics besides pelvis shape.

After discovering that female and male pelves were considerably variable but still sexually dimorphic, it became important to determine the specific areas of the pelvis responsible for the observed sex difference. This was accomplished by evaluating various

pelvic measurements for sex differences (Young and Ince 1940). These researchers examined the pelvic radiographs of 500 adult females and 50 adult males. The most valuable characteristics for distinguishing male from female pelvises were the size and proportion of the pelvic inlet and outlet, size of the subpubic angle, and the size of the sciatic notch.

Subsequent to the Young and Ince (1940) study, investigators focused on the examination of the sciatic notch and the subpubic angle. In 1948, Washburn measured the lengths of the ischium and pubis of the pelvis and observed that female pubes were longer than male pubes, resulting in a larger subpubic angle in females. It was also found that the ischium-pubis index was able to accurately sex 90% of the sample (Washburn 1948). Theime and Schull (1957) and Richman et al. (1979) also reported that the ischio-pubis index was a good sex discriminator. Theime and Schull (1957) accurately sexed ~93% of 200 individuals. Richman et al. (1979) was able to achieve ~95% accuracy rate on a sample of White Americans from the Terry Collection, ~94% of an African American sample from the Terry collection, and ~95% of an African American sample from the Howard University collection.

During the 1948 study, Washburn reported that 95% of the sample was accurately sexed using the width of the sciatic notch as well as the ischium-pubis index. Further research into sexual dimorphism of the adult sciatic notch by Singh and Potturi (1978) revealed that the female sciatic notch was significantly wider than the male notch. Also, the male notch was usually deeper than the female notch, though it was not significantly deeper (Singh and Potturi 1978). More specific, the posterior angle of the sciatic notch correctly sexed 92 to 100% of females and 75 to 88% of males (Singh and Potturi 1978). The sex difference in the width of the sciatic notch, in turn, affects the projection of the sacrum into the pelvic cavity (Caldwell and Moloy 1958). The further the sacrum projects into the pelvic

cavity, the more likely the sciatic notch is to be narrow, which occurs most often in males (Caldwell and Moloy 1958).

Sex Determination using Morphological Characteristics of the Pelvis

In 1969, Phenice produced a method for adult sex determination based on three morphological traits of the pelvis. These traits included the presence or absence of the ventral arc, subpubic concavity, and the ridge on the medial aspect of the ischio-pubic ramus (Phenice 1969). In this method, sex was determined based on the number of characteristics present or absent. A perfect female specimen was expected to present a ventral arc, subpubic concavity, and a ridge on the medial aspect of the ischio-pubic ramus. All of these traits were expected to be absent in males, but intermediate cases (in which some traits were absent while others were present) occurred in both sexes. Using these criteria, 95% of the sample tested by Phenice (1969) was accurately sexed. Although it was observed that the ventral arc was not as well developed in females under 20 years of age, which could lead to errors in sex estimation in younger females, Phenice (1969) stated that the ventral arc was the most reliable sex predictor. The ridge on the medial aspect of the ischio-pubic ramus was deemed the least reliable.

Subsequent studies have tested the accuracy of the method developed by Phenice (1969) and the reliability of the traits used (Lovell 1989; MacLaughlin 1990; Sutherland and Suchey 1991). Kelley's (1978) results, along with Sutherland and Suchey's (1991), agree with the conclusions of Phenice (1969) that the ventral arc is a reliable sex indicator. Sutherland and Suchey (1991) accurately sexed 96% of their sample using only the ventral arc. However, not all of the investigators testing the method achieved such a high degree of accuracy. Lovell (1989) tested the method's accuracy as well as how an observer's

osteological experience could affect the results. The average accuracy of the method was ~83% (Lovell 1989), in contrast to the 95% achieved by Phenice (1969). There was also a slight to negative correlation between the accuracy of the method and the age of the individual being assessed (Lovell 1989). Osteological experience did not significantly affect the results. In addition, the ventral arc was not found to be any better at discriminating sex than any of the other traits. McLaughlin (1990) tested Phenice's method on 3 separate European samples and found that the method was not as effective on European samples. Accuracy was 83% in an English sample, 68% in a Dutch sample, and 59% in a Scottish sample (MacLaughlin 1990). This suggests that the level of sexual dimorphism is variable between populations. In contrast to Lovell's (1989) study, the experience of the observer did significantly affect the overall level of accuracy of the results. Furthermore, subpubic concavity was the best sex discriminator in these samples, not the ventral arc (MacLaughlin 1990).

Sex Determination using Morphological Characteristics and Measurements of the Pelvis

Other investigators have combined morphological characteristics with pelvic measurements to sex adult skeletal remains. Meindl et al. (1985) used Phenice's (1969) morphological traits along with the sciatic notch, pre-auricular sulcus, pelvis shape, and overall size and rugosity of the acetabulum. Using these traits, 96% of the individuals in the sample were accurately sexed (Meindl et al. 1985). Rogers and Saunders (1994) evaluated 17 morphological traits to find the best combination of traits for sex determination. Phenice's (1969) traits were among the traits considered. Individually, obturator foramen shape and sacrum shape were the best measurements for determining sex, 94% correct. The combination of traits achieving the highest accuracy (98%) included obturator

foramen/ventral arc and obturator foramen/true pelvis size and shape (Rogers and Saunders 1994).

Discriminant Function and Sex Determination of the Adult Pelvis

Discriminant functions developed from pelvic measurements have also been used for sex determination. Day and Pitcher-Wilmott (1975) took 17 measurements on the adult pelvis and used these measurements to calculate 7 indices. Discriminant analysis using all 17 measurements and the 7 indices correctly sexed ~97% of the sample. Discriminant analysis using only the significant variables (13) achieved 98% accuracy (Day and Pitcher-Wilmott 1975). Novotny (1986) used slightly modified measurements of pubis and ischium length in a discriminant analysis and reached a 97% accuracy rate. Although the accuracy rate is impressive, Novotny (1986) observed that the amount of overlap (11%) between the sexes for the discriminant scores was high. A high amount of overlap indicates a greater likelihood of misclassification. Discriminant analysis using 5 sciatic notch dimensions sexed 92% of the sample, but accuracy increased to 100% by calculating a discriminant function using both the modified lengths of the ischium and pubis as well as the width of the upper part of the sciatic notch and the height of the sciatic notch (Novotny 1986). Upon testing the discriminant function with a modified sectioning point on a French sample, the high degree of accuracy was sustained (Novotny and Bruzek 1981).

Although discriminant functions for the pelvis appear to be accurate and useful, they are not always practical. A discriminant function is useless if the area to be measured is damaged. In the field, it is much easier and more practical to estimate sex using morphological traits of the pelvis. If one characteristic cannot be examined due to damage, other characteristics can be evaluated and taken into consideration collectively in order to

make an estimation of sex. “Standards for Data Collection from Human Skeletal Remains” (1994) advises investigators to examine the pelvis for several morphological characteristics in order to determine sex. These include the width and depth of the sciatic notch, Phenice’s (1969) traits, and the preauricular sulcus.

Adult Crania and Mandible Studies

In 1920, Hrdlička stated that the most important cranial morphological characteristics for sex identification were the supra-orbital ridges, mastoid processes, occipital crest, mandible, and base of the skull (listed in order of importance) (Keen 1950). Keen (1950) tested the efficacy of these characteristics, along with a few other measurements, on 50 female and 50 male skulls from an old Hottentot population. The morphological characteristics deemed imperative for sex estimation were the supraorbital ridges, external auditory meatus, and the occipital crest (Keen 1950). The measurements that were important for sex determination were the maximum length of the vault, maximum bizygomatic diameter, depth of the infratemporal fossa, and the length of the mastoid process. Using both the morphological characteristics and the measurements, 84% of the of the skulls were properly sexed (Keen 1950).

In 1970, Acsádi and Nemeskéri compiled a list of sexually dimorphic characteristics of the skull that had been used by past investigators for sex identification. The list included the following: cranial vault contour, size of the foramen magnum, size and shape of the forehead, size of the frontal and parietal eminences, rugosity of the glabella and superciliary arches, orbit shape, shape of the supraorbital margins, size of the mastoid processes, and size and shape of the mandible and mandibular angle. Although Acsádi and Nemeskéri (1970) did not include the size of the nuchal crest, size of the zygomatic arch, and palate shape in the

list, these characteristics are also important in sex determination. Each characteristic can be scored on a scale from most masculine to most feminine; an intermediate score is an indication of ambiguity. Buikstra and Ubelaker (1994) condensed these characteristics into a simple and easy to use scoring system. According to the method, the nuchal crest, mastoid processes, supra-orbital margin, supra-orbital ridge/glabella, and mental eminence of the mandible are scored on a scale from 1 to 5; with 1 being the most feminine and 5 being the most masculine (Buikstra and Ubelaker 1994). A scoring system for sex determination using the supraorbital margin was also developed (Graw et al. 1999). Graw et al. (1999) did not examine the protrusion or thickness of the supraorbital margin, as is done traditionally. Instead, the shape of the cross-section of the supraorbital margin was examined. The female supraorbital margin was expected to be more angularly shaped, while the cross-section of the male supraorbital margin was expected to be round. Approximately 70% of 101 modern German skulls were accurately sexed using this method (Graw et al. 1999).

Sex determination methods for the skull also include the use of discriminant analysis. Giles and Elliot (1963) accurately sexed ~86% of a large sample of White and African American skulls. The best discriminant function achieved 86.0% accuracy and included the following measurements: glabello-occipital length, maximum width of the crania, basion-bregma height, basion-nasion, maximum diameter of the bizygomatic, basion-prosthion, prosthion-nasion height, and mastoid length (Giles and Elliot 1963). Differences in the accuracy of the function between the White and African American portions of the sample were slight. Kajanoja (1966) tested the accuracy of one of the discriminant functions calculated by Giles and Elliot (1963) and found that the measurements performed poorly in distinguishing sex in Finnish crania. Giles and Elliot (1964) were able to correctly classify

84% of their sample with the function, while Kajanoja (1966) was only able to classify 65% of the Finnish sample. However, greater accuracy (~80%) was achieved using 8 measurements (maximum cranial width, maximum bizygomatic diameter, glabello-occipital length, basion-bregma height, basion-prosthion, basion-nasion, prosthion nasion, and nasal breadth) (Kajanoja 1966). Hunter and Garn (1972) correctly classified ~91% of their sample using a discriminant function composed of facial and mandibular measurements. Holland (1986) used multiple regression to sex individuals, using measurements of the cranial base. Nine measurements of the cranial base accurately classified 90% of the original sample and 85% of a holdout sample (Holland 1986). Regression equations requiring fewer measurements correctly classified 71 to 79% of the original sample and 70 to 85% of the holdout sample (Holland 1986).

Sex determination using Mandibular Measurements

Sex determination of individual mandibles has also been attempted. Giles (1964) took 9 mandibular measurements. These measurements included symphysis height, body height, body length, body thickness, minimum breadth of the ramus, maximum breadth of the ramus, ramus height, and bigonial diameter. A discriminant function consisting of seven of these measurements accurately sexed 85% of a sample of 61 White and 211 African Americans; body height and bigonial diameter were excluded from the discriminant function (Giles 1964).

Although discriminant analysis and regression appear to be a more objective way to sex individuals, the functions should only be used to sex individuals that come from the same population from which the function was calculated; or at least a very similar population (Henke 1977). It is not unusual for an individual's population of origin to be unknown or

uncertain in forensic cases; which limits the use of discriminant functions in sex determination. In some cases, the use of morphological characteristics to sex individuals may be more accurate than discriminant functions. Meindl et al. (1986) was able to accurately classify 92% of a sample using morphological characteristics, while the degree of accuracy using various discriminant functions ranged from ~75-90%. The preferred method for sex determination using the crania is the scoring of morphological characteristics. The method can be done quickly and easily in the field, but it has its drawbacks in populations that are less sexually dimorphic and also in much older individuals. As individuals age, the morphological characteristics of the crania begin to appear more masculine (Meindl et al. 1985). Information regarding the age of an individual should be taken into consideration before sex is estimated.

Adult Sex Determination of the Dentition

Sex determination using the adult dentition has been based solely on discriminant analysis. Measurements taken on the teeth include bucco-lingual and mesio-distal diameters, as well as root height and crown height. Analysis of the various teeth using these measurements has revealed that the most sexually dimorphic tooth is the mandibular canine (Ditch and Rose 1972; Owsley and Webb 1983; Rösing 1983). In the Native American sample evaluated by Ditch and Rose (1972), the bucco-lingual diameters of the mandibular canines were the best sex discriminators, followed by the bucco-lingual diameter of the maxillary canines. The best discriminant function included the following measurements: bucco-lingual diameters of the mandibular canine, bucco-lingual diameter of the 2nd maxillary premolar, bucco-lingual diameter of the 1st maxillary molar, mesio-distal diameter of the maxillary canine, and the bucco-lingual diameter of the maxillary diameter (Ditch and

Rose 1972). This discriminant function correctly classified ~96% of the sample. Sex estimation of a hold out sample ranged from 80 to 100% using several discriminant functions. However, it should be noted that the size of the holdout sample was very small and the majority of the sample consisted of females (Ditch and Rose 1972). Rösing (1983), as well as Owsley and Webb (1983), also found that the mandibular canine was the best tooth for sex discrimination. Approximately 97% of an ancient Egyptian sample was correctly sexed using the bucco-lingual diameter, mesio-distal diameter, root height and crown height of the mandibular and maxillary canine as well as the 1st mandibular and maxillary incisor or the 2nd mandibular and maxillary incisor (Rösing 1983). Owsley and Webb (1983) were able to accurately sex ~81% of a sample of White American adults using a discriminant function consisting of only 3 measurements from 3 mandibular teeth (bucco-lingual diameter of the canine, bucco-lingual diameter of the 1st premolar and the mesio-distal diameter of the 1st molar).

Although the degree of accuracy appears to be high, these classification rates are inflated by the use of discriminant functions on the same samples from which the functions were derived. Owsley and Webb (1983) provided a more realistic classification rate (~80%) by using a larger holdout sample and also by using a fairly equal number of females and males. Given that better accuracy can be achieved using other bones of the body, such as the pelvis, sex estimation using the dentition should be secondary to other, more accurate methods (Owsley and Webb 1983). Moreover, antemortem tooth loss or loss of teeth due to taphonomic processes hinders the use of discriminant formulas. Yet, these formulas can be useful if the preservation of the postcranial skeleton is poor, but the teeth are present and well preserved (Owsley and Webb 1983).

Sexual Dimorphism in Adult Long Bones

In 1955, Pons looked at the femora of a 19th century Portuguese sample and reported that the diameter of the femoral head and epicondylar breadth are more effective at differentiating sex than femur length or minimum transverse diameter of the femoral shaft. A discriminant function using femoral head diameter and epicondylar breadth properly sexed ~95% of the sample (Pons 1955). Using a sample of African American skeletal remains, Thieme and Schull (1957) found that femoral head diameter was the best single sex discriminator for long bone measurements. In contrast to the results of Thieme and Schull (1957), Van Gerven (1972) reported that epicondylar breadth was the most effective measurement in sex determination. A discriminant function using 4 femoral measurements classified the sample with ~87% accuracy (Van Gerven 1972). However, Dittrick and Suchey (1986) reported that maximum head diameter (~89% correct) and bicondylar breadth (~86% correct) were very good sex discriminators on their own. Combining the measurements into a single discriminant function did not significantly improve sex estimation (Dittrick and Suchey 1986). Although combining femoral measurements in a single discriminant function may not improve its accuracy (Dittrick and Suchey 1986), using a femoral measurement with pelvic measurements does improve accuracy. Richman (1979) reported that sorting individuals with ischium-pubis index followed by femoral head circumference permitted sex estimation with ~92% accuracy in African American samples and ~98% in a White American sample. Circumference of the femoral shaft was also observed to be significantly different between the sexes (Black III 1978a). Femoral shaft circumference accurately sexed 85% of a prehistoric sample (Black III 1978a). Yet, Dittrick and Suchey (1986) reported a slightly lower accuracy (~80%) using femoral shaft circumference.

Tibia measurements have proven to be effective at sex determination. Işcan and Miller-Schaivitz (1984) evaluated the efficacy of four tibia measurements for sex determination. Circumference of the tibia at the nutrient foramen was the best sex indicator out of the 4 measurements (Işcan and Miller-Schaivitz 1984b). Seventy-seven percent of the White American and 80% of the African American portion of the sample were properly sexed using the circumference of the tibia at the nutrient foramen. With the addition of length and antero-posterior diameter of the tibia to circumference, accuracy of the discriminant function increased to ~79 to 84% for the entire sample (Işcan and Miller-Schaivitz 1984b). Işcan and Miller-Schaivitz (1984a) evaluated the same sample using several additional measurements and reported that the breadth of the proximal epiphysis of the tibia was a better sex discriminator than circumference of the tibia at the nutrient foramen. Proximal epiphyseal breadth of the tibia accurately sexed ~87% of the sample. The combination of proximal epiphyseal breadth of the tibia and circumference of the tibia at the nutrient foramen in a discriminant function accurately classified ~86 to 90% of the sample (Işcan and Miller-Schaivitz 1984a). Holland (1991) also reported that proximal epiphyseal breadth of the tibia was effective (96% accurate) for sex estimation.

Significant sex differences are also present in the humerus and radius (Berrizbeitia 1989; Dittrick and Suchey 1986; Thieme and Schull 1957). According to the results of Thieme and Schull (1957), out of eight postcranial measurements the epicondylar width of the humerus is the second most sexually dimorphic measurement, preceded by femoral head diameter. Dittrick and Suchey (1986) were able to correctly classify ~90% of a prehistoric sample using the transverse diameter of the humeral head and 89% using the vertical diameter of the humeral head. In 1989, Berrizbeitia used the radial head to determine sex.

The cutoff point for minimum diameter of the radial head accurately estimated sex in 82% of a White and African American sample, while the maximum diameter of the radial head accurately sexed 83% of this sample. Ninety-six percent of a holdout sample from the same collection was accurately sexed using the same cutoff points (Berrizbeitia 1989).

Other Miscellaneous Bones

Thieme and Schull (1957) reported that clavicle length was the third most sexually dimorphic measurement out of a suite of eight measures, but Jit and Singh (1966) reported that clavicle length was a poor predictor of sex. According to Jit and Singh (1966), clavicle length only predicted sex in correctly in 8 to 20% of cases and clavicle weight and robusticity were not useful at all. However, circumference at the midshaft of the right clavicle was a better distinguisher of male individuals (72%) than females (10%) (Jit and Singh 1966). Using the same cutoff points as Jit and Singh (1966), Singh and Gangrade (1968) achieved a greater degree of accuracy in a sample comprised of individuals from two different regions of India. Once again, circumference at the midshaft of the clavicle was the best measurement for predicting sex (Singh and Gangrade 1968). Fifty-four percent of the sample was positively sexed using the midshaft circumference of the clavicle, and 66% was sexed using length, weight, and mid clavicle circumference (Singh and Gangrade 1968).

Several other bones have been evaluated for their utility in sex determination. Pons (1955), as well as Thieme and Schull, evaluated the sternum for sexual dimorphism. Pons (1955) was able to accurately determine the sex of 89% of a Portuguese sample using 5 sternal measurements. The results of Thieme and Schull (1957) suggest that sternum width is not as effective at sex discrimination as other postcranial measurements, such as femoral head diameter or epicondylar width of the humerus. Steele (1976) examined the talus and

calcaneus for sex differences. Talus length accurately sexed 81% of a sample taken from the Terry collection and 85% of an Arikara sample (Steele 1976). A discriminant function comprised of measurements taken from both the calcaneus and the talus achieved 89% accuracy when tested on the Terry collection sample (Steele 1976). Marino (1995) examined the first cervical vertebra and found that the articular surfaces and the vertebral foramina area of the first cervical vertebra are sexually dimorphic and could be used for sex determination. Regression equations and discriminant functions consisting of measurements taken from the first cervical vertebra sexed a sample from the Terry Collection with 77 to 85% and 75 to 85% accuracy, respectively. A control sample was sexed with 60 to 85% accuracy using the regression equations (Marino 1995).

After examining the hand radiographs of 4,379 White American and 1,589 African American individuals for sex differences in the total subperiosteal area, medullary area, and cortical area of the metacarpals, Garn et al. (1972) reported that the African American sample was not as sexually dimorphic as the White American sample. Although Garn et al. (1972) did not attempt to estimate sex using these measurements; it was cautioned that the use of a single cutoff point for both White and African Americans would lead to errors in sex estimation because of the differences in the amount of sexual dimorphism between the two groups.

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This brings up an important point. The limitations and specifications for specific sexing criteria should be considered before they are applied to skeletal material. Some methods are

more appropriate for individuals belonging to specific ancestral groups and should only be used on those groups; otherwise errors in sex estimation are likely.

Subadult Sexual Dimorphism

Investigators have examined the same areas of the subadult anatomy for sexual dimorphism that were examined in the adults. The pelvis has been the main focus for many investigators, although the crania, mandible, dentition, and long bones have also been evaluated. Some of these studies have attempted to use their results to develop sex determination methods for subadults. The following is a review of the literature focusing on sexual dimorphism and sex determination in subadults.

Sexual Dimorphism and Sex Determination of the Pelvis

Sex differences in the subpubic angle and sciatic notch of the subadult pelvis have been observed since the late 1800s (Fehling 1876; Thomson 1899; Verneau 1875), but results have not been consistent since this time. Therefore, sex differences in the subadult pelvis have never been confirmed. In several early studies using fetal samples, sex differences were detected by the 4th fetal month in the subpubic angle and the sciatic notch (Fehling 1876; Verneau 1875). Thomson's (1899) study on the pelves of 4 males and 4 females (aged 4-7 fetal months) also found these differences. Some of the early studies did not find any significant sexual dimorphism in the fetal pelvis, while other studies found some features were sexually dimorphic and others were not. In a study of 120 individuals ranging in age from birth to 20 years, Konikow (1894) did not find any sex differences in the pelves of pre-pubertal individuals. Villemin (1937) and Lazorthes and Lhez (1938, 1939) observed a wider fetal sciatic notch in females than males by the fourth fetal month, but found no difference in the depth of the sciatic notch.

The results of later studies continued to be as inconsistent as the earlier studies. Yamamura (1939) found no sex differences in the pelves of 70 male and 70 female Japanese fetuses. Likewise, Morton (1942) found no differences in the pelves of 10 females and 17 males aged from 3 ½- 10 fetal months. However, Boucher reported differences in studies conducted in 1955 and 1957. Boucher (1955) examined the ilia of 33 fetuses aged 6 fetal months to term and observed sex differences in the sciatic notch index (width/depth). Boucher continued to find these differences in 1957 in a study of the intact pelves of 96 African American still births (49 male, 47 female) and 33 White American still births (19 male, 14 female). The skeletal remains of 74 White British stillbirths were also examined, but these pelves were not intact (Boucher 1957). With the addition of the sample used in the 1955 study, the overall White British sample totaled 46 males and 61 females. Although no significant sex differences were found in the pubic index (ischium length/ pubis length), the subpubic angle was significantly greater in females than in males in both the White American and African American samples (Boucher 1957). Also, the depth, width, and index of the sciatic notch index were significantly larger in the African American and British females than in males. However, there was no significant difference between American White females and males in the depth, width, or index of the sciatic notch (Boucher 1955; Boucher 1957).

Radiographic Studies of Sexual Dimorphism in the Subadult Pelvis

Radiographic studies of infants and young children have also given inconsistent results regarding the existence of sexual dimorphism in the subadult pelvis. An examination of serial radiographs taken at regular intervals on 46 male and 49 female infants during the first post-natal year revealed sex differences in the pelvis, but these differences tended to

decrease with age (Reynolds 1945). At birth, males tended to be larger in measurements representing the outer structure of the pelvis, such as pelvis height and breadth, ilium length and breadth, and inter-iliac breadth (Reynolds 1945). Female infants were more likely to be larger in measurements representing the inner structure of the pelvis as well as possess a larger inlet (Reynolds 1945). The measurements that tended to be larger in the female infant include actual and relative depth of the inlet, relative breadth of the inlet, inter-pubic breadth (at birth and 1 month only), bi-ischial breadth, pubis length, and breadth of the sciatic notch, but the female pelvises were also found to be more variable than males, especially at 3, 6, and 9 months of age. Results were similar in a later study of slightly older children (15 months- 9 ½ years), except that boys tended to be larger in inlet breadth (only at 22 months old) and in ischium length (Reynolds 1947). The width of the ischio-iliac space was also sexually dimorphic (Reynolds 1945). Unfortunately, this sex difference is unobservable in the unfused pelvis because the cartilaginous material that fills the ischio-iliac space is usually lost during the decomposition process, making this difference useless in the forensic context.

In contrast to Reynolds' work, Morton and Hayden (1941) did not find any sex differences in the pre-pubertal portion of their sample. The radiographs of 59 girls and 16 boys ranging from 4 to 15 years of age did not reveal any differences in the sciatic notch or subpubic angle between pre-pubertal girls and boys (<11 years old) (Morton and Hayden 1941). Yet, studies conducted by Coleman (1969) and La Velle (1995) contradict this finding. Coleman (1969) conducted a radiographic study of 9 year olds (14 males, 16 females) and observed sex differences in both the subpubic angle and sciatic notch. The subpubic angle was narrower in males than in females; and the sciatic notch was deeper in males and more shallow in females (Coleman 1969). Additionally, growth at adolescence

reportedly accentuated this difference. After evaluating the pelvic radiographs of 108 eight year olds and 89 eighteen year olds, La Velle (1995) reported that the 8 year old portion of the sample was sexually dimorphic in the acetabular region and ischial breadth. Males tended to be larger in inter-acetabular breadth and acetabular diameter. Females tended to be larger in ischial breadth (LaVelle 1995). At 18 years, significant sexual dimorphism was found in the following measurements: ilium height, anterior inferior spine breadth, max diameter of the acetabulum, depth of the acetabulum, inter-acetabular diameter, medial acetabular diameter, transverse inlet diameter, pubis length, posterior inferior spine breadth, bi-ischial spine breadth, and max ischium breadth (LaVelle 1995). These results suggest that sex differences are present in the pre-pubertal pelvis, but most sex differences do not appear in the pelvis until adolescence and the commencement of the rapid period of pelvic growth and remodeling that accompanies it (LaVelle 1995).

Several studies provide insight into the aforementioned inconsistencies. Reynolds (1945, 1947) observed that sex differences tended to slightly decrease with age. Sexual dimorphism that is present during early infancy may become obscured by the growth process (Reynolds 1945; Reynolds 1947). This may explain why Morton and Hayden (1941) did not find significant sex differences in their radiographic studies of pre-pubertal children. Also, a positive relationship was found between pelvis breadth and weight and length at birth in both sexes; therefore the larger measurements in males may simply be caused by a greater weight and length at birth for males than females (Reynolds 1945). Hence, no sex differences would be found in infant samples in which the boys and girls are born with approximately the same weight and height. The results of a growth study of 107 girls ranging in age from 5 to 15 years and 2 months conducted by Greulich and Thoms (1944) suggests sexual dimorphism in

the pelvis develops at puberty. The female pre-pubertal pelvis grew slowly and symmetrical up till the pubertal period (Greulich and Thoms 1944). Pubertal remodeling of the pelvis took approximately 18 months, and after this rapid period of remodeling occurred, very little growth of the pelvic inlet and almost no further change in the superior pelvic aperture was observed (Greulich and Thoms 1944). Greulich and Thoms (1944) suggest that the rapid remodeling of the pelvis at puberty can be contributed to the increased activity of sex hormones because prior to the increase in sex hormone activity, and therefore puberty, growth in the pelvis is slow and symmetrical. These findings are in agreement with the suggestions of Morton (1942) and Morton and Hayden (1941) that all humans are born with a similarly shaped pelvis, and sexual differentiation of the pelvis does not occur until puberty because the rapid remodeling in the pelvis does not occur until this time.

Subadult Sex Determination Methods using the Pelvis

Although studies have been inconsistent in finding sexual dimorphism in the subadult pelvis, investigators have attempted to develop sex determination methods using the subadult pelvis. Fazekas and Kosa (1978) tested the fetal sciatic notch for sexual dimorphism using a sample of 61 males and 43 females aged 4 to 10 fetal months from Hungary. Fazekas and Kosa (1978) attempted to replicate the measurements used in Boucher's studies (1955, 1957). However, a different technique was used and a different tool was designed to take the measurements. Sex differences were found in the fetal sciatic notch. The sciatic notch was deeper in males and wider in females. No significant sex differences were found in the length or width of the ilium themselves, but these measurement were significant in relation to the dimensions of the fetal sciatic notch (Fazekas and Kosa 1978). In males, the depth of the sciatic notch was found to be more constant, while the width was more variable. Opposite

results were obtained for females. Sexing the sample using measurement indices (sciatic notch depth/length, notch length/ ilial length, sciatic notch length/ femoral length, sciatic notch depth/ ilial length) proved to be little better than chance; only 44.2 to 59% of cases could be sexed with absolute certainty (Fazekas and Kosa 1978). However, accuracy improved to 70 to 80% when the specimens that were not completely characteristic of their sex were added to the number of cases in which sex was certain, but this is not recommended. Sex determination for purposes of identification needs to be extremely accurate, and the amount of overlap between the sexes should not be ignored (Fazekas and Kosa 1978). It is necessary to continue to investigate sexual dimorphism in the fetal skeleton in order to develop more methods that can be used in conjunction with the sciatic notch (Fazekas and Kosa 1978). On its own, the morphology of the sciatic notch is not a reliable sex indicator in subadults.

Weaver's Method for Sex Determination

Weaver (1980) obtained measurements and examined one non-metric characteristic in the ilia of 153 (71 females, 82 males) fetal and infant skeletons from the Hrdlička collection housed at the Smithsonian Institution. The ilia were examined for elevation or non-elevation of the auricular surface. The following measurements were also taken: width and depth of the sciatic notch, lengths of the posterior and anterior ilium, and iliac height and width. In contrast to the results of Fazekas and Kosa (1978), iliac breadth (iliac width/ height) was the only index that was significantly different between the sexes, but only in the 6 month age group (3-6 months postpartum). Significant sex differences were found in auricular surface elevation (Weaver 1980). Males were significantly more likely to have non-elevated auricular surfaces than females. Non-elevation of the auricular surface accurately sexed

91.7% of the fetal males (6-8 fetal months), 90.6% of the males in the 6 month age group, and 73.1% of males in the newborn (birth-1 month) age group (Weaver 1980). Auricular surface elevation proved to be a poor predictor of femaleness. Only 75% of females in the fetal group, 54.2% in the newborn group, and 43.5% in the 6 month age group could be sexed accurately. Weaver (1980) concluded that non-elevation of the auricular surface was a good predictor of maleness, but elevation was not a good predictor for females because many females had non-elevated surfaces. However, other investigators have concluded the opposite, suggesting the method is unreliable.

In 1990, Hunt conducted an indirect test of Weaver's (1980) sexing method using a sample of 275 Arikara subadult ilia. The sex of the individuals was not known. In contrast to Weaver's (1980) results, Hunt (1990) concluded that auricular surface was more likely an aspect of growth because it was correlated with age. The ratio of elevated to non-elevated auricular surfaces was 6:1 in newborns, but dropped to 1:4 in young adolescents, with the inversion occurring approximately at 2 ½ years (Hunt 1990). The expected ratio of males to females in any population is usually 1:1, which would not be true in this sample if Weaver's method was accurate. Hunt (1990) described Weaver's method as unreliable at best.

Mittler and Sheridan (1992) also tested Weaver's method and found that auricular surface elevation was correlated with age. The test was conducted on 58 Nubian subadults dating from 550 to 1450 A.D. aged from birth to 18 years. The number of females with elevated auricular surfaces increased from 66.7% in females aged 10 to 18 years to 71.4% in females aged 14 to 18 years (Mittler and Sheridan 1992; Weaver 1980). In individuals younger than 9 years old, only 33% of females had elevated auricular surfaces and 70.6% males had a non-elevated surface (Mittler and Sheridan 1992). More importantly, Mittler and

Sheridan (1992) concluded that auricular surface elevation was a better predictor of femaleness. The method was most effective in females aged 10 years or older because, although 26% of the females had non-elevated auricular surfaces, all individuals with elevated surfaces in this age range were female, while not all individuals with non-raised surfaces were male (Mittler and Sheridan 1992).

Schutkowski's Method of Sex Determination

Schutkowski (1993) also took a non-metric approach to subadult sex determination using the ilium. The ilia of 22 girls and 29 boys aged from birth to 5 years were examined for 4 characteristics (Schutkowski 1993). The sample came from a cemetery collection in Spitalfields, London. The angle, "arch" and depth of sciatic notch were evaluated along with the curvature of the iliac crest. It was expected that female ilia would have a shallow sciatic notch with an angle exceeding 90°, an arch that crosses the auricular surface, and a faint S-shape of the iliac crest. Male ilia were expected to have a deep sciatic notch with an angle of ~90°, an arch that borders the auricular surface and an iliac crest that has a marked S-shape (Schutkowski 1993). All of the characters were significantly different between the sexes, but angle, arch and depth of the sciatic notch were the most significant. Nine-five percent of males had a narrow sciatic notch and 71.4% of females displayed wide sciatic notches. The deep and shallow criteria for the sciatic notch correctly sexed 81.2% of males and 76.5% of females, respectively (Schutkowski 1993). The arch criterion was less accurate, but it properly classified 73.3% of boys and 70.6% of girls. A pronounced S-shaped in the iliac crest was found in 81.2% of boys, but the faint S-shape was only observed in 62.1% of girls (Schutkowski 1993). Although it appears that narrowness and depth of the sciatic notch were

accurate discriminators in comparison to the other characteristics examined, all of the characteristics are very subjective.

A Morphometric Approach to Sex Determination

In an attempt to find a more objective method, Holcomb (1992) and Holcomb and Konigsberg (1995) used a morphometric technique to investigate sexual dimorphism in the fetal sciatic notch using the Trotter collection. Photographs of 133 (55 males, 73 females, 5 unknowns) fetal ilia between the ages of 16 to 58 postmenstrual weeks were digitized, and trace coordinates were taken on the outline of the ilia (Holcomb 1992; Holcomb and Konigsberg 1995). Interestingly, the sciatic notch index (depth/ width) was not sexually dimorphic. However, a significant sex difference was found in the location of the greatest depth of the sciatic notch. This suggested a sex difference in the shape of the sciatic notch (Holcomb 1992; Holcomb and Konigsberg 1995). The maximum depth of the sciatic notch was more anteriorly placed in males and more posterior in females. As was stated by Fazekas and Kosa (1978), Holcomb (1992) and Holcomb and Konigsberg (1995) concluded that, although a significant sex difference was found in the shape of the sciatic notch, the amount of overlap between male and female measurements is too great for use as an accurate sex indicator. Only 63.1% of the sample was correctly classified using a quadratic discriminant function or a linear discriminant function (Holcomb 1992; Holcomb and Konigsberg 1995). A less biased quadratic discriminant function calculated using a leave-one-out method performed even worse (58.2%) in sex determination (Holcomb 1992; Holcomb and Konigsberg 1995). These results on sex determination using the fetal sciatic notch, being the most objective, raise important questions about the accuracy of the previous more subjective methods.

The most current work testing subadult sex determination methods on fetal ilia was done by Johnson in 2000. Two-hundred twenty-nine (129 male, 100 female) fetal ilia aged from fetal to 20 months were selected from the Hrdlčka collection to test Weaver's auricular surface elevation criteria and Schutkowski's (1993) 4 iliac characteristics for reliability (Johnson 2000). Johnson (2000) concluded that auricular surface elevation was more accurate in predicting males than females, with an 83% accuracy rate in males and 30% in females (Johnson 2000). These results are not surprising considering the findings of Hunt (1990) and Mittler and Sheridan (1992) that age is correlated with auricular surface elevation. The auricular surfaces of many females would not be elevated till later on in life. In this study, the arch criterion was the best sex predictor, correctly assigning 79% of females and 55% of males (Johnson 2000). Greater sciatic notch depth and angle were not as effective at predicting sex (Johnson 2000). The angle of the greater sciatic notch (narrow or wide) correctly sexed 68% of the females and 53% of the males. Notch depth was the least effective in determining sex with 65% of females and 57% of males correctly sexed (Johnson 2000). In contrast to Schutkowski's findings, iliac crest curvature was better at predicting females (70% correct) than males (49% correct). Accuracy using all four characteristics was only slightly better (70%) than the accuracy using only the most effective sex predictor (~66%), arch criterion. The contrasting results of Johnson (2000) and Schutkowski (1993) may simply be caused by Schutkowski's (1993) small sample size or it could indicate that the 4 iliac characteristics are too subjective for reliable application. Population variation may be another cause for the contrasting results.

It is understandable why most studies of sexual dimorphism focus on the pelvis. Krogman (1962) stated that sex could be determined with 98% accuracy using only the adult

pelvis. Complete accuracy is only possible using the entire skeleton (Krogman 1962). The pelvis is considered one of the most sexually dimorphic skeletal elements in the adult body, but none of the studies on the subadult pelvis have produced consistent results or a reliable method. The inconsistency in results may be caused by the use of different methods. For example, Thomson's (1899) method requires an intact fetal pelvis, but it is unlikely to find an intact subadult pelvis because of the decomposition process. Likewise, radiographic studies have not been helpful in developing sex determination methods. Measurements that are found to be significantly sexually dimorphic in radiographs cannot be taken on a reconstructed subadult pelvis because the cartilage that holds the pelvis together is lost (Weaver 1980). This means that cartilage thickness must be estimated before measurements are taken (Sundick 1977). Therefore, studies that rely on reconstruction of the subadult pelvis are highly suspect because the results are based on estimated measures of cartilage thickness (Sundick 1977). It is also possible that radiographic studies have not produced consistent results because radiographs are difficult to read and it is impossible to position each pelvis in the exact same angle (Weaver 1980). Another problem is that landmarks are difficult to distinguish on radiographs, making measuring difficult (Weaver 1980). Any uncertainty in measurement is compounded by the small size of the subadult pelvis, making even small errors a problem when trying to use the measure to make a sex classification (Weaver 1980).

Sexual Dimorphism in the Subadult Mandible

Studies on the subadult mandible have not been excluded from the inconsistencies that have plagued the pelvic studies. Coben (1955), Meredith (1961), and Cannon (1970) concluded that there was a significant sex difference in the corpus length of the mandible, but Maj and Luzi (1964) did not find this difference. In 6 to 11 year olds, Riolo et al. (1974) also

did not find sexual dimorphism in corpus length. Newman and Meredith (1956) reported sexual dimorphism in mandibular breadth. Coben (1955), Maj and Luzi (1964), and Riolo et al. (1974) concluded that ramus height was sexually dimorphic, but Cannon's (1970) results did not agree. The inconsistencies in results may be due to the differences in the origin and ages of the various samples used in these studies. Coben's (1955) sample included individuals aged 8 to 16 years old, Meredith (1958, 1959, and 1961) examined 5 to 11 year olds, Maj and Luzi (1964) followed 9 year olds to the age of 13, and Cannon (1970) examined 3 year olds and 8 year olds. Pahl-Anderson and Kowalski (1976) concluded that total mandibular length was the best measure for sex discrimination in the sample under investigation, but only in subadults aged 10.6 years. The results of Buschang et al. (1986) were consistent with the findings of Pahl-Anderson and Kowalski (1976). Buschang et al. (1976) examined 54 subadults aged 6 to 10 years. A significant sex difference was discovered in corpus and mandibular length of 6 year olds, but no sex difference was found in the ramus height of individuals aged 6 to 10 years (Buschang et al. 1986).

Sex Determination Using a Subadult Mandible

Schutzkowski (1993) evaluated several morphological characteristics of the mandible for their utility in sex determination. Protrusion of the chin, shape of the anterior dental arcade, and eversion of the gonion region were examined in 37 boys and 24 girls from a cemetery collection in Spitalfields, London. These traits were most effective in discriminating sex in males under the age of five. Most boys had a prominent and angular chin (94.1%) and wide dental arcade (82.6%) (Schutzkowski 1993). Eversion of the gonial region occurred less frequently (73.9%) in males. Females were expected to have a smooth

chin, rounded dental arcade, and a non-everted gonial region. However, application of this criterion proved little better than chance for sexing females (Schutkowski 1993).

Johnson (2000) tested Schutkowski's mandibular traits on a collection of fetal and infant remains. None of the mandibles used in this study were fused, making estimation of the shape of the anterior dental arcade difficult. In accordance with Schutkowski's (1993) results, chin protrusion was the most effective characteristic in sex determination. In contrast to Schutkowski's (1993) results, chin protrusion was more accurate at sexing females (73%) than males (49%) (Johnson 2000). Shape of the dental arcade and eversion of the gonial region were also more effective in sexing females (60% and 67%) than males (53% and 34%), but accuracy was little better, if not worse, than chance for both sexes (Johnson 2000). Overall, these characteristics do not appear to be reliable sex indicators.

Sexual Dimorphism in the Subadult Craniofacial Complex

Sexual dimorphism in the development and size of the subadult craniofacial complex has also been examined. Like other growth studies, Buschang et al. (1983) concluded that females were more mature in craniofacial measures than males at all ages. The measurements were taken from the cephalograms of a mixed longitudinal sample of subadults aged 4 to 16 years. In a study of subadults aged 6 to 18 years, Baughan and Demirjian (1978) conclude that sex differences in size of the cranium were present prior to birth, but the large degree of sexual dimorphism that is present in adults does not occur until puberty. Head length was 2.5-3% larger in males than in females prior to puberty, but increased to 4% after puberty (Baughan and Demirjian 1978). Head volume showed a 5% sex difference prior to puberty and increased to 8% after puberty (Baughan and Demirjian 1978). Baughan and Demirjian (1978) suggest that the sexual dimorphism in the adult craniofacial complex is caused by a

cranial growth spurt that is experienced by males at puberty, but not by females (Baughan and Demirjian 1978). However, Nanda (1955) observed that females did experience a cranial growth spurt, but it occurred earlier and was much less intense (Nanda 1960).

Sex Determination using Subadult Craniofacial Characteristics

Discrete cranial characteristics have been combined with mandibular characteristics to evaluate the efficacy of applying adult discrete craniofacial characters to sex subadult craniofacial material. Molleson et al. (1998) examined orbit shape and mandibular characteristics of a sample of 20 subadults, most were less than 5 years old. Shape of the orbit and mandible were examined for sex characteristics as defined by Acsádi and Nemeskéri (1970) and Krogman and Işcan (1986). Females were expected to have rounded orbits with fairly sharp margins, large orbits relative to the entire face, and a rounded mandibular angle with fairly even curvature (Molleson et al. 1998). The male orbit was expected to be angularly shaped with rounded margins, an everted mandibular angle, and a heavy and square mentum with rugose muscular markings (Molleson et al. 1998). A scoring system based on the observed level of masculine or feminine characteristics was used to sex each individual. The scoring system was fairly successful in sexing the sample, 78% correct (Molleson et al. 1998).

Sex Determination and Sexual Dimorphism in Subadult Dentition

Studies of sexual dimorphism in subadult dentition can be divided into studies focusing on development, emergence, and size. Each of these types of studies can be further divided into studies focusing on deciduous and permanent dentition. Each study has its limitations for use in subadult sex determination, but the main problem for all of these studies

is that sexual dimorphism in the deciduous and permanent dentition is too small to be highly effective for determining the sex of subadults.

Developmental studies

During early development of the deciduous dentition, males are reportedly more advanced than females (Meredith 1946). Burdi et al. (1970) conducted a study on 52 male and 52 female first trimester stillborns to investigate this conclusion and was unable to reject it. Burdi et al. (1970) reported that males were significantly more advanced than females in the development of all deciduous dentition (Burdi et al. 1970). However, not all studies have come to the same conclusion. Fanning (1961) concluded that males and females were very similar in the development of the deciduous dentition, but that females were more advanced in root resorption of the deciduous dentition. This suggests that the male deciduous dentition is not simply more advanced than female dentition, but that there is a change at the very end of deciduous dental development in which females surpass males in dental maturity.

Although sexual dimorphism in the development of the permanent dentition is very small, 3% according to Garn et al. (1958), developmental studies of the permanent dentition have given more consistent results than the deciduous dentition. Meredith (1946), Nolla (1960), Fanning (1961), and Moorrees et al. (1963) have all reported that female subadults are consistently more advanced in the development of all the permanent teeth, except for the 3rd molar, which has been found to be very inconsistent. However, Demirjian and Levesque (1980) point out that the amount that girls are more advanced over boys in the development of the permanent dentition is population specific. This indicates that the level of success for using sex differences in dental development for sex determination is also population specific (Demirjian and Levesque 1980). Success in sex determination will be lower for populations

that have a smaller degree of sexual dimorphism in dental development and much higher for populations in which the sexual dimorphism is greater.

Bailit and Hunt (1964) attempted to use the limited difference in the development of the permanent dentition to sex subadults. The study used the radiographs of 25 female and 25 male subadults aged 7 to 12 years of age. The age group was chosen to maximize the sexual dimorphism in the permanent mandibular canine (Bailit and Hunt 1964). Both male and female developmental ages were assigned to each tooth in each individual, and sex was assigned based on the sex standard that showed the least amount of age variation between teeth (Bailit and Hunt 1964). Using this method, only 58% of the subadults in the sample were correctly sexed, indicating that sexual dimorphism in the development of the permanent dentition is too small to effectively sex subadults. Accuracy in sex determination increased to 70% if age was previously known, but this has limited use in the forensic setting because sex and age are usually unknown (Bailit and Hunt 1964).

Studies focusing on sex determination in subadults using the permanent dentition have taken advantage of fact that sex differences in dental maturation are much smaller than the sex differences in skeletal maturation (10-25%) (Garn et al. 1958). Generally, females mature more rapidly than males, as indicated by the results of ossification studies (Pryor 1923). Pryor (1923) concluded from the radiographs of infants that females are more advanced than males in the onset of ossification of the skeleton. Hunt and Gleiser (1955) used the contrast in sex differences between dental and skeletal maturity to determine the sex of 93 subadults from lateral jaw and hand radiographs. Ages based on dental maturity and skeletal maturity were compared. Dental age was used as a proxy for chronological age because sex differences in dental maturity are less than sex differences in skeletal maturity

(Hunt and Gleiser 1955). Male and female skeletal ages were calculated based on standards of hand ossification. If the female skeletal age agreed more closely with the dental age, the individual was classified as female. If the male skeletal age agreed more closely with the dental age, the individual was classified as male. Using this method of classification, 73% of 2 year olds, 76% of 5 year olds, and 81% of 8 year olds were classified correctly (Hunt and Gleiser 1955). This concept has potential, but the hand bones do not preserve well in the archaeological or forensic setting, making it unavailable for age estimation (Hunt and Gleiser 1955). In a test of this method using 300 subadult skeletons, Sundick (1977) agreed that the hand was a poor candidate for skeletal age estimation using skeletal remains and therefore is not useful in this context.

Emergence

Conclusions regarding the existence of sexual dimorphism in deciduous tooth eruption have also been fairly inconsistent. In one of the earliest studies, Boas (1927) reported that the 2nd deciduous molar erupted earlier in females than in males, but there were no other significant differences in eruption of the deciduous dentition. Although the children used by Boas (1927) were in very poor health, Lysell et al. (1962), Falkner (1957), Friedlaender and Bailit (1969), Doering and Allen (1942), Sandler (1944), Nanda (1960) and McGregor et al. (1968) also did not find any statistically significant sex differences in the eruption of the deciduous dentition. In contrast, Speidle and Stearns (1940), Robinow et al. (1942), Meredith (1946), Leighton (1968), Ferguson et al. (1957), Infante (1974) and Tanguay et al. (1984) reported that the deciduous dentition erupted slightly earlier in males than females. Furthermore, some of the studies found that males erupted some teeth earlier than females, while females erupted other teeth earlier than males or that males were only

advanced in the eruption of specific teeth (Doering and Allen 1942; Infante 1974; Lysell et al. 1962). It has also been suggested that the observed sex differences in deciduous tooth eruption have nothing to do with age or developmental differences. In a study of French Canadian children, Tanguay et al. (1986) found that sexual dimorphism in the emergence of deciduous teeth is associated with recumbent length of the teeth. The recumbent length of the deciduous dentition in boys was longer than in females, and emergence occurred earlier in boys, but no significant sex differences were found in the age of emergence of deciduous teeth (Tanguay et al. 1986). This may be an explanation for the inconsistent results regarding sex differences in deciduous tooth eruption.

Conclusions regarding the sex differences in the eruption of the permanent dentition have been much more consistent than the studies focusing on the deciduous dentition. Eruption occurs earlier in females than males in all permanent teeth excluding the 3rd molar (Demirjian and Levesque 1980; Garn et al. 1958; Hurme 1949; Nanda 1960). Although sex differences are present, the amount of sexual dimorphism in the eruption of the permanent dentition is very small. In the subadult sample studied by Garn et al. (1958), a 5% sex difference in eruption was reported, but, like development, the amount of sexual dimorphism in eruption of the permanent dentition is population specific.

Dimensional Studies

Coughlin (1967) observed significant sexual dimorphism in measurements of the deciduous 1st and 2nd maxillary molar as well as the deciduous 2nd mandibular molar in fetuses aged 28 to 38 interuterine weeks (18 male and 24 female). Females were significantly larger in the following measurements: distance from protocone to hypocone cusps in the first maxillary molar, buccolingual diameter, protocone-hypocone distance, and metacone-

hypocone distance of the 2nd maxillary molar, and the buccolingual diameter and metaconid-entoconid distance of the 2nd mandibular molar. Yet, a study using older subadults, but also examining the deciduous dentition, produced conflicting results. De Vito and Saunders (1990) evaluated the faciolingual and mesiodistal diameters of all deciduous teeth in 80 female and 82 males aged 3 to 4 years old. All male means were significantly larger than the female means. Greater sexual dimorphism was observed in the maxillary deciduous dentition than in the mandibular dentition. Sex determination was fairly successful using a discriminant function containing 3 to 5 measurements from the deciduous teeth; 76-90% of a hold out sample was accurately sexed (De Vito and Saunders 1990).

While the results of De Vito and Saunders (1990) were highly significant, they are also highly unusual because the deciduous dentition in the sample was more sexually dimorphic (1.91% and 6.44%) than is reported for other samples. In fact, it is in range of the dimorphism found in the permanent dentition (De Vito and Saunders 1990). However, Black III (1978b) was able to determine the sex of a less sexually dimorphic sample while remaining on the low end of the range of accuracy achieved by De Vito and Saunders (1990). Black III (1978b) correctly sexed 75% of a sample of 69 boys and 64 girls using a combination of 9 measurements on 7 deciduous teeth. The greatest percentage of sexual dimorphism (3.15%) was found in the buccolingual diameter of the maxillary 1st deciduous molar. Unlike the De Vito and Saunders (1990) study, all male means did not exceed all female means. The male means that exceeded the female means included the following mesiodistal diameters of the deciduous dentition: mandibular 2nd molar, maxillary 1st molar, maxillary 2nd molar, and maxillary canine (Black III 1978b).

Sexual dimorphism in the size of the permanent dentition is also small. The overall sex difference in the sample of subadults used by Garn et al. (1964) was 4%. The canine was the most sexually dimorphic (6%) and the incisors were the least sexually dimorphic (3%) (Giles 1964). Research suggests that sex differences, however small, in the size of the permanent and deciduous dentition are caused by a longer period of amelogenesis in males, which results in a greater enamel thickness (Moss and Moss-Salentijn 1977).

Studies using discriminant functions based on measurements of the permanent dentition have been fairly successful at sex determination. Garn et al. (1977) calculated discriminant functions using mesiodistal and buccolingual diameters of the right maxillary and mandibular permanent teeth from a sample of 204 subadults. Discrimination between the sexes was more successful using mesiodistal diameters than buccolingual diameters or ratio measures (Garn et al. 1977). Eighty-six percent accuracy was attained using the mesiodistal diameters of 14 teeth. A stepwise discriminant analysis achieved a slightly better accuracy rate, 87%, using a combination of mesiodistal diameters of the maxillary and mandibular canines, lateral incisors, mandibular 2nd molar and, maxillary 2nd premolar (Garn et al. 1977). In another study conducted on 16 and 17 year olds, Garn et al. (1979) reported that root length of the mandibular canine sexed up to 70% of their sample. Eighty-seven percent were accurately classified using a combination of root lengths, mesio-distal, and bucco-lingual diameters of six mandibular teeth (2nd incisor, canine, 1st and 2nd premolars, 1st and 2nd molars) (Garn et al. 1979). De Vito and Saunders (1990) also found significant sexual dimorphism in the diameters of subadult permanent molars and achieved a comparable level of accuracy in sex classification. A discriminant analysis using both permanent and

deciduous measurements accurately sexed 83-85% of a holdout sample (De Vito and Saunders 1990).

Sex Determination and Sexual Dimorphism in the 1st Cervical Vertebra

Hinck et al. (1962) examined the cervical spinal canal for sexual dimorphism using the radiographs of 24 boys and 20 girls aged 3 to 18 years of age. Each child was followed for an average of 7.5 years. Results showed that males were significantly larger than females, by an average of 2mm, in the anterior posterior diameter of the inner ring of the 1st cervical vertebra (Hinck et al. 1962). A greater diameter in the anterior-posterior diameter of the 1st cervical vertebra in males may be related to the greater overall size of the male cranium, foramen magnum, and the 1st cervical vertebra itself (Hinck et al. 1962).

The width and length of the superior and inferior facets of the 1st cervical vertebra have also been evaluated for sex differences. Johnson (2000) used a sample comprised of fetal and infant skeletal remains to investigate the efficacy of using these measurements for sex determination in subadults. Differences between males and females in the length and width of the inferior facets were insignificant, but males had significantly greater superior facet lengths while females had significantly greater widths of the superior facet. Using all 4 measurements, a very low predictive accuracy (59%) was achieved by logistic regression.

Sexual Dimorphism in Skeletal Ossification

As has been previously mentioned, the skeletal development of females tends to be more advanced than male skeletal development. Looking at the hand radiographs of children aged 3 months to 14 years, Pryor (1923) observed that females were ahead of males in ossification of hand bones. Although on average females are more advanced than males in ossification of skeletal elements, it cannot be automatically assumed that females and males

have the same order of ossification. Ossification order of the bones in the hand, foot, elbow, knee, shoulder, and pelvis have proven to be different between the sexes (Garn et al. 1966; 1975). For example, the ossification sequence of the elbow in 75% of boys is capitulum of the radius followed by the medial epicondyle of the humerus, while 70% of females experience the opposite sequence (Garn et al. 1966). The knee and pelvis displayed less sexual dimorphism in ossification sequence than the elbow. Also, it should not be assumed that similar ossification sequences will be observed in different populations (Garn et al. 1966). Garn et al. (1966) found that ossification sequences of the hand/wrist that were previously thought to be rare were regularly found in a sample of individuals from three Guatemalan villages.

Sex Determination and Sexual Dimorphism of Long Bone Dimensions

Sex differences have also been observed in long bone growth. Buschang (1982) examined the radiographs of the humerus, radius, femur, and tibia of 42 boys and 42 girls. Most subjects were followed from the age of 3 years to 11 years of age, but some had been followed since the age of 2 months. It was concluded that the larger male size was caused by consistent and slightly greater gains in long bone lengths during the male growth period than in the female growth period (Buschang 1982).

Fetal studies investigating sex differences in long bone length and weight have given contrasting results depending on the statistical analysis used. Trotter and Peterson (1968) did not find any significant differences in long bone length or long bone weight between fetal males and females using univariate methods of analysis. However the sample size was very small, consisting of 22 females and 7 males ranging in age from 17 fetal weeks old to two weeks after birth (Trotter and Peterson 1968). In a later study, a multivariate analysis

conducted on 115 fetal White and African American skeletons ranging in age from 16 to 44 fetal weeks found significant sex differences in lengths and weights of the long bones and weights of other bones (Choi and Trotter 1970). Out of the 26 ratios of the measurements, 7 ratios were chosen by step-wise selection and used for discriminant analysis. The discriminant function was able to accurately sex 72% of the sample (Choi and Trotter 1970). This study produced seemingly promising results for sex determination of fetal material, but one of the measurements used in the discriminant function would not be useful on fetal skeletal material found in the forensic setting. The use of the inferior limb weight/superior limb weight ratio is not practical because many of the small hand and foot bones are likely to be lost.

It is important to understand whether the sexual dimorphism found in the diameters of tubular bone is just a factor of size differences or due to true sex differences. Himes and Malina (1977) investigated this question using the 2nd metacarpal of 324 Mexican school children aged 6 to 11 years of age. Radiographs were examined and measurements of the diaphyseal and medullary diameters were taken. Cortical thickness was calculated by subtracting the medullary diameter from the diaphyseal diameter. Cortical area was also estimated. Sex differences in body size did affect metacarpal diaphyseal diameter and cortical thickness, but after correcting for body size, males were still significantly larger than females in these measurements (Himes and Malina 1977). Medullary diameter and percent cortical area were not affected by body size. Himes et al. (1976) found similar results in a study using Guatemalan children aged 1 to 7 years. This suggests that true sex differences in long bone diameters may be detectable in young subadults as well as older subadults.

The studies that have not found significant sex differences in prepubescent subadults claim this lack of sexual dimorphism suggests that detectable sexual dimorphism is not present until puberty. However, this idea is contradicted by Humphrey's (1998) results. Humphrey (1998) took cranial and postcranial measurements on a skeletal sample of 94 subadults from the Spitalfields cemetery aged from birth to 20 years. Humphrey (1998) reported that less sexual dimorphism is present in measurements of the early, faster-growing bones such as the skull and mandible, and greater in later, slower-growing bones such as long bone lengths and diameters as well as clavicle length and diameter. The results also indicate that sex differences in long bone diameters develop between birth and adolescence and differences in long bone length do not develop until adolescence (Humphrey 1998). Sexual dimorphism in glenoid cavity breadth develops prior to adolescence, and differences in clavicle length and midshaft diameter are already present at birth. Analysis of the growth curves of these measurements indicates that the sex differences that develop prior to adolescence are mainly caused by the difference in growth rate between the sexes (Humphrey 1998). Differences in growth duration are still a factor in the overall level of sexual dimorphism that is observed, but growth rate seems to account for a larger portion of the observed sexual dimorphism (Humphrey 1998). However, this may not hold true for all bones. Growth rate only accounts for 19 to 53% of sex differences in long bone length, suggesting that long bone length may be mostly affected by growth duration (Humphrey 1998). Males tend to experience their postcranial growth spurt later than females and therefore have a longer duration for long bone growth, resulting in greater long bone lengths (Roche 1986). Females experience their postcranial growth spurt earlier than males, which leads to earlier epiphyseal closures in the long bones and cessation of long bone growth in

length (Roche 1986). Although sexual dimorphism in long bone diameters has not previously been a focus, Humphrey's (1998) results appear to be the most promising. Long bone diameters are easy to measure and a long bone shaft is likely to be found in the forensic setting.

Chapter 2

Materials

This study utilized the Luís Lopes collection, housed at the National Museum of Natural History in Lisbon, Portugal. The individuals in the collection were taken from 3 cemeteries located throughout Lisbon. The following information is based on the work of Cardoso (2005, 2006), who researched the collection for his dissertation. In Lisbon, deceased individuals are commonly placed in temporary graves for 5 years or until skeletonization is complete. After the legally mandated 5 year period, the remains are exhumed from the temporary grave and placed in an ossuary. Relatives of the deceased must pay an annual fee for the remains to stay in the ossuary or pay a large fee for a 50 year period. If relatives do not pay this fee, cease payment, or remains are never claimed, the remains are either placed in a communal grave or cremated. In 1981, the National Museum of Natural History began collecting the remains designated for incineration or internment in a communal grave. Along with collecting the remains of individuals, the museum began compiling biographical information. The information was collected by using coffin plate numbers, grave numbers, and the cemetery registry. Cemetery records provided the following information: cemetery record number, name of the individual, parent's name, birthplace, marital status, occupation, address, age at death, cause of death, parish where the death took place, date and hour of death, date and hour of burial, grave number, ossuary number where the 2nd internment took place (if families were able to pay this fee for a certain amount of time, but ceased payment), and occasionally the hospital in which the death took place.

The collection is comprised of 1,692 individuals, but only 699 are fully documented (name, age, sex, birthplace, occupation, date and cause of death) and are therefore available

for study (Cardoso 2006). Of the 699 individuals available for study, 330 are females >20 years old, 43 are females <20 years old, 277 are males >20 years old, and 49 are males <20 years old. The majority of these individuals are Portuguese nationals who lived from 1805 to 1975 and are of low to middle socioeconomic status. Thirty percent of the males in the collection were in service or sales occupations, and 23% were either skilled workers, craftsmen, or something similar. Eighty-five percent of the females in the collection were classified as *doméstica*, which means housewife. Other occupations for women included student, teacher and maid.

Several categories of individual occur in low frequency or are not found in the collection at all. Wealthy individuals did not make it into the collection because they were more likely to be able to afford the high cost of permanent burials or the fees for the secondary internment (Cardoso 2005). However, a few persons of higher class status did make it into the collection. The occupations of these upper class individuals included teachers, students, priests, and engineers. Also, the very poor did not make it into the collection because the families of very poor individuals were not likely to have been able to afford the cost of the temporary burial. Most likely, the poorest individuals were placed directly into the communal grave upon death. The low frequency of subadults in the collection is attributed to the high incidence of direct internment of stillbirths and infants into the communal graves from 1875 to the early 20th century. It can also be attributed to the belief of cemetery workers that infant material is difficult to recover from the temporary graves, which may have led cemetery workers to be less vigilant in their recovery of the remains during exhumation.

The number of adult individuals from the Luís Lopes collection used for this study includes 99 males (18 to 56 years old) and 105 females (18-59 years old). Age frequencies for the adults are listed in Table 1. The subadult sample used in this study includes 40 males and 32 females aged from birth to 17 years of age. Age frequencies for subadults are listed in Table 2. The majority of the adults in this sample died from problems associated with the circulatory system (stroke, arteriosclerosis ~33%), respiratory system, cancer (13%) or tuberculosis (15%) (Cardoso 2006). Although tuberculosis was listed as the cause of death for 15% of the entire collection, it was found to be the cause of death for ~30% of the adults and ~31% of the subadults used in this study. Other causes of death for subadults included problems associated with the respiratory and circulatory systems.

Other materials used for this study included digital calipers manufactured by Swiss Precision Instruments, a tape measure manufactured by Paleo-Tech Concepts, and an osteometric board. Biographical information for the individuals used by this study was made available by the National Museum of Natural History in Lisbon, Portugal.

Table 1. Age and Sex Frequency in Adults

Age in years	# of females	# of males
18	4	2
19	2	2
20	3	5
21	4	4
22	2	0
23	4	4
24	3	0
25	4	2
26	3	4
27	2	2
28	3	2
29	1	1
30	0	6
31	0	4
32	6	1
33	2	2
34	1	1
35	4	3
36	0	0
37	0	1
38	0	1
39	2	2
40	1	2
41	1	1
42	2	2
43	1	3
44	3	1
45	2	5
46	3	0
47	2	4
48	3	2
49	0	5
50	5	6
51	3	3
52	8	3
53	6	4
54	8	6
55	3	2
56	0	1
57	1	0
58	2	0
59	1	0
Total	105	99

Table 2. Age and Sex Frequency in Subadults

Age in Years	# of females	# of males
.003	1	0
.008	0	1
.08	1	0
.21	0	1
.33	1	0
.42	1	0
1	1	5
1.17	0	1
1.33	0	1
1.67	1	0
1.92	1	0
2	1	5
2.08	1	0
3	2	0
4	3	3
5	2	1
6	1	1
7	0	1
8	0	1
9	2	1
10	2	1
11	2	2
12	1	1
13	1	1
14	1	3
15	3	2
16	2	5
17	1	3
Total	32	40

Chapter 3

Data collection Methods

Most adult bone measurements were measured to the nearest .01mm with digital calipers. Circumferences were taken to the nearest .1mm using a measuring tape. An osteometric board was employed to measure the clavicle lengths to the nearest .1 mm. Long bone lengths were also measured with an osteometric board to estimate the midshaft length. Table 3 lists the adult measurements used in this study. All measurements were taken according to the definitions listed in *Standards for Data Collection from Human Skeletal Remains* by Buiskstra and Ubelaker (1994). An effort was made to consistently measure the bones from the left side of the body. However, the right side was substituted whenever the left side was damaged or missing. If both the left and the right bones were damaged, the measurement was excluded from the suite of measurements available for that individual. Measurements were also excluded if the bone appeared abnormal due to poorly healed trauma or disease. Most individuals are missing at least one measurement, if not several measurements.

Subadult measurements were also taken with digital calipers, a measuring tape, and an osteometric board. The osteometric board was used to measure clavicle lengths in older subadults, as well as to measure long bone lengths for midshaft length estimation. Measurements using the osteometric board were taken to the nearest .1mm. Circumferences were taken to the nearest .1mm with a measuring tape. All other measurements were taken with digital calipers and were measured to the nearest .01mm. Table 4 is a list of the subadult measurements used in this study. All measurements were taken according to definitions listed in *Standards for Data Collection from Human Skeletal Remains* by Buiskstra and Ubelaker

Table 3. List of Adult Measurements

Measurement	Instrument
1. Maximum Clavicle Length	Osteometric board
2. Sagittal Diameter of the Clavicle at midshaft	Digital calipers
3. Vertical Diameter of the Clavicle at midshaft	Digital calipers
4. Circumference of the Clavicle at midshaft	Measuring tape
5. Maximum Glenoid Cavity Breadth	Digital Calipers
6. Maximum Diameter of the Humerus at midshaft	Digital Calipers
7. Minimum Diameter of the Humerus at midshaft	Digital Calipers
8. Circumference of the Humerus at midshaft	Measuring Tape
9. Epicondylar Breadth of the Humerus	Digital Calipers
10. Transverse Diameter of the Radius at midshaft	Digital Calipers
11. Sagittal Diameter of the Radius at midshaft	Digital Calipers
12. Circumference of the Radius at midshaft	Measuring Tape
13. Dorso-volar Diameter of the Ulna	Digital Calipers
14. Transverse Diameter of the Ulna	Digital Calipers
15. Minimum Circumference of the Ulna	Digital Calipers
16. Anterior-posterior Diameter of the Femur at midshaft	Digital Calipers
17. Transverse Diameter of the Femur at midshaft	Digital Calipers
18. Circumference of the Femur at midshaft	Measuring Tape
19. Epicondylar Breadth of the Femur	Digital Calipers
20. Maximum Diameter of the Tibia at the Nutrient Foramen	Digital Calipers
21. Minimum Diameter of the Tibia at the Nutrient Foramen	Digital Calipers
22. Circumference of the Tibia at the Nutrient Foramen	Measuring Tape
23. Maximum Epiphysis Breadth of the Proximal Tibia	Digital Calipers
24. Maximum Diameter of the Fibula at midshaft	Digital Calipers
25. Minimum Diameter of the Fibula at midshaft	Digital Calipers
26. Circumference of the Fibula at midshaft	Measuring Tape

Table 4. List of Subadult Measurements

Measurement	Instrument
1. Maximum Clavicle Length	Osteometric board* or digital calipers
2. Maximum Diameter of the Clavicle at midshaft	Digital calipers
3. Minimum Diameter of the Clavicle at midshaft	Digital calipers
4. Circumference of the Clavicle at midshaft	Measuring tape
5. Maximum Glenoid Cavity Breadth	Digital Calipers
6. Maximum Diameter of the Humerus at midshaft	Digital Calipers
7. Minimum Diameter of the Humerus at midshaft	Digital Calipers
8. Circumference of the Humerus at midshaft	Measuring Tape
9. Maximum Breadth of the Distal Humerus	Digital Calipers
10. Maximum Diameter of the Radius at midshaft	Digital Calipers
11. Minimum Diameter of the Radius at midshaft	Digital Calipers
12. Circumference of the Radius at midshaft	Measuring Tape
13. Maximum Diameter of the Ulna at midshaft	Digital Calipers
14. Minimum Diameter of the Ulna at midshaft	Digital Calipers
15. Circumference of the Ulna at midshaft	Digital Calipers
16. Maximum Diameter of the Femur at midshaft	Digital Calipers
17. Minimum Diameter of the Femur at midshaft	Digital Calipers
18. Circumference of the Femur at midshaft	Measuring Tape
19. Maximum Breadth of the Distal Femur	Digital Calipers
20. Maximum Diameter of the Tibia at midshaft	Digital Calipers
21. Minimum Diameter of the Tibia at midshaft	Digital Calipers
22. Circumference of the Tibia at midshaft	Measuring Tape
23. Maximum Breadth of the Proximal Tibia	Digital Calipers
24. Maximum Diameter of the Fibula at midshaft	Digital Calipers
25. Minimum Diameter of the Fibula at midshaft	Digital Calipers
26. Circumference of the Fibula at midshaft	Measuring Tape

*used on older individuals

(1994). Following the methods used on the adult sample, an effort was made to consistently measure the left side of the body. If the left side was damaged or missing, the right counterpart was substituted. In many cases, several measurements per individual were excluded because of damaged or missing bones.

Statistical Methods

Prior to analysis, all adult bone measurements were tested for normality to determine whether the normality assumption for the following analyses was satisfied. After testing for normality, the measurements were divided into groups based on the bone from which the measurements were taken. The seven groups that were produced included clavicle measurements, humerus measurements (including max. glenoid cavity breadth), ulna measurements, radius measurements, femur measurements, tibia measurements, and fibula measurements (Table 5). A Multivariate Analysis of Covariance (MANCOVA) was performed on each of the 7 groups using the statistical software SPSS 16.0 for Windows (2007) to test whether sex was a significant variable in the models. Age was used as a covariate in the MANCOVAs to evaluate whether age affected the size of each measurement. Differences were considered significant if the p-value was $\leq .05$. Tests of between-subjects effects (univariate F-tests) were also examined to assess which measurements exhibited significant sex and age differences.

Each adult measurement was ranked in terms of degree of sexual dimorphism. The index of sexual dimorphism developed by Bennett (1981) was used to rank the measurements. The proportion of the non-overlapping male-female area underneath the normal cumulative curve was calculated for each measurement. The z statistic was calculated by using the following equation: $(\bar{x}_m - \bar{x}_f) / (sd_m + sd_f)$. Then the Normal Cumulative

Table 5. List of Adult Measurements by Group Number

Measurement	Group #
Maximum Clavicle Length	Group 1
Sagittal Diameter of the Clavicle at midshaft	Group 1
Vertical Diameter of the Clavicle at midshaft	Group 1
Circumference of the Clavicle at midshaft	Group 1
Maximum Glenoid Cavity Breadth	Group 2
Maximum Diameter of the Humerus at midshaft	Group 2
Minimum Diameter of the Humerus at midshaft	Group 2
Circumference of the Humerus at midshaft	Group 2
Epicondylar Breadth of the Humerus	Group 2
Transverse Diameter of the Radius at midshaft	Group 3
Sagittal Diameter of the Radius at midshaft	Group 3
Circumference of the Radius at midshaft	Group 3
Dorso-volar Diameter of the Ulna	Group 4
Transverse Diameter of the Ulna	Group 4
Minimum Circumference of the Ulna	Group 4
Anterior-Posterior Diameter of the Femur at midshaft	Group 5
Transverse Diameter of the Femur at midshaft	Group 5
Circumference of the Femur at midshaft	Group 5
Epicondylar Breadth of the Femur	Group 5
Maximum Diameter of the Tibia at the Nutrient Foramen	Group 6
Minimum Diameter of the Tibia at the Nutrient Foramen	Group 6
Circumference of the Tibia at the Nutrient Foramen	Group 6
Maximum Epiphysis Breadth of the Proximal Tibia	Group 6
Maximum Diameter of the Fibula at midshaft	Group 7
Minimum Diameter of the Fibula at midshaft	Group 7
Circumference of the Fibula at midshaft	Group 7

Distribution Table was consulted to find the area using the value of the z statistic. The area represents the proportion of the population that would be correctly classified using the measurement. Therefore, the measurements with the greatest areas were the highest ranking and therefore the most sexually dimorphic. Measurements with equal areas were given equal ranks.

Logistic regressions were performed on the adult data to determine the probability of classifying an adult into the correct sex group based on the applied model. Separate logistic regressions were performed on models constructed from each group of measurements. A final logistic regression was carried out using all adult measurements. Variable selection was accomplished by the backward stepwise procedure. Entry into the model required a significance value of $\leq .05$ and variable removal required a significance value greater than .10.

Subadult data was divided into two age groups in order to decrease the age range of the sample and also to decrease the amount of the size variance due to age. The young subadult age group included individuals ≤ 11 years old, and the older subadult age group included individuals that were ≥ 12 years old. Prior to analysis, the normality of the data from both subadult groups was assessed to determine if the normality assumption for the MANCOVA tests was satisfied. Following normality testing, the measurements were divided into 7 groups, using the same criterion that was used to divide the adult measurements (Table 6).

MANCOVA tests were performed on models constructed from each of the 7 groups of measurements to evaluate whether sex was a significant variable in the models. Age and age² were used as covariates in all subadult models to decrease the amount of size variance

Table 6. List of Subadult Measurements by Group Number

Measurement	Group #
Maximum Clavicle Length	Group 1
Maximum Diameter of the Clavicle at midshaft	Group 1
Minimum Diameter of the Clavicle at midshaft	Group 1
Circumference of the Clavicle at midshaft	Group 1
Maximum Glenoid Cavity Breadth	Group 2
Maximum Diameter of the Humerus at midshaft	Group 2
Minimum Diameter of the Humerus at midshaft	Group 2
Circumference of the Humerus at midshaft	Group 2
Maximum Breadth of the Distal Humerus	Group 2
Maximum Diameter of the Radius at midshaft	Group 3
Minimum Diameter of the Radius at midshaft	Group 3
Circumference of the Radius at midshaft	Group 3
Maximum Diameter of the Ulna at midshaft	Group 4
Minimum Diameter of the Ulna at midshaft	Group 4
Circumference of the Ulna at midshaft	Group 4
Maximum Diameter of the Femur at midshaft	Group 5
Minimum Diameter of the Femur at midshaft	Group 5
Circumference of the Femur at midshaft	Group 5
Maximum Breadth of the Distal Femur	Group 5
Maximum Diameter of the Tibia at midshaft	Group 6
Minimum Diameter of the Tibia at midshaft	Group 6
Circumference of the Tibia at midshaft	Group 6
Maximum Breadth of the Proximal Tibia	Group 6
Maximum Diameter of the Fibula at midshaft	Group 7
Minimum Diameter of the Fibula at midshaft	Group 7
Circumference of the Fibula at midshaft	Group 7

due to age differences. A quadratic model was deemed appropriate after examining curve estimation plots and R^2 statistics for quadratic and linear models of each measurement. Sex was considered a statistically significant variable if the p-value was $\leq .05$. Univariate F-tests of the variables in each model were examined to determine which measurements were significantly sexually dimorphic. If sex was not a significant variable in the model, a Bonferroni correction was used to assess the significance of the univariate F-tests. The statistical software SPSS 16.0 for Windows (2007) was employed for this analysis.

Logistic regressions were also run on each subadult model to determine the probability of correctly predicting sex. The backward stepwise procedure was used for variable selection. A significance value of $\leq .05$ was required for entry into model. Removing a variable required a significance value of $> .10$. All statistical analyses were carried out using the statistical software program SPSS 16.0 for Windows (2007).

Chapter 4

Results

Adult Results

The normality of each measurement was examined to ensure that the assumptions of the multivariate analysis of covariance (MANCOVA) were satisfied. A Shapiro-Wilks test was performed on all adult measurements to assess normality. The values of all Shapiro-Wilks' statistics were $\geq .96$ (Table 7). Some probabilities were below the value of .05, but the Shapiro-Wilks test is very sensitive to skewness and kurtosis in large sample sizes.

Therefore, all data was considered normal.

MANCOVA Tests of the Adult Data

A MANCOVA was performed on models constructed from each group of measurements. All MANCOVA results for the adults appear in Table 8. As mentioned previously, the measurements were grouped by the bone on which they were taken, except for glenoid cavity breadth which was grouped with the humerus measurements. The following results will be referred to by the Group number of the measurements. (The list of measurements by group can be found in Table 5). Age was used as a covariate in all models. MANCOVA testing revealed that sex was a significant variable in all models constructed from the adult data. Univariate F-tests found significant sexual dimorphism in every measurement. These results will be discussed in detail in the following section.

MANCOVA testing of the model containing Group 1 (clavicle) measurements revealed that sex was a significant variable ($P=.000$) and age was a significant covariate ($P=.005$). After accounting for age, all clavicle measurements remained significantly ($P=.000$) sexually dimorphic (Table 9). Tests of between-subject effects showed that age was

Table 7. Adult Normality Results

Measurement	Shapiro-Wilks Statistic	p-value
1. Maximum Clavicle Length	.993	.545
2. Sagittal Diameter of the Clavicle at midshaft	.986	.053
3. Vertical Diameter of the Clavicle at midshaft	.960	.000
4. Circumference of the Clavicle at midshaft	.980	.007
5. Maximum Glenoid Cavity Breadth	.981	.010
6. Maximum Diameter of the Humerus at midshaft	.989	.150
7. Minimum Diameter of the Humerus at midshaft	.990	.204
8. Circumference of the Humerus at midshaft	.991	.285
9. Epicondylar Breadth of the Humerus	.988	.140
10. Transverse Diameter of the Radius at midshaft	.986	.046
11. Sagittal Diameter of the Radius at midshaft	.984	.021
12. Circumference of the Radius at midshaft	.984	.025
13. Dorso-volar Diameter of the Ulna	.974	.001
14. Transverse Diameter of the Ulna	.995	.448
15. Minimum Circumference of the Ulna	.987	.074
16. Anterior-Posterior Diameter of the Femur at midshaft	.999	.593
17. Transverse Diameter of the Femur at midshaft	.992	.314
18. Circumference of the Femur at midshaft	.988	.078
19. Epicondylar Breadth of the Femur	.967	.000
20. Maximum Diameter of the Tibia at the Nutrient Foramen	.992	.305
21. Minimum Diameter of the Tibia at the Nutrient Foramen	.988	.087
22. Circumference of the Tibia at the Nutrient Foramen	.995	.767
23. Maximum Epiphysis Breadth of the proximal Tibia	.979	.006
24. Maximum Diameter of the Fibula at midshaft	.990	.170
25. Minimum Diameter of the Fibula at midshaft	.990	.161
26. Circumference of the Fibula at midshaft	.987	.071

Table 8. Adult: Multivariate Tests^b

Measurement Group	Effect		Value	F	Hypothesis df	Error df	Sig.
Group 1	Intercept	Wilks' Lambda	.031	1.416E3	4.000	184.000	.000
	Age	Wilks' Lambda	.923	3.824 ^a	4.000	184.000	.005
	Sex	Wilks' Lambda	.472	51.385 ^a	4.000	184.000	.000
Group 2	Intercept	Wilks' Lambda	.036	8.467E2	5.000	158.000	.000
	Age	Wilks' Lambda	.886	4.082 ^a	5.000	158.000	.002
	Sex	Wilks' Lambda	.396	48.178 ^a	5.000	158.000	.000
Group 3	Intercept	Wilks' Lambda	.059	1.030E3	3.000	193.000	.000
	Age	Wilks' Lambda	.937	4.348 ^a	3.000	193.000	.005
	Sex	Wilks' Lambda	.508	62.287 ^a	3.000	193.000	.000
Group 4	Intercept	Wilks' Lambda	.070	8.450E2	3.000	190.000	.000
	Age	Wilks' Lambda	.861	10.228 ^a	3.000	190.000	.000
	Sex	Wilks' Lambda	.462	73.779 ^a	3.000	190.000	.000
Group 5	Intercept	Wilks' Lambda	.025	1.855E3	4.000	189.000	.000
	Age	Wilks' Lambda	.810	11.115 ^a	4.000	189.000	.000
	Sex	Wilks' Lambda	.418	65.705 ^a	4.000	189.000	.000
Group 6	Intercept	Wilks' Lambda	.027	1.643E3	4.000	179.000	.000
	Age	Wilks' Lambda	.936	3.043 ^a	4.000	179.000	.019
	Sex	Wilks' Lambda	.399	67.301 ^a	4.000	179.000	.000
Group 7	Intercept	Wilks' Lambda	.081	7.240E2	3.000	192.000	.000
	Age	Wilks' Lambda	.967	2.162 ^a	3.000	192.000	.094
	Sex	Wilks' Lambda	.769	19.277 ^a	3.000	192.000	.000
a. Exact statistic							
b. Design: Intercept + Age + Sex							

Table 9. Adult: Group 1 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Age	Max. Clavicle Length	112.244	1	112.244	1.490	.224
	Sag. Dia. of the Clavicle	.116	1	.116	.077	.781
	Vert. Dia. of the Clavicle	12.225	1	12.225	9.976	.002
	Circ. of the Clavicle	18.061	1	18.061	1.797	.182
Sex	Max. Clavicle Length	8627.318	1	8627.318	114.554	.000
	Sag. Dia. of the Clavicle	153.668	1	153.668	102.538	.000
	Vert. Dia. of the Clavicle	121.066	1	121.066	98.791	.000
	Circ. of the Clavicle	1263.149	1	1263.149	125.650	.000
Further information is found in Table 9A, in the Appendix.						

only a significant covariate ($P=.002$) for the vertical diameter of the clavicle (Table 9). Pearson correlations were calculated for all Group 1 measurements to determine which clavicle measurements were significantly correlated with age (Table 10). Again, the vertical diameter of clavicle was the only measurement significantly ($P=.013$) correlated with age. The Pearson correlation coefficient of the vertical diameter of the clavicle was used to calculate the coefficient of determination. The coefficient of determination indicated that 3% of the variation in the vertical diameter of the clavicle could be explained by age differences.

Sex ($P=.000$) and age ($P=.002$) were significant variables in the model containing Group 2 (humerus measurements including glenoid cavity breadth) measurements . After accounting for age, all measurements continued to be significantly different ($P=.000$) between the sexes (Table 11). The analysis also indicated that age was a significant covariate for maximum glenoid cavity breadth ($P=.004$), maximum diameter of the humerus ($P=.000$), and circumference of the humerus ($P=.001$). Further testing confirmed that age was significantly correlated with glenoid cavity breadth ($P=.033$), maximum diameter ($P=.000$), and circumference ($P=.004$) of the humerus at midshaft (Table 12). The coefficients of determination calculated for each measurement indicated that age accounted for ~2% of the size variation in glenoid cavity breadth and ~4% of the variation in circumference of the humerus. However, age differences were responsible for ~7% of the size variation in the maximum diameter of the humerus.

Sex ($P=.000$) and age ($P=.005$) were significant variables in the Group 3 model. Table 13 displays the results for the tests of between-subjects effects. After accounting for age, sex differences remained significant for all radius measurements ($P=.000$). Univariate F-tests indicated that age was a significant covariate for the sagittal diameter ($P=.000$) and the

Table 10. Adult: Group 1 Correlations

		Age	Max. Clavicle Length	Sag. Dia. of the Clavicle	Vert. Dia. of the Clavicle	Circ. of the Clavicle
Age	Pearson Correlation	1.000	-.087	-.034	.176*	.060
	Sig. (2-tailed)		.230	.638	.013	.404
	N	204.000	191	196	197	197

*. Correlation is significant at the 0.05 level (2-tailed).
Further information is found in Table 10A, in the Appendix.

Table 11. Adult: Group 2 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Age	Max. breadth of the Glenoid Cavity	26.779	1	26.779	8.366	.004
	Max. Dia. of the Humerus	40.943	1	40.943	16.393	.000
	Min. Dia. of the Humerus	4.232	1	4.232	2.365	.126
	Circ. of the Humerus	194.877	1	194.877	10.703	.001
	Epicondylar Breadth o f the Humerus	45.308	1	45.308	3.620	.059
Sex	Max. breadth of the Glenoid Cavity	553.324	1	553.324	172.855	.000
	Max. Dia. of the Humerus	227.976	1	227.976	91.277	.000
	Min. Dia. of the Humerus	266.185	1	266.185	148.776	.000
	Circ. of the Humerus	2237.915	1	2237.915	122.907	.000
	Epicondylar Breadth o f the Humerus	2219.535	1	2219.535	177.346	.000

Further information is found in Table 11A, in the Appendix.

Table 12. Adult Group 2 Correlations

		Age	Max. Glenoid Cavity Breadth	Max. Dia. of the Humerus	Min. Dia. of the Humerus	Circ. of the Humerus	Epicondylar Breadth of the Humerus
Age	Pearson Correlation	1.000	.153*	.255**	.114	.203**	.075
	Sig. (2-tailed)		.033	.000	.111	.004	.331
	N	204.000	193	197	197	197	172
*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). Further information is found in Table 12A, in the Appendix.							

Table 13. Adult Group 3 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Age	Tran. Dia. of the Radius	5.050	1	5.050	2.921	.089
	Sag. Dia. of the Radius	10.713	1	10.713	12.760	.000
	Circ. of the Radius	67.380	1	67.380	7.545	.007
Sex	Tran. Dia. of the Radius	131.432	1	131.432	76.024	.000
	Sag. Dia. of the Radius	152.407	1	152.407	181.530	.000
	Circ. of the Radius	1230.901	1	1230.901	137.834	.000
Further information is found in Table 13A, in the Appendix.						

circumference ($P=.007$) of the radius. The Pearson correlations calculated for all radius measurements (Table 14) confirmed that the sagittal diameter of the radius was significantly ($P=.019$) correlated with age, but the tests also revealed that the circumference of the radius was not ($P=.058$) significantly correlated with age. The coefficient of determination indicated that age differences only accounted for ~3% of the size variation in the sagittal diameter of the radius.

Age ($P=.000$) and sex ($P=.000$) were significant variables in the Group 4 model. After accounting for age, sex differences for all ulna measurements remained significant ($P=.000$) (Table 15). Age was only a significant covariate for the minimum circumference of the ulna ($P=.001$) and dorso-volar diameter of the ulna ($P=.038$). Pearson correlations for all ulna measurements are given in Table 16. Age was significantly correlated ($P=.039$) with minimum circumference of the ulna, but not the dorso-volar diameter of the ulna ($P=.213$). The coefficient of determination for the minimum circumference revealed that age only accounted for ~2% of the variation in that measurement.

Age was a significant covariate ($P=.000$) in the Group 5 model. After accounting for age differences, sex continued to be a statistically significant ($P=.000$) variable. Univariate F-tests of the variables in the model indicated that age had a significant effect on the transverse diameter ($P=.000$) and circumference of the femur ($P=.002$) (Table 17). After accounting for age effects, significant sex differences remained present for all femur measurements ($P=.000$). Pearson correlations were calculated to examine the correlation of age with the other femur measurements. The correlation matrix is presented in Table 18. Age was significantly correlated with the circumference ($P=.018$) and transverse diameter ($P=.000$) of

Table 14. Adult: Group 3 Correlations

		Age	Tran. Dia. of the Radius	Sag. Dia. of the Radius	Circ. of the Radius
Age	Pearson Correlation	1.000	.092	.166*	.135
	Sig. (2-tailed)		.200	.019	.058
	N	204.000	198	198	198
*. Correlation is significant at the 0.05 level (2-tailed). Further information is found in Table 14A, in the Appendix.					

Table 15. Adult: Group 4 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Age	Tran. Dia. of the Ulna	5.621	1	5.621	3.341	.069
	Dorso-Volar Dia. of the Ulna	5.700	1	5.700	4.372	.038
	Min. Circ. of the Ulna	140.198	1	140.198	11.816	.001
Sex	Tran. Dia. of the Ulna	317.797	1	317.797	188.856	.000
	Dorso-Volar Dia. of the Ulna	222.152	1	222.152	170.378	.000
	Min. Circ. of the Ulna	2544.692	1	2544.692	214.463	.000
Further information is found in Table 15A, in the Appendix.						

Table 16. Adult: Group 4 Correlations

		Age	Tran. Dia. of the Ulna	Dorso-Volar Dia. of the Ulna	Min. Circ. of the Ulna
Age	Pearson Correlation	1.000	.073	.090	.148*
	Sig. (2-tailed)		.311	.213	.039
	N	204.000	195	195	195
*. Correlation is significant at the 0.05 level (2-tailed). Further information is found in Table 16A, in the Appendix.					

Table 17. Adult: Group 5 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Age	Anterio-Posterior Dia. of the Femur	12.838	1	12.838	2.438	.120
	Tran. Dia. of the Femur	122.743	1	122.743	31.905	.000
	Circ. of the Femur	286.202	1	286.202	9.761	.002
	Epicondylar Breadth of the Femur	13.673	1	13.673	.932	.336
Sex	Anterio-Posterior Dia. of the Femur	492.016	1	492.016	93.449	.000
	Tran. Dia. of the Femur	276.334	1	276.334	71.828	.000
	Circ. of the Femur	3639.323	1	3639.323	124.118	.000
	Epicondylar Breadth of the Femur	3828.751	1	3828.751	260.983	.000
Further information is found in Table 17A, in the Appendix.						

Table 18. Adult: Group 5 Correlations

		Age	Anterio-Posterior Dia. of the Femur	Tran. Dia. of the Femur	Circ. of the Femur	Epicondylar Breadth of the Femur
Age	Pearson Correlation	1.000	.086	.321**	.166*	.030
	Sig. (2-tailed)		.225	.000	.018	.672
	N	204.000	203	203	203	195
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Further information is found in Table 18A, in the Appendix.						

the femur at the midshaft. As indicated by the coefficients of determination, age accounted for ~10% of the variation in the transverse diameter of the femur and ~3% of the variation in the circumference of the femur.

Age ($P=.019$) and sex ($P=.000$) were significant variables in the Group 6 model. Age significantly affected maximum diameter of the tibia at the nutrient foramen ($P=.032$) and maximum epiphysis breadth of the proximal tibia ($P=.042$) (Table 19). However, none of the tibia measurements were significantly correlated with age. All tibia measurements were significantly ($P=.000$) sexually dimorphic.

Sex was a significant ($P=.000$) variable in the Group 7 model, but age was not ($P=.094$). Between-subject tests for the Group 7 measurements also reaffirmed that age was not a significant factor in any of the fibula measurements (Table 20). Significant sexual dimorphism ($P=.000$) was detected in all of the fibula measurements.

Ranks of the Adult Measurements

Each measurement was ranked according to Bennett's (1981) index of sexual dimorphism. Measurements were ranked from 1 to 22, with 1 being the most sexually dimorphic and the 22 being the least. If the areas calculated for each measurement were equal, the measurements were given equal rank. The ranks and the areas for each measurement are given in Table 21. In general, measurements of the maximum breadth of articular surfaces gained the highest ranks, while circumference measurements achieved mediocre ranks. Fibula measurements were the lowest ranking.

Logistic Regression of the Adult Data

Logistic regressions were performed on the same 7 models that underwent MANCOVA testing. In each regression, sex was the dependent variable. Females were

Table 19. Adult: Group 6 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Age	Max Dia. of the Tibia at the Nutrient Foramen	34.451	1	34.451	4.663	.032
	Tran. Dia. of the Tibia at the Nutrient Foramen	.000	1	.000	.000	.995
	Circ. of the Tibia at the Nutrient Foramen	41.250	1	41.250	.862	.355
	Max. Epiphysis Breadth of the Proximal Tibia	53.596	1	53.596	4.196	.042
Sex	Max Dia. of the Tibia at the Nutrient Foramen	1211.686	1	1211.686	163.995	.000
	Tran. Dia. of the Tibia at the Nutrient Foramen	464.906	1	464.906	86.156	.000
	Circ. of the Tibia at the Nutrient Foramen	7299.541	1	7299.541	152.474	.000
	Max. Epiphysis Breadth of the Proximal Tibia	3095.217	1	3095.217	242.311	.000
Further information is found in Table 19A, in the Appendix.						

Table 20. Adult: Group 7 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Age	Max. Dia. of the Fibula	.006	1	.006	.002	.960
	Min. Dia. of the Fibula	2.411	1	2.411	1.572	.211
	Cir. of the Fibula	16.347	1	16.347	1.230	.269
Sex	Max. Dia. of the Fibula	69.086	1	69.086	30.461	.000
	Min. Dia. of the Fibula	76.016	1	76.016	49.568	.000
	Cir. of the Fibula	678.399	1	678.399	51.066	.000
Further information is found in Table 20A, in the Appendix.						

Table 21. Ranking of Measurements by Degree of Sexual Dimorphism

Measurement	Males			Females				
	N	Mean	S. D.	N	Mean	S. D.	Area	Rank
Epicondylar Breadth of the Femur	93	79.83	4.20	102	70.97	3.46	.8770	1
Maximum Epiphysis Breadth of the Proximal Tibia	91	74.23	3.73	94	66.02	3.48	.8729	2
Epicondylar Breadth of the Humerus	77	58.84	3.48	88	51.53	3.64	.8485	3
Minimum Circumference of the Ulna	94	46.50	3.89	101	39.32	3.18	.8461	4
Maximum Glenoid Cavity Breadth	77	26.72	1.67	88	23.08	1.96	.8413	5
Transverse Diameter of the Ulna	94	16.33	1.38	101	13.78	1.23	.8365	6
Minimum Diameter of the Humerus at midshaft	77	17.42	1.42	88	14.88	1.27	.8264	7
Maximum Diameter of the Tibia at the Nutrient Foramen	91	35.26	2.74	94	30.12	2.75	.8264	7
Sagittal Diameter of the Radius at midshaft	97	11.42	1.06	101	9.67	.81	.8238	8
Dorso-volar Diameter of the Ulna	94	12.28	1.30	101	10.15	1.00	.8238	8
Circumference of the Tibia at the Nutrient Foramen	91	94.73	7.18	94	82.14	6.65	.8186	9
Circumference of the Humerus at midshaft	77	63.43	4.44	88	56.13	4.35	.7967	10
Circumference of the Radius at midshaft	97	42.06	3.09	101	37.09	2.99	.7939	11
Circumference of the Clavicle at midshaft	91	35.98	3.16	99	30.83	3.20	.7910	12
Maximum Clavicle Length	91	147.97	8.56	99	134.43	8.81	.7823	13
Circumference of the Femur at midshaft	93	86.62	5.70	102	78.02	5.38	.7823	13
Sagittal Diameter of the Clavicle at midshaft	91	12.31	1.31	99	10.51	1.14	.7704	14
Vertical Diameter of the Clavicle at midshaft	91	9.61	1.34	99	8.03	.90	.7611	15
Maximum Diameter of the Humerus at midshaft	77	21.68	1.72	88	19.36	1.59	.7580	16
Anterior-Posterior Diameter of the Femur at midshaft	93	28.91	2.29	102	25.74	2.32	.7549	17
Minimum Diameter of the Tibia at the Nutrient Foramen	91	24.68	2.47	94	21.51	2.16	.7549	17
Transverse Diameter of the Radius at midshaft	97	14.81	1.37	101	13.19	1.27	.7291	18
Transverse Diameter of the Femur at midshaft	93	26.56	2.15	102	24.21	2.08	.7123	19
Circumference of the Fibula at midshaft	94	42.00	3.58	103	38.31	3.70	.6950	20
Minimum Diameter of the Fibula at midshaft	94	10.94	1.31	103	9.71	1.17	.6915	21
Maximum Diameter of the Fibula at midshaft	94	14.50	1.41	103	13.31	1.58	.6554	22

defined as equal to 0 and males were defined as equal to 1. The backward stepwise selection procedure was used to select variables. Details of the results of each logistic regression are provided in the following section.

The final model chosen from the Group 1 measurements by logistic regression accurately predicted the sex of 87.4% of the adult sample (Table 22). This model included maximum length, sagittal diameter, and vertical diameter of the clavicle. Details regarding the variables entered in other steps of the regression can be found in Table 23.

The final model selected from the Group 2 measurements accurately classified 88.5% of the sample (Table 24). The variables in the final model included glenoid cavity breadth ($P=.086$), minimum diameter of the humerus ($P=.005$), and epicondylar breadth of the humerus ($P=.001$). Table 25 shows the variables in the final model.

Table 22. Adult: Group 1 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	88	11	88.9
	M	13	78	85.7
	Overall Percentage			87.4
Further information is in Table 22A, in the Appendix				

Table 23. Adult: Group 1 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Max. Clav. Length	.121	.030	16.585	1	.000	1.128
	Sag. Dia. of the Clavicle	.711	.196	13.145	1	.000	2.037
	Vert. Dia. of the Clavicle	.823	.209	15.484	1	.000	2.276
	Constant	-32.445	4.765	46.362	1	.000	.000
a. Variable(s) entered on step 1: Max. Clav. Length, Sag. Dia. of the Clavicle, Vert. Dia. of the Clavicle, Circ. of the Clavicle. b. The cut value is .500 Further information is in Table 23A, in the Appendix.							

Table 24. Adult: Group 2 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	79	9	89.8
	M	10	67	87.0
	Overall Percentage			88.5
Further information is in Table 24A, in the Appendix.				

Table 25. Adult: Group 2 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Glenoid Cavity Breadth	.334	.194	2.947	1	.086	1.396
	Min. Dia. of the Humerus	.725	.257	7.975	1	.005	2.064
	Epicondylar Breadth of the Humerus	.296	.092	10.422	1	.001	1.344
	Constant	-36.456	5.428	45.109	1	.000	.000
a. Variable(s) entered on step 1: Glenoid Cavity Breadth, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Epicondylar Breadth of the Humerus. b. The cut value is .500 Further information is in Table 25A, in the Appendix.							

The final model selected from the Group 3 measurements accurately predicted the sex of 83.3% of the adult sample (Table 26). Predictive accuracy increased to 84.8% if all radius measurements were kept in the model. The only variable included in the final model was the sagittal diameter of the radius (Table 27).

The final model selected from the Group 4 measurements accurately classified 88.7% of the adult sample (Table 28). However, the most accurate model for predicting sex (89.2%) included all adult ulna measurements. The variables included in the final model were transverse and dorso-volar diameter of the ulna (Table 29).

The final model chosen from the Group 5 measurements accurately sexed 87.2% of the sample, but the most accurate model (89.2%) occurred in Step 2 of the regression (Table 30). The variables used in Step 2 included transverse diameter ($P=.304$), circumference ($P=.178$), and epicondylar breadth of the femur ($P=.000$) (Table 31). The only variable included in the final model was epicondylar breadth of the femur.

Table 26. Adult: Group 3 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 2	Sex	F	87	14	86.1
		M	16	81	83.5
		Overall Percentage			84.8
Final Model	Sex	F	85	16	84.2
		M	17	80	82.5
		Overall Percentage			83.3
Further information is in Table 26A, in the Appendix.					

Table 27. Adult: Group 3 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Sag. Dia. of the Radius	1.716	.374	21.044	1	.000	5.565
	Circ. of the Radius	.126	.097	1.663	1	.197	1.134
	Constant	-22.960	3.196	51.608	1	.000	.000
Final Model ^a	Sag. Dia. of the Radius	2.055	.282	52.937	1	.000	7.807
	Constant	-21.538	2.945	53.486	1	.000	.000
a. Variable(s) entered on step 1: Tran. Dia. of the Radius, Sag. Dia. of the Radius, Circ. of the Radius. b. The cut value is .500 Further information is found in Table 27A, in the Appendix.							

Table 28. Adult: Group 4 Classification Table

		Predicted Sex		
	Observed	F	M	Percentage Correct
Step 1	Sex			
	F	92	9	91.1
	M	12	82	87.2
	Overall Percentage			89.2
Final Model	Sex			
	F	92	9	91.1
	M	13	81	86.2
	Overall Percentage			88.7

Table 29. Adult: Group 4 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Tran. Dia. of the Ulna	1.336	.459	8.470	1	.004	3.802
	Dorso-Volar Dia. of the Ulna	.870	.385	5.101	1	.024	2.386
	Min. Circ. of the Ulna	-.016	.216	.006	1	.939	.984
	Constant	-29.027	4.211	47.509	1	.000	.000
Final Model ^a	Tran. Dia. of the Ulna	1.308	.279	21.935	1	.000	3.698
	Dorso-Volar Dia. of the Ulna	.848	.256	10.991	1	.001	2.334
	Constant	-29.069	4.178	48.416	1	.000	.000
a. Variable(s) entered on step 1: Tran. Dia. of the Ulna, Dorso-Volar Dia. of the Ulna, Min. Circ. of the Ulna. b. The cut value is .500							

Table 30. Adult: Group 5 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 2 Final Model	Sex	F	92	10	90.2
		M	11	82	88.2
		Overall Percentage			89.2
	Sex	F	92	10	90.2
		M	15	78	83.9
		Overall Percentage			87.2
Further information is in Table 30A, in the Appendix.					

Table 31. Adult: Group 5 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Tran. Dia. of the Femur	-.187	.182	1.056	1	.304	.829
	Circ. of the Femur	.103	.077	1.811	1	.178	1.109
	Epicondylar Breadth of the Femur	.461	.080	33.433	1	.000	1.586
	Constant	-38.482	5.073	57.548	1	.000	.000
Final Model ^a	Epicondylar Breadth of the Femur	.500	.066	58.099	1	.000	1.649
	Constant	-37.677	4.927	58.470	1	.000	.000
a. Variable(s) entered on step 1: Anterior-Posterior Dia. of the Femur, Tran. Dia. of the Femur, Circ. of the Femur, Epicondylar Breadth of the Femur. b. The cut value is .500 Further information is in Table 31A, in the Appendix.							

Table 32. Adult: Group 6 Classification Table

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 2	Sex	F	86	8	91.5
		M	9	82	90.1
		Overall Percentage			90.8
Final Model	Sex	F	85	9	90.4
		M	10	81	89.0
		Overall Percentage			89.7
Further information is in Table 32A, in the Appendix.					

The final model selected from the Group 6 measurements correctly predicted the sex of 89.7% of the sample (Table 32). The addition of maximum diameter of the tibia at the nutrient foramen ($P=.549$) (Step2) increased the predictive accuracy of the final model to 90.8%. The variables in the Step 2 model include maximum diameter and circumference of the tibia at the nutrient foramen, as well as maximum epiphysis breadth of the proximal tibia. The variables included in others steps can be found in Table 33.

The final model selected from the Group 7 measurements correctly predicted the sex of 70.6% of the adult sample (Table 34). The final model included the minimum diameter ($P=.027$) and the circumference ($P=.008$) of the fibula at the midshaft (Table 35). If all fibula measurements remained in the model, predictive accuracy of the adult sample increased to 71.1%.

A logistic regression was also performed using all skeletal measurements. Twenty steps were performed to reach the final model. The final model included 7 variables and accurately classified 94.1 % of the adult sample (Table 36). However, a more accurate model was produced in Step 2 of the regression. The model in Step 2 included all skeletal

Table 33. Adult: Group 6 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Max. Dia. of the Tibia at the Nutrient Foramen	.125	.208	.359	1	.549	1.133
	Circ. of the Tibia at the Nutrient Foramen	.095	.089	1.128	1	.288	1.099
	Max. Epiphysis Breadth of the Proximal Tibia	.406	.081	25.242	1	.000	1.501
	Constant	-40.908	5.889	48.253	1	.000	.000
Final Model ^a	Circ. of the Tibia at the Nutrient Foramen	.141	.046	9.469	1	.002	1.151
	Max. Epiphysis Breadth of the Proximal Tibia	.416	.080	27.101	1	.000	1.516
	Constant	-41.606	5.849	50.606	1	.000	.000
a. Variable(s) entered on step 1: Max. Dia. of the Tibia at the Nutrient Foramen, Tran. Dia. of the Tibia at the Nutrient Foramen, Circ. of the Tibia at the Nutrient Foramen, Max. Epiphysis Breadth of the Proximal Tibia. b. The cut value is .500 Further information is in Table 33A, in the Appendix.							

Table 34. Adult: Group 7 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	75	28	72.8
		M	29	65	69.1
		Overall Percentage			71.1
Final Model	Sex	F	75	28	72.8
		M	30	64	68.1
		Overall Percentage			70.6

Table 35. Adult: Group 7 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Max. Dia. of the Fibula	.115	.289	.160	1	.690	1.122
	Min. Dia. of the Fibula	.485	.250	3.781	1	.052	1.625
	Circ. of the Fibula	.125	.158	.631	1	.427	1.133
	Constant	-11.703	2.042	32.840	1	.000	.000
Final Model ^a	Min. Dia. of the Fibula	.422	.191	4.862	1	.027	1.525
	Circ. of the Fibula	.182	.068	7.087	1	.008	1.200
	Constant	-11.727	2.042	32.987	1	.000	.000
a. Variable(s) entered on step 1: Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula.							
b. The cut value is .500							

Table 36. Adult: All Measurements Classification Table

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Final Model	Sex	F	71	3	95.9
		M	5	57	91.9
		Overall Percentage			94.1
Further information is in Table 36A, in the Appendix.					

measurements, except circumference of the femur, and accurately classified 96.3% of the adult sample. The variables included in each step are presented in Table 37.

Subadult Results

The subadult sample was divided into two age groups. The younger subadults range in age from birth to 11 years and the older subadults range in age from 12 to 17 years. Normality results for the younger and older subadults are given in Tables 38 and 39, respectively. Data was considered normal if the Shapiro-Wilks statistic was equal to or greater than .90. All measurement data was normal for both subadult groups.

MANCOVA Testing of the Subadult Data

Subadult measurements were divided into groups in the same manner as the adult measurements. A MANCOVA test was performed on models constructed from each group of measurements. Also, separate MANCOVA tests were performed on each subadult age group. Age² and age were used as covariates in every analysis. Sex was the fixed factor in every analysis. These results are displayed in Table 40. If MANCOVA tests were determined to be insignificant by a p-value of .05, Bonferroni corrections were used to assess the significance of the tests of the between-subjects effects.

MANCOVA results of the Young Subadult (≤ 11 years old) Data

Sex was a statistically significant variable ($P=.020$) in the Group 1 model. Results of the univariate F-tests are presented in Table 41. Sex differences were statistically significant for the maximum diameter ($P=.002$) and the circumference ($P=.008$) of the clavicle.

Two models were constructed from Group 2 measurements. The first model included all Group 2 measurements except for maximum breadth of the distal humerus. Maximum breadth of the distal humerus was excluded to maximize the young subadult sample size. Sex

Table 37. Adult: All Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Max. Clavicle Length	.158	.069	5.223	1	.022	1.171
	Vert. Dia. of the Clavicle	.827	.520	2.530	1	.112	2.286
	Glenoid Cavity Breadth	-.642	.353	3.312	1	.069	.526
	Tran. Dia. of the Ulna	1.615	.534	9.162	1	.002	5.030
	Anterio-Posterior Dia. of the Femur	-.648	.302	4.605	1	.032	.523
	Epicondylar Breadth of the Femur	.352	.160	4.831	1	.028	1.422
	Max. Dia. of the Tibia at the Nutrient Foramen	.381	.203	3.514	1	.061	1.463
	Constant	-59.390	12.426	22.844	1	.000	.000
a. Variable(s) entered on step 1: Max. Clavicle Length, Sag. Dia. of the Clavicle, Vert. Dia. of the Clavicle, Circ. of the Clavicle, Glenoid Cavity Breadth, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Epicondylar Breadth of the Humerus, Tran. Dia. of the Ulna, Dorso-Volar Dia. of the Ulna, Min. Circ. of the Ulna, Tran. Dia. of the Radius, Sag. Dia. of the Radius, Circ. of the Radius, Anterio-Posterior Dia. of the Femur, Tran. Dia. of the Femur, Circ. of the Femur, Epicondylar Breadth of the Femur, Max. Dia. of the Tibia at the Nutrient Foramen, Tran. Dia. of the Tibia at the Nutrient Foramen, Circ. of the Tibia at the Nutrient Foramen, Max. Epiphysis Breadth of the Proximal Tibia, Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula. b. The cut value is .500 Further information is in Table 37A, in the Appendix.							

Table 38. Young Subadult Normality Results

Measurement	Shapiro-Wilks Statistic	p-value
1. Maximum Clavicle Length	.938	.079
2. Maximum Diameter of the Clavicle at midshaft	.919	.012
3. Minimum Diameter of the Clavicle at midshaft	.957	.168
4. Circumference of the Clavicle at midshaft	.919	.012
5. Maximum Glenoid Cavity Breadth	.976	.775
6. Maximum Diameter of the Humerus at midshaft	.973	.637
7. Minimum Diameter of the Humerus at midshaft	.975	.691
8. Circumference of the Humerus at midshaft	.974	.651
9. Maximum Breadth of the distal Humerus	.951	.545
10. Maximum Diameter of the Radius at midshaft	.963	.412
11. Minimum Diameter of the Radius at midshaft	.974	.703
12. Circumference of the Radius at midshaft	.972	.630
13. Maximum Diameter of the Ulna at midshaft	.967	.523
14. Minimum Diameter of the Ulna at midshaft	.978	.820
15. Circumference of the Ulna at midshaft	.973	.673
16. Maximum Diameter of the Femur at midshaft	.964	.144
17. Minimum Diameter of the Femur at midshaft	.978	.490
18. Circumference of the Femur at midshaft	.975	.394
19. Maximum Breadth of the distal Femur	.962	.229
20. Maximum Diameter of the Tibia at midshaft	.962	.186
21. Minimum Diameter of the Tibia at midshaft	.981	.714
22. Circumference of the Tibia at midshaft	.976	.546
23. Maximum Breadth of the proximal Tibia	.961	.261
24. Maximum Diameter of the Fibula at midshaft	.956	.166
25. Minimum Diameter of the Fibula at midshaft	.951	.109
26. Circumference of the Fibula at midshaft	.969	.388

Table 39. Older Subadult Normality Results

Measurement	Shapiro-Wilks Statistic	p-value
1. Maximum Clavicle Length	.981	.931
2. Maximum Diameter of the Clavicle at midshaft	.978	.861
3. Minimum Diameter of the Clavicle at midshaft	.947	.255
4. Circumference of the Clavicle at midshaft	.951	.307
5. Maximum Glenoid Cavity Breadth	.985	.974
6. Maximum Diameter of the Humerus at midshaft	.984	.981
7. Minimum Diameter of the Humerus at midshaft	.981	.957
8. Circumference of the Humerus at midshaft	.974	.845
9. Maximum Breadth of the distal Humerus	.975	.933
10. Maximum Diameter of the Radius at midshaft	.934	.146
11. Minimum Diameter of the Radius at midshaft	.972	.767
12. Circumference of the Radius at midshaft	.963	.560
13. Maximum Diameter of the Ulna at midshaft	.922	.084
14. Minimum Diameter of the Ulna at midshaft	.976	.842
15. Circumference of the Ulna at midshaft	.978	.888
16. Maximum Diameter of the Femur at midshaft	.990	.996
17. Minimum Diameter of the Femur at midshaft	.974	.766
18. Circumference of the Femur at midshaft	.987	.986
19. Maximum Breadth of the distal Femur	.972	.726
20. Maximum Diameter of the Tibia at midshaft	.932	.108
21. Minimum Diameter of the Tibia at midshaft	.940	.166
22. Circumference of the Tibia at midshaft	.968	.617
23. Maximum Breadth of the Proximal Tibia	.974	.774
24. Maximum Diameter of the Fibula at midshaft	.979	.868
25. Minimum Diameter of the Fibula at midshaft	.982	.932
26. Circumference of the Fibula at midshaft	.972	.725

Table 40. Young Subadult Multivariate Tests^{bc}

Measurement Group in Model	Effect		Value	F	Hypothesis df	Error df	Sig.
Group 1 Measurements	Intercept	Wilks' Lambda	.050	1.049E2	4.000	22.000	.000
	AgeSquare	Wilks' Lambda	.783	1.524 ^a	4.000	22.000	.230
	Age	Wilks' Lambda	.451	6.692 ^a	4.000	22.000	.001
	Sex	Wilks' Lambda	.600	3.667 ^a	4.000	22.000	.020
Group 2 (excludes Max. Breadth of the Distal Humerus)	Intercept	Wilks' Lambda	.093	3.660E1	4.000	15.000	.000
	AgeSquare	Wilks' Lambda	.403	5.552 ^a	4.000	15.000	.006
	Age	Wilks' Lambda	.287	9.333 ^a	4.000	15.000	.001
	Sex	Wilks' Lambda	.594	2.567 ^a	4.000	15.000	.081
All Group 2 Measurements	Intercept	Wilks' Lambda	.053	1.793E1	5.000	5.000	.003
	AgeSquare	Wilks' Lambda	.398	1.514 ^a	5.000	5.000	.330
	Age	Wilks' Lambda	.209	3.779 ^a	5.000	5.000	.085
	Sex	Wilks' Lambda	.432	1.316 ^a	5.000	5.000	.385
Group 3 Measurements	Intercept	Wilks' Lambda	.125	5.136E1	3.000	22.000	.000
	AgeSquare	Wilks' Lambda	.856	1.233 ^a	3.000	22.000	.322
	Age	Wilks' Lambda	.645	4.031 ^a	3.000	22.000	.020
	Sex	Wilks' Lambda	.684	3.384 ^a	3.000	22.000	.036
Group 4 Measurements	Intercept	Wilks' Lambda	.131	4.657E1	3.000	21.000	.000
	AgeSquare	Wilks' Lambda	.756	2.254 ^a	3.000	21.000	.112
	Age	Wilks' Lambda	.584	4.992 ^a	3.000	21.000	.009
	Sex	Wilks' Lambda	.726	2.643 ^a	3.000	21.000	.076
Group 5 (excludes Max. Br. of the Distal Femur)	Intercept	Wilks' Lambda	.152	7.803E1	3.000	42.000	.000
	AgeSquare	Wilks' Lambda	.832	2.836 ^a	3.000	42.000	.050
	Age	Wilks' Lambda	.506	1.368E1	3.000	42.000	.000
	Sex	Wilks' Lambda	.873	2.038 ^a	3.000	42.000	.123
All Group 5 Measurements	Intercept	Wilks' Lambda	.113	5.886E1	4.000	30.000	.000
	AgeSquare	Wilks' Lambda	.476	8.268 ^a	4.000	30.000	.000
	Age	Wilks' Lambda	.280	1.930E1	4.000	30.000	.000
	Sex	Wilks' Lambda	.780	2.119 ^a	4.000	30.000	.103
Group 6 (excludes Max. Breadth of the Prox. Tibia)	Intercept	Wilks' Lambda	.156	6.318E1	3.000	35.000	.000
	AgeSquare	Wilks' Lambda	.788	3.140 ^a	3.000	35.000	.037
	Age	Wilks' Lambda	.538	1.004E1	3.000	35.000	.000
	Sex	Wilks' Lambda	.791	3.091 ^a	3.000	35.000	.039
All Group 6 Measurements	Intercept	Wilks' Lambda	.161	3.261E1	4.000	25.000	.000
	AgeSquare	Wilks' Lambda	.329	1.276E1	4.000	25.000	.000
	Age	Wilks' Lambda	.246	1.913E1	4.000	25.000	.000
	Sex	Wilks' Lambda	.749	2.090 ^a	4.000	25.000	.112

Table 40. Contin.

Measurement Group in Model	Effect	Value	F	Hypothesis df	Error df	Sig.	
Group 7 Measurements	Intercept	Wilks' Lambda	.206	3.849E1	3.000	30.000	.000
	AgeSquare	Wilks' Lambda	.874	1.435 ^a	3.000	30.000	.252
	Age	Wilks' Lambda	.598	6.730 ^a	3.000	30.000	.001
	Sex	Wilks' Lambda	.766	3.057 ^a	3.000	30.000	.043
a. Exact statistic							
b. Design: Intercept + AgeSquare + Age + Sex							

Table 41. Young Subadult: Group 1 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Clavicle Length	240.314	1	240.314	5.421	.028
	Max. Dia. of the Clavicle	9.170	1	9.170	12.382	.002
	Min. Dia. of the Clavicle	1.118	1	1.118	3.148	.088
	Circ. of the Clavicle	47.742	1	47.742	8.363	.008
Further information is in Table 41A, in the Appendix.						

was not a statistically significant ($P=.081$) variable in this model. However, examination of the univariate F-tests revealed significant sex differences for maximum glenoid cavity breadth ($P=.009$) based on a Bonferroni correction (.0125) (Table 42). The second model included all Group 2 measurements. The addition of the maximum breadth of the distal humerus reduced the sample size from 13 females and 9 males, to 8 females and 5 males. Sex continued to be an insignificant ($P=.385$) variable in the second model. Furthermore, maximum breadth of the glenoid cavity ($P=.031$) was not significant based on a Bonferroni correction of .01 (Table 43).

Sex was a statistically significant ($P=.036$) variable in the Group 3 model. Results for the tests of the between-subjects effects are listed in Table 44. Sex differences were statistically significant ($P=.017$) for the minimum diameter of the radius (Table 44).

MANCOVA testing of the model including all Group 4 measurements revealed that sex was not a significant variable ($P=.076$) in the model. Results for the tests of the between-subjects effects are shown in Table 45. A Bonferroni correction was used to assess the significance of the tests of the between-subjects effects. Sex differences for the minimum diameter of the ulna were statistically significant ($P=.012$).

Table 42. Young Subadult: Group 2 Tests of Between-Subjects Effects (excludes Max. Breadth of the Distal Humerus)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Humerus	6.623	1	6.623	3.942	.063
	Min. Dia. of the Humerus	8.396	1	8.396	7.413	.014
	Circ. of the Humerus	70.082	1	70.082	4.909	.040
	Max. Glenoid cavity breadth	14.906	1	14.906	8.707	.009
Further information is in Table 42A, in the Appendix.						

Table 43. Young Subadult: Group 2 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Humerus	6.570	1	6.570	2.519	.147
	Min. Dia. of the Humerus	7.058	1	7.058	4.563	.061
	Circ. of the Humerus	69.405	1	69.405	3.408	.098
	Max. Glenoid cavity breadth	13.709	1	13.709	6.520	.031
	Max. breadth of the distal Humerus	13.642	1	13.642	.834	.385
Further information is in Table 43A, in the Appendix.						

Table 44. Young Subadult: Group 3 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Radius	2.070	1	2.070	1.601	.218
	Min. Dia. of the Radius	3.533	1	3.533	6.575	.017
	Circ. of the Radius	28.014	1	28.014	3.235	.085
Further information is in Table 44A, in the Appendix.						

Table 45. Young Subadult: Group 4 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Ulna	3.371	1	3.371	2.715	.113
	Min. Dia. of the Ulna	4.244	1	4.244	7.369	.012
	Circ. of the Ulna	45.216	1	45.216	4.995	.035
Further information is in Table 45A, in the Appendix.						

MANCOVA testing was performed on two models constructed from the Group 5 measurements. The first model contained all Group 5 measurements, except for maximum breadth of the distal femur. Maximum breadth of the distal femur was excluded from this analysis to maximize the young subadult sample size. Sex was not a statistically significant ($P=.123$) variable in the model. Based on a Bonferroni correction of .017, sex differences were statistically significant ($P=.016$) for the circumference of the femur (Table 46). The second model constructed from the Group 2 measurements included all humerus measurements. The addition of the maximum breadth of the distal femur reduced the young subadult sample size from 23 females and 25 males, to 17 females and 20 males. Sex remained an insignificant variable ($P=.103$) in the second model. A Bonferroni correction (.0125) was used to assess the significance of the univariate F-tests. Results of the univariate F-tests are shown in Table 47. Significant sex differences ($P=.008$) were found in the maximum breadth of the distal femur.

MANCOVA testing was performed on two models constructed from the Group 6 measurements. The first model included all Group 6 measurements, except maximum breadth of the proximal tibia. Maximum breadth of the proximal tibia was excluded to maximize the young subadult sample size. Sex was a statistically significant ($P=.039$)

Table 46. Young Subadult: Group 5 Tests of Between-Subjects Effects (excludes Max. Br. of the Distal Femur)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Femur	22.450	1	22.450	6.087	.018
	Min. Dia. of the Femur	13.191	1	13.191	5.713	.021
	Circ. of the Femur	181.215	1	181.215	6.337	.016
Further information is in Table 46A, in the Appendix.						

Table 47. Young Subadult: Group 5 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Femur	27.349	1	27.349	6.355	.017
	Min. Dia. of the Femur	13.241	1	13.241	4.992	.032
	Circ. of the Femur	209.780	1	209.780	6.298	.017
	Max. breadth of the distal Femur	174.476	1	174.476	7.924	.008
Further information is in Table 47A, in the Appendix.						

variable in this model. Examination of the tests of the between-subject effects revealed significant sex differences in the maximum diameter ($P=.016$), minimum ($P=.012$) diameter, and circumference ($P=.018$) of the tibia (Table 48). The second model constructed from Group 6 measurements included all tibia measurements. The addition of the maximum breadth of the proximal tibia reduced the young subadult sample from 22 females and 19 males, to 17 females and 19 males. Sex was not a statistically significant ($P=.112$) variable in this model. Based on a Bonferroni correction, no significant sexual dimorphism was detected in the tests of the between-subject effects (Table 49).

Sex was a statistically significant ($P=.043$) variable in the Group 7 model. Significant sex differences were present in the minimum diameter of the fibula ($P=.040$) and the circumference of the fibula ($P=.035$) (Table 50).

Older Subadult (≥ 12 years old) MANCOVAs

Regarding the older subadults, MANCOVA results for all of the models tested are listed in Table 51. Sex was a statistically significant ($P=.008$) variable in the Group 1 model. The univariate F-tests indicated that sex differences were statistically significant for the maximum ($P=.001$) and minimum ($P=.012$) diameters of the clavicle (Table 52). Sex differences were also statistically significant ($P=.0004$) for the circumference of the clavicle.

Table 48. Young Subadult: Group 6 Tests of Between-Subjects Effects (excludes Max. Br. of the Prox. Tibia)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Tibia	27.417	1	27.417	6.375	.016
	Min. Dia. of the Tibia	14.025	1	14.025	6.953	.012
	Circ. of the Tibia	183.926	1	183.926	6.098	.018
Further information is in Table 48A, in the Appendix						

Table 49. Young Subadult: Group 6 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Tibia	23.339	1	23.339	4.648	.040
	Min. Dia. of the Tibia	10.396	1	10.396	4.548	.042
	Circ. of the Tibia	140.892	1	140.892	3.979	.056
	Max. breadth of the proximal Tibia	117.941	1	117.941	6.147	.019
Further information is in Table 49A, in the Appendix						

Table 50. Young Subadult: Group 7 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Fibula	3.074	1	3.074	2.412	.130
	Min. Dia. of the Fibula	3.482	1	3.482	4.567	.040
	Circ. of the Fibula	42.993	1	42.993	4.849	.035
Further information is in Table 50A, in the Appendix.						

Table 51. Older Subadult Multivariate Tests^{bc}

Group of Measurements in Each Model	Effect		Value	F	Hypothesis df	Error df	Sig.
Group 1	Intercept	Wilks' Lambda	.740	1.320E0	4.000	15.000	.308
	AgeSquare	Wilks' Lambda	.719	1.468E0	4.000	15.000	.261
	Age	Wilks' Lambda	.692	1.666E0	4.000	15.000	.210
	Sex	Wilks' Lambda	.423	5.116E0	4.000	15.000	.008
Group 2 (excludes Glenoid Cavity Breadth and Max. Br. of the Distal Humerus)	Intercept	Wilks' Lambda	.824	.926 ^a	3.000	13.000	.456
	AgeSquare	Wilks' Lambda	.796	1.112E0	3.000	13.000	.380
	Age	Wilks' Lambda	.787	1.174E0	3.000	13.000	.358
	Sex	Wilks' Lambda	.503	4.290E0	3.000	13.000	.026
Group 2 (excludes Max. Br. of the Distal Humerus)	Intercept	Wilks' Lambda	.794	.714 ^a	4.000	11.000	.599
	AgeSquare	Wilks' Lambda	.775	.801 ^a	4.000	11.000	.549
	Age	Wilks' Lambda	.769	.826 ^a	4.000	11.000	.536
	Sex	Wilks' Lambda	.501	2.740E0	4.000	11.000	.084
All Group 2 Measurements	Intercept	Wilks' Lambda	.141	3.665E0	5.000	3.000	.157
	AgeSquare	Wilks' Lambda	.137	3.781E0	5.000	3.000	.151
	Age	Wilks' Lambda	.142	3.635E0	5.000	3.000	.159
	Sex	Wilks' Lambda	.497	.607 ^a	5.000	3.000	.709
Group 3 Measurements	Intercept	Wilks' Lambda	.907	.548 ^a	3.000	16.000	.657
	AgeSquare	Wilks' Lambda	.897	.614 ^a	3.000	16.000	.616
	Age	Wilks' Lambda	.906	.553 ^a	3.000	16.000	.653
	Sex	Wilks' Lambda	.828	1.108E0	3.000	16.000	.375
Group 4 Measurements	Intercept	Wilks' Lambda	.866	.828 ^a	3.000	16.000	.498
	AgeSquare	Wilks' Lambda	.855	.907 ^a	3.000	16.000	.459
	Age	Wilks' Lambda	.836	1.048E0	3.000	16.000	.398
	Sex	Wilks' Lambda	.505	5.219E0	3.000	16.000	.011
Group 5 Measurements	Intercept	Wilks' Lambda	.849	.758 ^a	4.000	17.000	.566
	AgeSquare	Wilks' Lambda	.831	.863 ^a	4.000	17.000	.506
	Age	Wilks' Lambda	.835	.838 ^a	4.000	17.000	.520
	Sex	Wilks' Lambda	.583	3.010E0	4.000	17.000	.048
Group 6 Measurements	Intercept	Wilks' Lambda	.912	.387 ^a	4.000	16.000	.815
	AgeSquare	Wilks' Lambda	.921	.341 ^a	4.000	16.000	.846
	Age	Wilks' Lambda	.910	.394 ^a	4.000	16.000	.810
	Sex	Wilks' Lambda	.405	5.875E0	4.000	16.000	.004
Group 7 Measurements	Intercept	Wilks' Lambda	.831	1.224E0	3.000	18.000	.330
	AgeSquare	Wilks' Lambda	.814	1.375E0	3.000	18.000	.282
	Age	Wilks' Lambda	.808	1.430E0	3.000	18.000	.267
	Sex	Wilks' Lambda	.555	4.817E0	3.000	18.000	.012
a. Exact statistic							
b. Design: Intercept + AgeSquare + Age + Sex							

Table 52. Older Subadult: Group 1 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Clavicle Length	21.620	1	21.620	.213	.650
	Max. Dia. of the Clavicle	12.401	1	12.401	14.267	.001
	Min. Dia. of the Clavicle	7.577	1	7.577	7.735	.012
	Circ. of the Clavicle	107.002	1	107.002	18.354	.000
Further information is in Table 52A, in the Appendix.						

Three models were constructed from the Group 2 measurements and underwent MANCOVA testing. The first model contained all Group 2 measurement, except maximum glenoid cavity breadth and maximum breadth of the distal humerus. Maximum breadth of the glenoid cavity and distal humerus were excluded from the first model to maximize the size of the older subadult sample. Sex was a statistically significant ($P=.026$) variable in this model. Results for the tests of the between-subjects effects for the first model are reported in Table 53. Sex differences were statistically significant ($P=.016$) for the minimum diameter of the humerus. The second model of the Group 2 measurements included all humerus measurements except maximum breadth of the distal humerus. Maximum breadth of the distal humerus was excluded to maximize the older subadult sample size. The addition of maximum glenoid cavity breadth to the second model decreased the sample size from 9 females and 10 males, to 8 females and 10 males. Sex was not a statistically significant variable ($P=.084$) in this model. Results for the tests of the between-subjects effects are given in Table 54. Sex differences were considered significant if the p-value was $\leq .0125$ (Bonferroni correction). No sex differences were statistically significant. The third model

Table 53. Older Subadult: Group 2 Tests of Between-Subjects Effects (excludes Max. Glenoid cavity breadth and Max. Breadth of the Distal Humerus)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Humerus	4.263	1	4.263	.820	.379
	Min. Dia. of the Humerus	15.738	1	15.738	7.314	.016
	Circ. of the Humerus	77.559	1	77.559	2.172	.161
Further information is in Table 53A, in the Appendix.						

Table 54. Older Subadult: Group 2 Tests of Between-Subjects Effects (excludes Max. Breadth of the Distal Humerus)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Humerus	5.282	1	5.282	.979	.339
	Min. Dia. of the Humerus	15.423	1	15.423	6.692	.022
	Circ. of the Humerus	86.186	1	86.186	2.308	.151
	Max. Glenoid cavity breadth	10.348	1	10.348	2.860	.113
Further information is in Table 54A, in the Appendix.						

constructed from the Group 2 measurements included all humerus measurements and maximum glenoid cavity breadth. The older subadult sample size decreased to 5 females and 6 males with the addition of maximum breadth of the distal humerus. Sex was not a significant variable ($P=.709$) in this model. Results for the tests of the between-subjects effects for the variables in the third model are given in Table 55. Examination of the univariate F-tests did not reveal any significant sex differences.

Sex was not a significant variable ($P=.375$) in the Group 3 model of the older subadults. Results for the univariate F-tests are presented in Table 56. No significant sex differences were found in any of the radius measurements.

Sex was a statistically significant ($P=.011$) variable in the Group 4 model. Results for the tests of the between-subjects effects are displayed in Table 57. Sex differences were

Table 55. Group 2 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Humerus	.021	1	.021	.002	.962
	Min. Dia. of the Humerus	1.418	1	1.418	.479	.511
	Circ. of the Humerus	2.587	1	2.587	.043	.841
	Max. Glenoid cavity breadth	1.023	1	1.023	.281	.612
	Max. breadth of the distal Humerus	11.081	1	11.081	.432	.532
Further information is in Table 55A, in the Appendix.						

Table 56. Older Subadult: Group 3 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Radius	.036	1	.036	.017	.898
	Min. Dia. of the Radius	.346	1	.346	.398	.536
	Circ. of the Radius	6.884	1	6.884	.575	.458
Further information is in Table 56A, in the Appendix.						

Table 57. Older Subadult: Group 4 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Ulna	5.879	1	5.879	3.819	.066
	Min. Dia. of the Ulna	14.062	1	14.062	13.494	.002
	Circ. of the Ulna	99.199	1	99.199	9.614	.006
Further information is in Table 57A, in the Appendix						

Table 58. Older Subadult: Group 5 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Femur	29.945	1	29.945	10.437	.004
	Min. Dia. of the Femur	20.305	1	20.305	5.060	.036
	Circ. of the Femur	185.062	1	185.062	4.567	.045
	Max. breadth of the distal Femur	78.544	1	78.544	2.878	.105
Further information is in Table 58A, in the Appendix.						

significant for the minimum diameter ($P=.002$) and circumference ($P=.006$) of the ulna.

Sex was a statistically significant ($P=.048$) variable in the Group 5 model. Results for the tests of the between-subjects effects are reported in Table 58. Significant sexual dimorphism was detected in the maximum diameter ($P=.004$), minimum diameter ($P=.036$), and circumference of the femur ($P=.045$).

Sex was a statistically significant ($P=.004$) variable in the Group 6 model. Results for the tests of the between-subjects effects for this model are shown in Table 59. Sex differences were statistically significant for the maximum diameter ($P=.004$), minimum diameter ($P=.001$), and circumference ($P=.001$) of the tibia at the midshaft.

Sex was a statistically significant ($P=.012$) variable in the Group 7 model. Results for the tests of the between-subjects effects are reported in Table 60. Statistically significant sex differences were found in the maximum diameter ($P=.049$), minimum diameter ($P=.009$) and circumference ($P=.006$) of the fibula.

Logistic Regressions

Logistic regressions were performed on models constructed from each of the 7 groups of measurements for each subadult group. A logistic regression was also performed on models consisting of measurements from several different bones of the body to find the model with

Table 59. Older Subadult: Group 6 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex	Max. Dia. of the Tibia	79.575	1	79.575	10.491	.004
	Min. Dia. of the Tibia	45.671	1	45.671	16.407	.001
	Circ. of the Tibia	600.780	1	600.780	15.031	.001
	Max. breadth of the proximal Tibia	4.044	1	4.044	.098	.758
Further information is in Table 59A, in the Appendix.						

Table 60. Older Subadult: Group 7 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Sex	Max. Dia. of the Fibula	17.247	1	17.247	4.397	.049
	Min. Dia. of the Fibula	16.064	1	16.064	8.513	.009
	Circ. of the Fibula	171.802	1	171.802	9.511	.006
Further information is in Table 60A, in the Appendix.						

the highest predictive accuracy for each subadult group. This process was limited by the necessity to use variables that maximized sample size.

Logistic Regression Results of the Young Subadult (≤ 11 years) Data

The final model selected from the Group 1 measurements accurately predicted the sex of 75.9% of the young subadult sample (Table 61). This model included age and the maximum diameter of the clavicle (Table 62). However, the model produced in Step 3 proved to be more accurate (82.8%) than the final model for predicting sex using the Group 1 measurements. The variables used in Step 3 included age, maximum clavicle length, and maximum diameter of the clavicle.

Three logistic regressions were performed using the Group 2 measurements. Maximum glenoid cavity breadth and maximum breadth of the distal humerus were excluded from the first logistic regression to maximize the young subadult sample size. The final

Table 61. Young Subadult: Group 1 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 3	Sex	F	13	2	86.7
		M	3	11	78.6
		Overall Percentage			82.8
Final Step	Sex	F	12	3	80.0
		M	4	10	71.4
		Overall Percentage			75.9
Further information is in Table 61A, in the Appendix.					

Table 62. Young Subadult: Group 1 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 3 ^a	Age	-1.462	.609	5.756	1	.016	.232
	Max. Clavicle Length	.125	.091	1.905	1	.168	1.133
	Max. Dia. of the Clavicle	1.846	.809	5.208	1	.022	6.332
	Constant	-15.116	6.364	5.642	1	.018	.000
Final Model ^a	Age	-.848	.332	6.515	1	.011	.428
	Max. Dia. of the Clavicle	1.966	.783	6.309	1	.012	7.142
	Constant	-8.767	3.658	5.744	1	.017	.000
a. Variable(s) entered on step 1: Age, Max. Clavicle Length, Max. Dia. of the Clavicle, Min. Dia. of the Clavicle, Circ. of the Clavicle. b. The cut value is .500 Further information is in Table 62A, in the Appendix.							

model of the first logistic regression accurately classified 70% of the young subadult sample (Table 63). This model included age and the minimum diameter of the humerus (Table 64). The second logistic regression included all Group 2 measurements except maximum breadth of the distal humerus. This addition reduced the sample size from 18 females and 12 males, to 13 females and 9 males. The final model of the second logistic regression correctly classified 68.2% of the young subadult sample (Table 65). The variables in the final model included age and minimum diameter of the humerus. Step 2 of the second logistic regression achieved an overall accuracy rate of 77.3%, which was greater than the accuracy rate of the final model. The most accurate model of the second logistic regression included age,

Table 63. Young Subadult: Group 2 Classification Table (excludes Glenoid Cavity Breadth and Max. Breadth of the Distal Humerus)

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Final Model	Sex	F	15	3	83.3
		M	6	6	50.0
		Overall Percentage			70.0
Further information is in Table 63A, in the Appendix.					

Table 64. Young Subadult: Group 2 Variables in the Equation (excludes Glenoid Cavity Breadth and Max. Breadth of the Distal Humerus)

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Age	-.505	.260	3.781	1	.052	.603
	Min. Dia. of the Humerus	.900	.414	4.721	1	.030	2.458
	Constant	-6.413	2.861	5.023	1	.025	.002
a. Variable(s) entered on step 1: Age, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus. b. The cut value is .500 Further information is in Table 64A, in the Appendix.							

Table 65. Young Subadult: Group 2 Classification Table (excludes Max. Breadth of the Distal Humerus)

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 2 Final Model	Sex	F	11	2	84.6
		M	3	6	66.7
		Overall Percentage			77.3
	Sex	F	10	3	76.9
		M	4	5	55.6
		Overall Percentage			68.2
Further information is in Table 65A, in the Appendix.					

minimum diameter of the humerus, circumference of the humerus, and glenoid cavity breadth. Details regarding the variables entered into each step of the second logistic regression are given in Table 66. All Group 2 measurements were entered in the first step of the third logistic regression. This addition reduced the sample size to 8 females and 5 males. Four steps were performed to calculate the final model and all steps were 100% accurate at predicting sex (Table 67). The final model of the third logistic regression included age, maximum breadth of the glenoid cavity, and maximum breadth of the distal humerus. For a complete list of the variables entered in each step of the third logistic regression see Table 68.

The final model chosen from the Group 3 measurements accurately predicted the sex of 82.1% of the young subadult sample (Table 69). The final model included age, maximum diameter, and minimum diameter of the radius (Table 70).

The final model selected from the Group 4 measurements correctly classified 70.4% of the young subadults (Table 71). The final model included age and minimum diameter of

Table 66. Young Subadult: Group 2 Variables in the Equation (excludes Max. Breadth of the Distal Humerus)

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Age	-1.909	1.125	2.879	1	.090	.148
	Min. Dia. of the Humerus	3.215	1.938	2.752	1	.097	24.909
	Circ. of the Humerus	-.885	.648	1.864	1	.172	.413
	Glenoid Cavity Breadth	1.701	1.127	2.278	1	.131	5.479
	Constant	-15.380	8.843	3.025	1	.082	.000
Final Model ^a	Age	-.824	.411	4.024	1	.045	.439
	Min. Dia. of the Humerus	1.362	.639	4.534	1	.033	3.902
	Constant	-9.719	4.567	4.530	1	.033	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Glenoid Cavity Breadth. b. The cut value is .500 Further information is in Table 66A, in the Appendix.							

Table 67. Young Subadult: Group 2 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	8	0	100.0
	M	0	5	100.0
	Overall Percentage			100.0
Further information is in Table 67A, in the Appendix.				

Table 68. Young Subadult: Group 2 Variables in the Equation^c

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^b	Age	-126.206	1961081.187	.000	1	1.000	.000
	Max. Dia. of the Humerus	101.724	9491737.307	.000	1	1.000	1.507E44
	Min. Dia. of the Humerus	32.592	24687890.925	.000	1	1.000	1.428E14
	Glenoid Cavity Breadth	221.191	23111272.988	.000	1	1.000	1.153E96
	Max. Breadth the Distal Humerus	-89.678	1137890.237	.000	1	1.000	.000
	Constant	-1285.316	18493798.934	.000	1	1.000	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Glenoid Cavity Breadth, Max. Breadth the Distal Humerus. b. Variable(s) entered on step 4: Min. Dia. of the Humerus. c. Stepwise procedure stopped because removing the least significant variable result in a previously fitted model. d. The cut value is .500 Further information is in Table 68A, in the Appendix.							

Table 69. Young Subadult: Group 3 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	15	0	100.0
	M	5	8	61.5
	Overall Percentage			82.1
Further information is in Table 69A, in the Appendix.				

Table 70. Young Subadult: Group 3 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model ^a	Age	-.606	.387	2.444	1	.118	.546
	Max. Dia. of the Radius	-1.623	.979	2.747	1	.097	.197
	Min. Dia. of the Radius	4.037	1.810	4.973	1	.026	56.643
	Constant	-7.938	3.814	4.332	1	.037	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Radius, Min. Dia. of the Radius, Circ. of the Radius. b. The cut value is .500 Further information is in Table 70A, in the Appendix.							

Table 71. Young Subadult: Group 4 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 2	Sex	F	12	3	80.0
		M	4	8	66.7
		Overall Percentage			74.1
Final Model	Sex	F	11	4	73.3
		M	4	8	66.7
		Overall Percentage			70.4
Further information is in Table 71A, in the Appendix.					

the ulna (Table 72). However, the model in Step 2 had a greater predictive accuracy (74.1%) than the final model for the young subadult sample (Table 71). The variables included in the Step 2 model included age, maximum diameter, and minimum diameter of the ulna (Table 72).

Two separate logistic regressions were performed on the young subadult sample using the Group 5 measurements. In order to maximize the sample size, the first logistic regression excluded the maximum breadth of the distal femur. The final model of the first logistic regression accurately predicted the sex of 62.5% of the young subadult sample (Table 73). The final model included age and the circumference of the femur (Table 74). The model produced in Step 2 of the first logistic regression was more accurate (64.6%) at predicting sex than the final model (Table 73). The model in Step 2 included age, maximum diameter, minimum diameter, and circumference of the femur. The second logistic regression included all Group 5 measurements. The addition of the maximum breadth of the distal femur decreased the sample size from 23 females and 25 males, to 17 females and 20

Table 72. Young Subadult: Group 4 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 2 ^a	Age	-.413	.312	1.755	1	.185	.662
	Max. Dia. of the Ulna	-.623	.816	.584	1	.445	.536
	Min. Dia. of the Ulna	2.259	1.233	3.359	1	.067	9.578
	Constant	-7.403	3.471	4.548	1	.033	.001
Final Model ^a	Age	-.540	.293	3.386	1	.066	.583
	Min. Dia. of the Ulna	1.552	.709	4.794	1	.029	4.720
	Constant	-7.549	3.425	4.857	1	.028	.001
a. Variable(s) entered on step 1: Age, Max. Dia. of the Ulna, Min. Dia. of the Ulna, Circ. of the Ulna. b. The cut value is .500 Further information is in Table 72A, in the Appendix.							

Table 73. Young Subadult: Group 5 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	13	10	56.5
		M	7	18	72.0
		Overall Percentage			64.6
Final Model	Sex	F	12	11	52.2
		M	7	18	72.0
		Overall Percentage			62.5
Further information is in Table 73A, in the Appendix.					

Table 74. Young Subadult: Group 5 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-.475	.245	3.762	1	.052	.622
	Max. Dia. of the Femur	.139	.922	.023	1	.880	1.149
	Min. Dia. of the Femur	-.219	.955	.053	1	.818	.803
	Circ. of the Femur	.155	.494	.099	1	.753	1.168
	Constant	-3.522	1.898	3.446	1	.063	.030
Final Model ^a	Age	-.500	.230	4.709	1	.030	.607
	Circ. of the Femur	.143	.065	4.753	1	.029	1.153
	Constant	-3.657	1.864	3.849	1	.050	.026
a. Variable(s) entered on step 1: Age, Max. Dia. of the Femur, Min. Dia. of the Femur, Circ. of the Femur. b. The cut value is .500 Further information is in Table 74A, in the Appendix.							

males. The final model produced by the second logistic regression correctly classified 64.9% of the young subadult sample (Table 75). This model included age and circumference of the femur (Table 76). Step 2 of the second logistic regression produced a more accurate (73%) model or predicting sex in the young subadult sample than the final model (Table 75). The model included age, maximum breadth of the distal femur, minimum diameter, and circumference of the femur (Table 76).

Two logistic regressions were performed on models containing Group 6 measurements. The first logistic regression did not include maximum breadth of the proximal tibia. The final model of the first logistic regression correctly predicted the sex of 63.4% of the young subadult sample (Table 77). The final model included age, minimum diameter, maximum diameter, and circumference of the tibia (Table 78). The second logistic regression included all tibia measurements. The addition of maximum breadth of the proximal tibia reduced the sample size from 22 females and 19 males, to 17 females and 15 males. The final model produced by the second logistic regression correctly classified 68.8% of the young

Table 75. Young Subadult: Group 5 Classification Table

			Predicted		
			Sex		
			F	M	Percentage Correct
Observed					
Step 2	Sex	F	11	6	64.7
		M	4	16	80.0
		Overall Percentage			73.0
Final Model	Sex	F	9	8	52.9
		M	5	15	75.0
		Overall Percentage			64.9
Further information is in Table 75A, in the Appendix.					

Table 76. Young Subadult: Group 5 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Age	-.429	.269	2.550	1	.110	.651
	Min. Dia. of the Femur	-1.363	1.250	1.189	1	.276	.256
	Circ. of the Femur	.457	.354	1.662	1	.197	1.579
	Max. Breadth of the Distal Femur	.099	.108	.840	1	.359	1.104
	Constant	-4.334	2.121	4.176	1	.041	.013
Final Model ^a	Age	-.543	.256	4.490	1	.034	.581
	Circ. of the Femur	.166	.074	5.046	1	.025	1.181
	Constant	-4.203	2.051	4.200	1	.040	.015
a. Variable(s) entered on step 1: Age, Max. Dia. of the Femur, Min. Dia. of the Femur, Circ. of the Femur, Max. Breadth of the Distal Femur. b. The cut value is .500 Further information is in Table 76A, in the Appendix.							

Table 77. Young Subadult: Group 6 Classification Table (excludes Max. Breadth of the Proximal Tibia)

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Final Model	Sex	F	15	7	68.2
		M	8	11	57.9
		Overall Percentage			63.4

Table 78. Young Subadult: Group 6 Variables in the Equation (excludes Max. Breadth of the Proximal Tibia)

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model ^a	Age	-.696	.296	5.542	1	.019	.499
	Max. Dia. of the Tibia	2.269	1.159	3.834	1	.050	9.671
	Min. Dia. of the Tibia	2.497	1.378	3.286	1	.070	12.149
	Circ. of the Tibia	-1.264	.696	3.298	1	.069	.283
	Constant	-5.389	2.242	5.779	1	.016	.005
a. Variable(s) entered on step 1: Age, Max. Dia. of the Tibia, Min. Dia. of the Tibia, Circ. of the Tibia.							
b. The cut value is .500							

subadult sample (Table 79). This model was identical to the final model of the first logistic regression using tibia measurements (age, maximum diameter, minimum diameter, and circumference of the tibia) (Table 80). If all tibia measurements remained in the model (including max. breadth of the proximal tibia), predictive accuracy of the second logistic regression increased to 71.9% (Table 79).

The final model chosen from the Group 7 measurements accurately classified 72.2% of the young subadult sample (Table 81). This model included age, maximum diameter, and circumference of the fibula (Table 82).

A logistic regression was performed on the young subadult sample using measurements from different long bones. The analysis used a sample of 12 females and 11 males. The first step of the logistic regression included the following variables: age, maximum diameter of the clavicle, minimum diameter of the ulna, maximum diameter of the femur, and minimum diameter of the femur. Approximately 91% of the young subadult sample was classified into the correct sex group using the variables in Step 1 (Table 83). Minimum diameter of the femur was excluded from the final model, but this exclusion

Table 79. Young Subadult: Group 6 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Step 1	Sex	F	4	76.5
		M	10	66.7
		Overall Percentage		71.9
Final Model	Sex	F	5	70.6
		M	10	66.7
		Overall Percentage		68.8

Table 80. Young Subadult: Group 6 Classification Table^a

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.787	.356	4.887	1	.027	.455
	Max. Dia. of the Tibia	2.852	1.347	4.486	1	.034	17.329
	Min. Dia. of the Tibia	2.186	1.463	2.233	1	.135	8.902
	Circ. of the Tibia	-1.526	.785	3.780	1	.052	.217
	Max. Breadth of the Proximal Tibia	.167	.182	.847	1	.357	1.182
	Constant	-5.023	2.446	4.217	1	.040	.007
Final Model ^a	Age	-.782	.366	4.551	1	.033	.458
	Max. Dia. of the Tibia	2.696	1.353	3.971	1	.046	14.823
	Min. Dia. of the Tibia	2.369	1.442	2.701	1	.100	10.687
	Circ. of the Tibia	-1.379	.755	3.341	1	.068	.252
	Constant	-4.889	2.512	3.788	1	.052	.008
a. Variable(s) entered on step 1: Age, Max. Dia. of the Tibia, Min. Dia. of the Tibia, Circ. of the Tibia, Max. Breadth of the Proximal Tibia. b. The cut value is .500							

Table 81. Young Subadult: Group 7 Classification Table

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Final Model	Sex	F	16	4	80.0
		M	6	10	62.5
		Overall Percentage			72.2
Further information is in Table 81A, in the Appendix					

Table 82. Young Subadult: Group 7 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Age	-.535	.294	3.321	1	.068	.585
	Max. Dia. of the Fibula	-2.906	1.492	3.792	1	.052	.055
	Circ. of the Fibula	1.342	.597	5.048	1	.025	3.828
	Constant	-4.166	2.140	3.789	1	.052	.016
a. Variable(s) entered on step 1: Age, Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula. b. The cut value is .500 Further information is in Table 82A, in the Appendix.							

Table 83. Young Subadult: Best Model Classification Table

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 1	Sex	F	11	1	91.7
		M	1	10	90.9
		Overall Percentage			91.3
Final Model	Sex	F	9	3	75.0
		M	1	10	90.9
		Overall Percentage			82.6

reduced the predictive accuracy to ~83% (Table 83 and 84).

Older Subadult (≥ 12 years old) Logistic Regression

The most accurate model produced by logistic regression selected from the Group 1 measurements correctly predicted the sex of 95.5% of the older subadult sample (Table 85). The model included age, maximum clavicle length, and circumference of the clavicle (Table 86). The final model accurately sexed 90.9% of the older subadult sample. This model included age and circumference of the clavicle.

Three logistic regressions were performed on the older subadult sample using the Group 2 measurements. In order to maximize sample size, the first logistic regression excluded maximum glenoid cavity breadth and maximum breadth of the distal humerus. The final model accurately predicted the sex of 84.2% of the sample (Table 87). The final model

Table 84. Young Subadult: Best Model Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-3.004	1.386	4.696	1	.030	.050
	Max. Dia. of the Clavicle	3.773	1.777	4.507	1	.034	43.512
	Min. Dia. of the Ulna	3.019	1.971	2.346	1	.126	20.476
	Max. Dia. of the Tibia	2.279	1.323	2.968	1	.085	9.764
	Max. Dia. of the Femur	-4.247	2.244	3.582	1	.058	.014
	Min. Dia. of the Femur	2.529	1.798	1.978	1	.160	12.544
	Constant	-33.173	15.820	4.397	1	.036	.000
Final Model ^a	Age	-1.948	.911	4.566	1	.033	.143
	Max. Dia. of the Clavicle	2.754	1.415	3.791	1	.052	15.713
	Min. Dia. of the Ulna	2.279	1.473	2.393	1	.122	9.764
	Max. Dia. of the Tibia	2.170	1.204	3.249	1	.071	8.754
	Max. Dia. of the Femur	-2.306	1.334	2.986	1	.084	.100
	Constant	-21.094	9.922	4.519	1	.034	.000
	a. Variable(s) entered on step 1: Age, Max. Dia. of the Clavicle, Min. Dia. of the Ulna, Max. Dia. of the Tibia, Max. Dia. of the Femur, Min. Dia. of the Femur.						
	b. The cut value is .500						

Table 85. Older Subadult: Group 1 Classification Table

		Predicted			
		Sex			
	Observed		F	M	Percentage Correct
Step 3	Sex	F	8	1	88.9
		M	0	13	100.0
		Overall Percentage			95.5
Final Model	Sex	F	8	1	88.9
		M	1	12	92.3
		Overall Percentage			90.9
Further information is in Table 85A, in the Appendix.					

Table 86. Older Subadult: Group 1 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 3 ^a	Age	-.425	.562	.571	1	.450	.654
	Max. Clavicle Length	-.132	.093	2.008	1	.156	.876
	Circ. of the Clavicle	.895	.389	5.277	1	.022	2.446
	Constant	-2.826	7.936	.127	1	.722	.059
Final Model ^a	Age	-.657	.502	1.713	1	.191	.518
	Circ. of the Clavicle	.640	.265	5.804	1	.016	1.896
	Constant	-8.452	6.584	1.648	1	.199	.000
a. Variable(s) entered on step 1: Max. Clavicle Length, Max. Dia. of the Clavicle, Min. Dia. of the Clavicle, Circ. of the Clavicle. b. The cut value is .500 Further information is in Table 86A, in the Appendix.							

Table 87. Older Subadult: Group 2 Classification Table (excludes Glenoid Cavity Breadth and Max. Breadth of the Distal Humerus)

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Final Model	Sex	F	8	1	88.9
		M	2	8	80.0
		Overall Percentage			84.2
Further information is in Table 87A, in the Appendix.					

of the first logistic regression included age, maximum, and minimum diameters of the humerus (Table 88). The second logistic regression included the maximum breadth of the glenoid cavity in the first step, but excluded maximum breadth of the distal humerus. This addition decreased the sample size from 9 females and 10 males, to 8 females and 10 males. The final model of the second logistic regression correctly classified 94.4% of the older subadult sample (Table 89). This model included age, maximum and minimum diameters of the humerus, as well as maximum breadth of the glenoid cavity (Table 90). The third logistic regression substituted the ratio of maximum diameter/minimum diameter of the humerus for the individual measurements and included maximum breadth of the distal humerus. The addition of maximum breadth of the distal humerus reduced the sample size to 5 females and 6 males. The final model produced by the third logistic regression was 100% accurate (Table 91). However, all steps of this logistic regression were completely accurate. The variables in the final model of the third logistic regression included age, glenoid cavity breadth, and the ratio of the diameters of the humerus (Table 92).

The final model selected from the Group 3 measurements accurately sexed 68.2% of the older subadult sample (Table 93). The variables in the final model were age, maximum diameter, and circumference of the radius (Table 94). If minimum diameter of the radius remained in the model (Step 1) the predictive accuracy increased to 72.7%.

The final model for predicting sex using the Group 4 measurements accurately classified 81.8% of the older subadult sample (Table 95). This model included age, maximum diameter, and circumference of the ulna (Table 96). However, the use of all ulna measurements and age increased predictive accuracy to 86.4% (Table 95 and 96).

Table 88. Older Subadult: Group 2 Variables in the Equation (excludes Glenoid Cavity Breadth and Max. Breadth of the Distal Humerus)

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model ^a	Age	-.239	.789	.092	1	.762	.787
	Max. Dia. of the Humerus	-1.173	.650	3.254	1	.071	.309
	Min. Dia. of the Humerus	2.681	1.243	4.648	1	.031	14.597
	Constant	-13.173	12.542	1.103	1	.294	.000
a. Variable(s) entered on step 1: Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus. b. The cut value is .500 Further information is in Table 88A, in the Appendix.							

Table 89. Older Subadult: Group 2 Classification Table (excludes Max. Breadth of the Distal Humerus)

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	7	1	87.5
	M	0	10	100.0
	Overall Percentage			94.4
Further information is in Table 89A, in the Appendix.				

Table 90. Older Subadult: Group 2 Variables in the Equation(excludes Max. Breadth of the Distal Humerus)

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model ^a	Age	-2.435	3.176	.588	1	.443	.088
	Max. Dia. of the Humerus	-3.003	2.740	1.201	1	.273	.050
	Min. Dia. of the Humerus	5.700	5.468	1.087	1	.297	299.016
	Glenoid Cavity Breadth	1.625	1.616	1.011	1	.315	5.078
	Constant	-25.931	23.122	1.258	1	.262	.000
a. Variable(s) entered on step 1: Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Glenoid Cavity Breadth. b. The cut value is .500 Further information is in Table 90A, in the Appendix.							

Table 91. Older Subadult: Group 2 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex			
	F	5	0	100.0
	M	0	6	100.0
	Overall Percentage			100.0
Further information is in Table 91A, in the Appendix.				

Table 92. Older Subadult: Group 2 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Age	-31.843	9493.921	.000	1	.997	.000
	Glenoid Cavity Breadth	49.234	10399.642	.000	1	.996	2.411E21
	Humerus Ratio	-672.161	140647.464	.000	1	.996	.000
	Constant	235.136	74269.620	.000	1	.997	1.312E102
a. Variable(s) entered on step 1: Circ. of the Humerus, Glenoid Cavity Breadth, Humerus Ratio, Max. Breadth of the Distal Humerus. b. The cut value is .500 Further information is in Table 92A, in the Appendix.							

Table 93. Older Subadult: Group 3 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Step 1	Sex			
	F	4	4	50.0
	M	2	12	85.7
	Overall Percentage			72.7
Final Model	Sex			
	F	4	4	50.0
	M	3	11	78.6
	Overall Percentage			68.2
Further information is in Table 93A, in the Appendix.				

Table 94. Older Subadult: Group 3 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-.154	.565	.074	1	.785	.857
	Max. Dia. of the Radius	-4.471	2.417	3.422	1	.064	.011
	Min. Dia. of the Radius	-1.559	1.841	.716	1	.397	.210
	Circ. of the Radius	2.383	1.352	3.106	1	.078	10.838
	Constant	-9.549	6.739	2.007	1	.157	.000
Final Model ^a	Age	-.189	.556	.115	1	.734	.828
	Max. Dia. of the Radius	-3.423	1.964	3.037	1	.081	.033
	Circ. of the Radius	1.551	.861	3.242	1	.072	4.715
	Constant	-7.468	5.641	1.753	1	.186	.001
a. Variable(s) entered on step 1: Max. Dia. of the Radius, Min. Dia. of the Radius, Circ. of the Radius. b. The cut value is .500 Further information is in Table 94A, in the Appendix.							

Table 95. Older Subadult: Group 4 Classification Table

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 1	Sex	F	7	2	77.8
		M	1	12	92.3
		Overall Percentage			86.4
Final Model	Sex	F	7	2	77.8
		M	2	11	84.6
		Overall Percentage			81.8

Table 96. Older Subadult: Group 4 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.442	.664	.444	1	.505	.642
	Max. Dia. of the Ulna	-3.795	2.387	2.528	1	.112	.022
	Min. Dia. of the Ulna	1.746	1.712	1.040	1	.308	5.730
	Circ. of the Ulna	1.482	1.095	1.831	1	.176	4.402
	Constant	-14.997	10.625	1.992	1	.158	.000
Final Model ^a	Age	-.554	.642	.745	1	.388	.575
	Max. Dia. of the Ulna	-3.967	2.138	3.443	1	.064	.019
	Circ. of the Ulna	1.968	.953	4.263	1	.039	7.158
	Constant	-12.205	8.368	2.127	1	.145	.000
a. Variable(s) entered on step 1: Max. Dia. of the Ulna, Min. Dia. of the Ulna, Circ. of the Ulna. b. The cut value is .500							

The final model selected from all the Group 5 measurements correctly classified 79.2% of the older subadult sample (Table 97). This model included age and maximum diameter of the femur (Table 98). The model produced in Step 2 of the regression was the best model for predicting the sex (83.3%) in the older subadult sample. The model in Step 2 included age, maximum diameter, minimum diameter, and circumference of the femur (Table 98).

Several logistic regressions were carried out using the Group 6 measurements. All tibia measurements could not be used together in a single logistic regression due to partial separation of the tibia measurements between the sexes. A logistic regression was carried out using individual tibia measurements. The first logistic regression examined the predictive accuracy of the maximum diameter of the tibia at the midshaft. A model consisting of age and the maximum diameter of the tibia accurately classified 79.2% of the older subadult sample (Table 99 and 100). The second logistic regression tested the predictive accuracy of the minimum diameter of the tibia. A model consisting of age and minimum diameter of the tibia accurately predicted the sex of 91.7% of the older subadult sample (Table 101 and 102). The third logistic regression tested the predictive accuracy of the circumference of the tibia. A model consisting of age and circumference of the tibia accurately classified 91.7% of the older subadult sample (Table 103 and 104). The predictive accuracy of the maximum breadth of the proximal tibia was assessed in a fourth logistic regression. The maximum breadth of the proximal tibia and age accurately classified 69.6% of the sample (Table 105 and 106). The fifth logistic regression contained all of the tibia data. Due to statistical problems with partial separation, the data for the minimum and maximum diameters of the tibia had to be condensed into a ratio. All models produced by the fifth logistic regression were completely accurate (Table 107). The variables entered into the first step of the fifth

Table 97. Older Subadult: Group 5 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 2	Sex	F	7	2	77.8
		M	2	13	86.7
		Overall Percentage			83.3
Final Model	Sex	F	6	3	66.7
		M	2	13	86.7
		Overall Percentage			79.2
Further information is in Table 97A, in the Appendix.					

Table 98. Older Subadult: Group 5 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Age	-1.461	.751	3.782	1	.052	.232
	Max. Dia. of the Femur	2.030	1.045	3.774	1	.052	7.617
	Min. Dia. of the Femur	.713	.818	.760	1	.383	2.040
	Circ. of the Femur	-.462	.365	1.597	1	.206	.630
	Constant	-7.846	7.626	1.059	1	.304	.000
Final Model ^a	Age	-1.034	.601	2.959	1	.085	.356
	Max. Dia. of the Femur	1.022	.460	4.944	1	.026	2.778
	Constant	-8.562	6.407	1.786	1	.181	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Femur, Min. Dia. of the Femur, Circ. of the Femur, Max. Breadth of the Distal Femur. b. The cut value is .500 Further information is in Table 98A, in the Appendix.							

Table 99. Older Subadult: Max. Dia. of the Tibia Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Final Model	Sex	F	7	2	77.8
		M	3	12	80.0
		Overall Percentage			79.2

Table 100. Older Subadult: Max. Dia. of the Tibia Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model	Age	-.876	.670	1.707	1	.191	.416
	Max. Dia. of the Tibia	1.648	.768	4.605	1	.032	5.198
	Constant	-26.441	14.022	3.556	1	.059	.000
a. The cut value is .500							

Table 101. Older Subadult: Min. Diameter of the Tibia Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	8	1	88.9
	M	1	14	93.3
	Overall Percentage			91.7

Table 102. Older Subadult: Min. Diameter of the Tibia Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model	Age	-2.127	2.290	.863	1	.353	.119
	Min. Dia. of the Tibia	6.056	5.007	1.463	1	.226	426.822
	Constant	-73.288	56.839	1.663	1	.197	.000
a. The cut value is .500							

Table 103. Older Subadult: Circ. of the Tibia Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex F	8	1	88.9
	M	1	14	93.3
	Overall Percentage			91.7

Table 104. Older Subadult: Circ. of the Tibia Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model ^a	Age	-2.135	1.253	2.903	1	.088	.118
	Circ. of the Tibia	1.478	.861	2.944	1	.086	4.383
	Constant	-65.881	42.052	2.454	1	.117	.000
a. Variable(s) entered on step 1: AgeSquare, Age, Circ. of the Tibia. b. The cut value is .500							

Table 105. Older Subadult: Max. Breadth of the Proximal Tibia Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Step 1	Sex	F	1	7
		M	0	15
		Overall Percentage		69.6
Final Model	Sex	F	0	8
		M	0	15
		Overall Percentage		65.2

Table 106. Older Subadult: Max. Breadth of the Proximal Tibia Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	.077	.438	.031	1	.860	1.080
	Max. Breadth of the Proximal Tibia	.027	.077	.123	1	.726	1.027
	Constant	-2.192	4.352	.254	1	.614	.112
Step 2 ^a	Age	.194	.289	.451	1	.502	1.214
	Constant	-2.278	4.332	.277	1	.599	.102
a. Variable(s) entered on step 1: Max. Breadth of the Proximal Tibia. b. The cut value is .500							

Table 107. Older Subadult: Group 6 Classification Table

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Final Model	Sex	F	8	0	100.0
		M	0	15	100.0
		Overall Percentage			100.0
Further information is in Table 107A, in the Appendix.					

logistic regression included age, tibia ratio (maximum diameter/minimum diameter), circumference of the tibia, and maximum breadth of the proximal tibia (Table 108). The final model included age, circumference of the tibia, and maximum breadth of the proximal tibia.

The final model selected from the Group 7 measurements accurately predicted the sex of 91.7% of the older subadult sample (Table 109). The final model included age, maximum diameter, and circumference of the fibula (Table 110). Two logistic regressions were carried out on the older subadult sample using measurements from several long bones. The measurements entered into Step 1 of the first logistic regression included age, circumference of the clavicle, minimum diameter of the tibia, and maximum diameter of the femur. The final model accurately classified 91.3% of the older subadult sample (Table 111). This model included age and the minimum diameter of the tibia (Table 112). The variables entered into Step 1 of the second logistic regression included age, maximum clavicle length, circumference of the clavicle, minimum diameter of the tibia, and maximum diameter of the femur. The final model of the second logistic regression accurately classified 100% of the older subadult sample and included maximum clavicle length, circumference of the clavicle, and maximum diameter of the femur (Table 113 and 114). However, all steps in the second logistic regression were completely accurate at predicting sex.

Table 108. Older Subadult: Group 6 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Final Model ^a	Age	-88.574	2380.381	.001	1	.970	.000
	Circ. of the Tibia	135.786	3376.926	.002	1	.968	9.360E58
	Max. Breadth of the Proximal Tibia	-18.521	444.330	.002	1	.967	.000
	Constant	-6518.682	162369.226	.002	1	.968	.000
a. Variable(s) entered on step 1: Age, Tibia ratio, Circ. of the Tibia, Max. Breadth of the Proximal Tibia. b. The cut value is .500 Further information is in Table 108A, in the Appendix.							

Table 109. Older Subadult: Group 7 Classification Table

		Predicted		
		Sex		
	Observed	F	M	Percentage Correct
Final Model	Sex			
	F	8	1	88.9
	M	1	14	93.3
	Overall Percentage			91.7
Further information is in Table 109A, in the Appendix.				

Table 110. Older Subadult: Group 7 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Age	-.267	.400	.447	1	.504	.765
	Max. Dia. of the Fibula	-1.458	.918	2.524	1	.112	.233
	Circ. of the Fibula	1.032	.485	4.521	1	.033	2.806
	Constant	-13.487	8.913	2.290	1	.130	.000
a. Variable(s) entered on step 1: Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula. b. The cut value is .500 Further information is in Table 110A, in the Appendix.							

Table 111. Older Subadult: Best Model Classification Table

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Final Model	Sex	F	8	1	88.9
		M	1	13	92.9
		Overall Percentage			91.3
Further information is in Table 111A, in the Appendix.					

Table 112. Older Subadult: Best Model Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Age	-2.127	2.290	.863	1	.353	.119
	Min. Dia. of the Tibia	6.056	5.007	1.463	1	.226	426.822
	Constant	-73.288	56.839	1.663	1	.197	.000
a. Variable(s) entered on step 1: Age, Circ. of the Clavicle, Min. Dia. of the Tibia, Max. Dia. of the Femur. b. The cut value is .500 Further information is in Table 112A, in the Appendix.							

Table 113. Older Subadult: Best Model Classification Table

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Final Model	Sex	F	9	0	100.0
		M	0	13	100.0
		Overall Percentage			100.0
Further information is in Table 113A, in the Appendix.					

Table 114. Older Subadult: Best Model Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Final Model ^a	Age	-24.643	2360.602	.000	1	.992	.000
	Min. Dia. of the Tibia	70.461	6023.602	.000	1	.991	3.989E30
	Max. Dia. of the Femur	50.795	4969.939	.000	1	.992	1.148E22
	Max. Clavicle Length	-7.185	753.153	.000	1	.992	.001
	Constant	-1158.899	97732.981	.000	1	.991	.000
a. Variable(s) entered on step 1: Age, Circ. of the Clavicle, Min. Dia. of the Tibia, Max. Dia. of the Femur, Max. Clavicle Length. b. The cut value is .500 Further information is in Table 114A, in the Appendix.							

Chapter 5

Discussion

An adult sample was examined to evaluate sexual dimorphism in the adult portion of the population. It was assumed that an absence or low level of adult sexual dimorphism would indicate that sexual dimorphism would be low, if not absent, in the subadult sample. However, this was not found to be the case in either the adult or subadult sample. Significant sexual dimorphism was found in both the adult and subadult sample. The following is a discussion of the results.

Discussion of the Adult Results

MANCOVA testing revealed that age was a significant covariate in every adult model that was evaluated, except for the model consisting of fibula measurements. According to the univariate F-tests, age had a significant effect on the following measurements: vertical diameter of the clavicle, maximum glenoid cavity breadth, maximum diameter of the humerus, circumference of the humerus, sagittal diameter of the radius, circumference of the ulna, transverse diameter of the femur, circumference of the femur, maximum diameter of the tibia at the nutrient foramen, and maximum epiphysis breadth of the proximal tibia. Age is most likely a significant covariate in this sample because growth was still occurring in the younger individuals of the adult sample. The lower age range in the adult sample begins at 18 years of age. Humphrey's (1998) research indicated that many long bone dimensions attain 90% of their adult size between the ages of 18 and 24 years. In Humphrey's (1998) study, these long bone dimensions are referred to as intermediate to very late growing variables. At approximately 18 years of age, the intermediate to late growing variables are completing growth, while the intermediate to very late growing variables have completed 90% of their

growth (Humphrey 1998). This may explain why age covaried with some of the measurements used in this study and not others. Most likely, the variables that were not correlated with age completed their growth prior to 18 years of age.

Humphrey (1998) classified the variables in this study as intermediate to late growing variables or intermediate to very late growing variables. Minimum diameter of the clavicle, maximum glenoid cavity breadth, maximum diameter of the humerus, and minimum femur diameter are classified as intermediate to very late growing variables (Humphrey 1998).

Humphrey (1998) did not include vertical diameter of the clavicle or transverse diameter of the femur, but these adult measurements are often the minimum diameters of the clavicle and femur, which Humphrey (1998) does include. The circumferences of the humerus, ulna and femur were also not included in Humphrey's (1998) study, but these measurements would probably be classified as intermediate to very late growing variables because of the correlation of circumference with minimum and maximum diameters. Humphrey (1998) classified the maximum diameter of the tibia as an intermediate to very late growing variable and the minimum diameter of the tibia as an intermediate to late growing variable.

Humphrey's (1998) tibia measurements were taken at the midshaft, while the minimum and maximum diameters of the tibia in this study were taken at the level of the nutrient foramen.

Most likely, the tibia measurements used in this study would also be classified as intermediate to very late growing variables. Humphrey (1998) classifies minimum and maximum diameter of the radius as intermediate to late growing variables, which suggests that the sagittal diameter of the radius would also be included in this category. Age only accounted for a small percentage of the variance in the measurements that were significantly correlated with age. The percentage of size variance may be small because these variables are

nearing the completion of their growth. At this point in the growth period, size is probably more correlated with sex than age.

The predictive accuracy of the models produced by the logistic regressions ranged from ~71-96%. The most accurate model (~96%) included 25 variables and was selected from all the skeletal measurements. See Table 37A in the Appendix for a comprehensive list of variables used in each step of this regression. This model accurately predicted the sex of 96.8% of the adult male sample and 95.9% of the female sample (Step 2 of Table 36A). However, the predictive accuracy of the final model selected from all the skeletal measurements only slightly decreased (94.1%) (Step 20 of Table 36A). The final model was a 7 variable model (Step 20 of Table 37A). Predictive accuracy of the female sample remained the same in the final model (95.9%), but only 91.9% of the male sample was accurately classified. The final model included clavicle length, vertical diameter of the clavicle, glenoid cavity breadth, transverse diameter of the ulna, anterior-posterior diameter of the femur, epicondylar breadth of the femur, and maximum epiphysis breadth of the proximal tibia (Step 20 of Table 37A). Although the predictive accuracy of the males was reduced, the model containing fewer variables may be a better choice than the more accurate model because it requires fewer variables, while maintaining an acceptable level of predictive accuracy.

Using the measurements from a single bone to predict sex gave varying results. Out of all the adult single bone models, the model using tibia measurements produced the most accurate classification. A model containing age, the maximum diameter of the tibia at the nutrient foramen, circumference of the tibia at the nutrient foramen, and maximum epiphysis breadth of the proximal tibia correctly predicted the sex of ~91% of the adult sample. The

maximum diameter of the tibia at the nutrient foramen was excluded from the final model because it was insignificant ($P=.549$), reducing the overall accuracy by ~1%. Although the maximum diameter of the tibia was insignificant in the model constructed from other tibia measurements, it was included in the final model chosen from all the skeletal measurements. The inclusion of the maximum diameter of the tibia in the most accurate tibia model and the model chosen from all the skeletal measurements suggests that the measurement has predictive power. However, the exclusion of the maximum diameter of the tibia from the final model chosen from the tibia measurements only decreased predictive accuracy by ~1%. This suggests that, when used in combination, tibia measurements have a high predictive power for adults. The data also suggest that the maximum diameter of the tibia at the nutrient foramen only significantly adds to the predictive power of a model when used in combination with other skeletal measurements.

The final model consisting of Group 2 measurements also performed well. The most accurate model selected from the Group 2 measurements correctly classified ~89% of the adult sample, with only a slight sex difference in predictive accuracy (Females ~90%, Males 87%). The variables in this model included glenoid cavity breadth, minimum diameter of the humerus, and epicondylar breadth of the humerus. The exclusion of the maximum diameter and circumference of the humerus from the final Group 2 model selected may be indicative of the measurements' overall low rank in comparison to the other humerus measurements. Out of the 22 possible ranks, maximum diameter of the humerus was 16th and circumference of the humerus was 10th. The minimum diameter of the humerus ranked 7th and epicondylar breadth of the humerus ranked 3rd. Although, glenoid cavity breadth is not a humerus measurement, it was included with this group because it articulates with the humerus.

Maximum glenoid cavity breadth was the highest ranking measurement (5th) in the Group 2 measurements. Glenoid cavity breadth was included in the final model selected from all skeletal measurements, which is suggestive of its high rank. No humerus measurements were included in the final model chosen from all the skeletal measurements. This may indicate that humerus measurements are good sex predictors in combination, but do not add any power to models that contain measurements from other long bones.

The most accurate model selected from the ulna measurements correctly sexed 89.2% of the adult sample. Approximately 91% of the females and ~87% of the males were correctly classified. The most accurate model included transverse diameter, dorso-volar diameter, and minimum circumference of the ulna. Although the minimum diameter of the ulna was the highest ranking (4th) ulna measurement in terms of sexual dimorphism, it was excluded from the final model. The exclusion of the minimum circumference of the ulna from the final model selected from the ulna measurements had little effect on the overall predictive accuracy. Male predictive accuracy was decreased to ~86%, but female predictive accuracy was not affected. This suggests that most of the information needed to predict sex using the ulna measurements can be taken from the transverse and dorso-volar diameters. Transverse diameter of the ulna was the only ulna measurement included in the final model selected from all the skeletal measurements.

Models using femur measurements were able to predict sex with 87 to 89% accuracy. The most accurate (89.2%) model chosen from the femur measurements included transverse diameter of the femur, circumference of the femur, and epicondylar breadth of the femur. Approximately 90% of females and ~88% of males were correctly classified using this model. The final model chosen from the femur measurements only included epicondylar

breadth, but was able to correctly classify 87.2% of the adult sample. Predictive accuracy of the females remained the same, but accuracy of the male classification dropped to ~84%. The predictive power of the epicondylar breadth of the femur is indicative of its rank.

Epicondylar breadth of the femur is the highest ranking measurement of all the measurements used in this study. These results indicate that the epicondylar breadth of the femur have a high predictive power. The anterior-posterior diameter of the femur is the lowest ranking (17th) measurement of all the femur measurements used in this study, which may explain its exclusion in Step 1 of the logistic regression. However, anterior-posterior diameter was included in the final model chosen from all the skeletal measurements. This suggests that the anterior-posterior diameter of the femur increases the predictive power of a model if it is combined with other long bone measurements.

The most accurate model chosen from the clavicle measurements correctly classified 87.4% of the adult sample. The model included maximum clavicle length, sagittal diameter of the clavicle, and vertical diameter of the clavicle. The predictive accuracy for the females was ~89% and ~87% for the males. Maximum clavicle length and vertical diameter of the clavicle were used in both the clavicle model and the most accurate model selected from all skeletal measurements. This suggests that combination of these two clavicle measurements increase the predictive power of a model.

The most accurate model chosen from the radius measurements correctly predicted the sex of ~85% of the adult sample, classifying ~86% of females and ~84% of males. This model included sagittal diameter and circumference of the radius. The only variable in the final model was sagittal diameter of the radius and correctly sexed ~83% of the adult sample. In the final model, both sexes experienced a reduction in predictive accuracy (Females ~84%,

Males ~83%). The final model selected from all skeletal measurements did not include any of the radius measurements. These results suggest that radius measurements work well together to predict sex, but may not be significant in a model containing measurements from other long bones.

The most accurate model selected from the fibula measurements had the lowest predictive accuracy (71.1%) of all the adult models evaluated in this study. Approximately 73% of females and ~69% of males were correctly classified. This model included all fibula measurements. Fibula measurements were not included in the final model selected from all skeletal measurements. The low predictive accuracy as well as the exclusion of the fibula measurements from the final model selected from all skeletal measurements indicates that the fibula is the worst long bone for predicting sex. This is also suggested by the fibula measurements' low ranks in comparison to other skeletal measurements. Fibula measurements were the lowest ranking in terms of sexual dimorphism.

Discussion of the Young Subadult (≤ 11 years) Results

Sex was a significant variable in the clavicle, radius, fibula, and possibly tibia models. Two MANCOVAs were performed on models containing tibia measurements. Sex was not a significant variable in the model containing all tibia measurements. However if maximum breadth of the proximal tibia was excluded from the model, sex was a significant variable. Most likely, the difference in significance is caused by the reduction of the young subadult sample size from 19 males and 22 females, to 15 males and 17 females, by the addition of the maximum breadth of the proximal tibia. Sex was not a significant variable in the models constructed from humerus, ulna, or femur measurements.

Tests of the between-subjects effects were evaluated to determine which measurements were responsible for the sexual dimorphism detected in each bone. Humphrey (1998) reported that sexual dimorphism in the maximum and a minimum diameter of the clavicle was detectable at birth. This study's results support Humphrey's (1998) findings. Sex differences were significant for the maximum diameter and circumference of the clavicle. The most accurate model chosen from the clavicle measurements correctly classified ~83% of the young subadult sample. The model was better at predicting the female sex (~87%) than the male sex (79%). The variables included in the model were age, maximum clavicle length, and maximum diameter of the clavicle. The odds ratio of the maximum diameter of the clavicle indicated that for every 1 unit increase in the measurement, the individual was 6 times more likely to be male. Maximum clavicle length was excluded from the final model because of its statistical insignificance, but its exclusion decreased the predictive accuracy of the model to ~76%. The final model was also better at predicting the female sex (80%) than the male sex (~71%).

Humphrey (1998) also reported that sexual dimorphism in the minimum and maximum diameter of the radius was observable at birth. In the present study, minimum diameter of the radius was significantly sexually dimorphic in the young subadult sample. The final model selected from the radius measurements accurately predicted the sex of ~82% of the young subadult sample. However, the overall percentage does not reflect the sex bias in predictive accuracy. In the final model, all females were accurately sexed, but only 61.5% of the males were correctly classified. The final model included age, maximum diameter, and minimum diameter of the radius. The odds ratio for minimum diameter of the radius was very high, indicating that for every unit of increase in the measurement the individual was 56

times more likely to be male. The odds ratio of the maximum diameter of the radius was not as impressive. However, the combination of the negative Beta and odds ratio indicate that the individual is .2 times less likely to be male for every 1 unit increase in the maximum diameter of the radius. This was not expected, since an increase in the size of a measurement is usually an indication of maleness. The negative Beta for the maximum diameter of the radius may indicate a greater female growth rate for the radius in comparison to males during this period or a sex difference in the diaphysis shape. The small sample size may also be responsible for the difference in predictive accuracy between the sexes. A small sample size may accentuate a small difference in age distribution between the sexes, but no significant age differences were found between the sexes of the sample. Nevertheless, the radius model appears to be better at predicting the sex of females than males in the young subadult sample.

Humphrey (1998) reports that sexual dimorphism can be observed by 2.3 years of age in the maximum diameter of the fibula and by 11.2 years in the minimum diameter of the fibula. These findings were supported by the results of the MANCOVA test performed on the model constructed from the fibula measurements and by the univariate F-tests. Sex was a significant variable in the overall model and significant sexual dimorphism was detected in the minimum diameter and circumference of the fibula. The final model selected by logistic regression accurately sexed ~72% of the young subadult sample and included age, maximum diameter, and circumference of the fibula. This model was more accurate at predicting the sex of young subadult females (80%) than males (62.5%). The odds ratio of the circumference of the fibula suggests that for every 1 unit increase in circumference, the individual is almost 4 times more likely to be male. The results also indicate that for every 1 unit increase in maximum diameter of the fibula, the individual is .055 times less likely to be

male. As previously mentioned, the negative Beta value for the maximum diameter of the fibula may indicate a difference in the growth rate or diaphysis shape between the sexes in the young subadults. Overall, fibula measurements are much more accurate at classifying females than males in this age group.

The results of the MANCOVA tests performed on the two models constructed from the tibia measurements produced contrasting results. Sex was a significant variable in the model excluding maximum breadth of the proximal tibia. According to the univariate F-tests conducted on this model, the maximum diameter, minimum diameter, and circumference of the tibia were significantly sexually dimorphic. If maximum breadth of the proximal tibia was included in the model, sex became an insignificant variable in the model. A Bonferroni correction was used to assess the significance of the tests of the between-subjects effects. No significant sex differences were detected in any of the tibia measurements in this model. Inclusion of the maximum breadth of the proximal tibia reduced the sample size in the second tibia model. Finding significant sexual dimorphism in the first tibia and not in the second indicates that the reduced sample size caused the insignificant results. Humphrey (1998) reported that sexual dimorphism was detectable in the maximum diameter of the tibia at 4.2 years and at 5.3 years for the minimum diameter. This also supports the conclusion that the reduced sample size is responsible for the lack of significant results.

The models selected from the tibia measurements by logistic regression also produced contrasting results. The final model selected from all tibia measurements, except maximum breadth of the proximal tibia included age, maximum diameter, minimum diameter, and circumference of the tibia. This model accurately sexed ~63% of the young subadult sample. However, the predictive accuracy for each sex was different (68.2% female, and 57.9%

male). The inclusion of maximum breadth of the proximal tibia reduced the sample size, but increased the accuracy of the model to ~72%. The predictive accuracy increased for both sexes, but the accuracy rate continued to favor females (~77% females, ~67% males). The increase in the predictive accuracy of the second model could be a factor of the reduced sample size because the odds ratios for the maximum and minimum diameters remained high in both models. The increase in the overall predictive power of the second model may also be caused by the combination of the maximum breadth of the proximal tibia with the other tibia measurements.

Results of the MANCOVA tests performed on two models constructed from Group 2 measurements revealed that sex was not a significant variable. Between-subjects effects tests were performed on the variables in both models. The first model did not include maximum breadth of the distal humerus. The significance of the univariate F-tests was assessed using a Bonferroni correction. Using this correction, significant sex differences were detected in the maximum breadth of the glenoid cavity. Humphrey (1998) reported that significant sexual dimorphism could be detected in maximum glenoid cavity breadth by 4.2 years. The second model included the maximum breadth of the distal humerus. In contrast to the previous results, maximum breadth of the glenoid cavity was not significantly sexually dimorphic. The lack of significant sexual dimorphism in the second model is most likely a factor of reduced sample size. The sample size in the first model included 13 females and 9 males, but was reduced to 9 males and 8 females in the second model. Humphrey (1998) also reported that significant sex differences were present in the maximum diameter of the humerus by birth and the minimum diameter of the humerus by ~1 year, but those results are not supported by

this study's findings. However, this could also be a factor of the small sample size used in this study.

To maximize sample size, three logistic regressions were performed on different models constructed from the humerus measurements. The most accurate model selected from the humerus measurements entered into the first logistic regression correctly classified 70% of the young subadult sample. A large difference in predictive accuracy was present between the sexes. Fifty percent of males and 83.3% of females were accurately sexed using the model produced by the first logistic regression. This model included age and minimum diameter of the humerus. The best model produced by the second logistic regression was completely different than the model produced by the first logistic regression. The second model was also more accurate at predicting sex. This model correctly classified ~77% of the young subadult sample. An increase in the predictive accuracy of the males in the young subadult sample is responsible for the increase in the overall accuracy of the second model. The sex of ~85% of the females and ~67% of the males was accurately predicted. It is likely that addition of the maximum glenoid cavity breadth to the second model is responsible for the increase in the male predictive accuracy. The model included age, minimum diameter of the humerus, circumference of the humerus, and maximum glenoid cavity breadth. The reduction of the sample size does not appear to have adversely affected the predictive capability of the second model. The third logistic regression included all humerus measurements, as well as maximum glenoid cavity breadth and maximum breadth of the distal humerus. All models produced by this logistic regression were 100% accurate. However, the validity of these results is highly questionable because the sample size has been reduced greatly. The sample size for the third logistic regression only included eight females

and five males. Sample size would have to be increased considerably before the results of any of the models produced by the third logistic regression could be discussed with any certainty.

Humphrey (1998) reported that sexual dimorphism in the maximum and minimum diameter of the ulna was present at birth. Although sex was not a significant variable in the model constructed from ulna measurements, Humphrey's (1998) conclusion was supported by the results of the univariate F-tests. A Bonferroni correction was used to assess the significance of the univariate F-tests. Significant sexual dimorphism was detected in the minimum diameter of the ulna, which lends some support to Humphrey's (1998) conclusions. However, the significance of minimum diameter of the ulna is not firmly supported because the MANCOVA test failed to detect it. The most accurate model produced by the logistic regression from the ulna measurements accurately sexed ~82% of the young subadult sample. The difference in the predictive accuracy between the sexes was highly skewed. This model accurately classified 100% of females and 61.5% of males and included age, maximum diameter, and minimum diameter of the ulna. The odds ratio of the minimum diameter of the ulna indicated that for every 1 unit increase in this measurement, the individual was 56 times more likely to be male. A negative Beta value was calculated for the maximum diameter of the ulna, possibly indicating a difference in the growth rate or diaphysis shape between the sexes in the young subadults.

The minimum and maximum diameter of the femur are also measurements that are reported to exhibit significant sexual dimorphism at birth (Humphrey 1998). The results of the MANCOVA tests performed on the models constructed from the femur measurements do not entirely support Humphrey's (1998) findings. MANCOVA tests were performed on 2

models. The first model excluded maximum breadth of the distal femur to maximize sample size, while the second included the measurement. Sex was not a significant variable in either model. A Bonferroni correction was used to assess the significance of the univariate F-tests performed on the variables in both models. Circumference of the femur at the midshaft was significantly sexually dimorphic in the first model, but was insignificant in the second model. Finding significant sex differences in the circumference of the femur lends some support to Humphrey's (1998) conclusions. The reduction of the sample size by the addition of the maximum breadth of the distal femur probably caused the sex differences in the circumference of the femur to become insignificant. Maximum breadth of the distal femur was significantly sexually dimorphic in the second model. Considering that the epicondylar breadth of the femur is the most sexually dimorphic measurement in the adults of this study, it was likely that this measurement would be sexually dimorphic in the subadults.

Two logistic regressions were performed on models constructed from the femur measurements. The first logistic regression selected a model from all femur measurements, excluding maximum breadth of the distal femur. The most accurate model (~65%) with the least number of variables included age, maximum diameter, minimum diameter, and circumference of the femur. The model accurately classified 56.5% of females and 72% of males. The second logistic regression included maximum breadth of the distal femur in Step 1 of the regression. The most accurate model (73%) with the least number of variables produced by the second logistic regression included age, minimum diameter of the femur, circumference of the femur, and maximum breadth of the distal femur. The model accurately sexed 64.7% of the females and 80% of the males in the sample. The predictive accuracies of the models suggest that the femur measurements are better at predicting males than females

in the young subadult sample. Although the reduction of the sample size is likely to be a factor in the increase in predictive accuracy, it is clear that the inclusion of maximum breadth of the distal femur adds to the predictive power of the model. The negative Beta for the minimum diameter of the humerus could indicate a sex difference in growth rate or diaphysis shape.

All models, except for the model constructed from femur measurements, were more accurate at predicting females than males in the young subadult sample. Femur measurements were better at predicting males. The difference in predictive accuracies between the sexes may have several causes. There may be a slight difference in the age distribution between the sexes in the young subadult sample causing one sex to be more accurately sexed than the other. However, no significant age differences were found between the sexes. Nevertheless, the sample size is small and even slight differences could affect the results. Another possibility is that the female growth rate is greater than the male growth rate in the young subadults, which is causing the increase in the female predictive accuracies. There may also be a sex difference in the diaphysis shape of the long bones. This is suggested by the difference in the signs of the betas of the maximum and minimum diameters. Most of the maximum diameters have a negative Beta. The femur is an exception. The minimum diameter of the femur had a negative Beta, while the maximum diameter had a positive Beta. Finally, the females in the young subadult sample may be less variable in long bone dimensions in comparison to the males in the sample causing a greater female accuracy in most of the models. However, this does not seem to be the case for the femur measurements.

A logistic regression was performed on a model constructed from different long bone measurements. Besides the model constructed from the clavicle measurements (~83%), this

model was the most accurate for predicting sex in the young subadult sample. The measurements were selected for inclusion into the model based on their availability to maximize the sample size. The sample size for this analysis included 12 females and 11 males. The variables entered in Step 1 of the logistic regression included age, maximum diameter of the clavicle, minimum diameter of the ulna, maximum diameter of the tibia, maximum diameter of the femur, and minimum diameter of the femur. This model was 91.3% accurate and correctly classified ~92% of females and 91% of males. Minimum diameter of the femur was excluded from the final model, but this decreased the predictive accuracy to 82.6%. The combination of upper limb and lower limb measurements may be responsible for the high degree of accuracy achieved, as well as the nearly equal predictive accuracies between the sexes. There is also a high probability that the small sample size contributed to the overall predictive accuracy.

Discussion of the Older Subadult (≥ 12 years) Results

MANCOVA tests detected more instances of significant sex differences in the older subadult sample than in the young subadult sample. Sex was a significant variable in models containing clavicle measurements, ulna measurements, femur measurements, tibia measurements, and fibula measurements. MANCOVA tests were performed on 3 different models constructed from Group 2 measurements. Sex was a significant variable in the first model, which excluded glenoid cavity breadth and maximum breadth of the distal humerus, but was not a significant variable in the second model (included maximum glenoid cavity breadth) or the third model (included maximum glenoid cavity breadth and maximum breadth of the distal humerus). The absence of a significant sex variable in the second and third models constructed from the Group 2 measurements is probably due to the reduced

sample size and not a truly insignificant result. The addition of maximum glenoid cavity breadth reduced the already small sample size. The use of glenoid cavity breadth and maximum breadth of the distal humerus reduced the older subadult sample even further. Lastly, sex was not a significant variable in the model constructed from radius measurements.

After establishing that sex was a significant variable in the clavicle model, results of the univariate F-tests were examined to determine which measurements were significantly sexually dimorphic. Statistical testing revealed that maximum clavicle length and maximum diameter of the clavicle were significantly sexually dimorphic. These measurements were also sexually dimorphic in the young subadult sample. The results also revealed significant sexual dimorphism in the minimum diameter of the clavicle, which was not detected in the young subadult sample. This may indicate that the minimum diameter of the clavicle becomes significantly more sexually dimorphic during the pubertal growth period. The predictive accuracy of the most accurate model constructed from clavicle measurements was very high (95.5%). All males and ~89% of females were accurately classified. The model included age, maximum clavicle length, and circumference of the clavicle. The increase in the predictive accuracy of the older subadult clavicle model, in comparison to the young subadult clavicle model, is probably caused by greater sexual dimorphism in the older subadults. The adult model only achieved a classification rate of ~87%, which suggests that the smaller size of the older subadult is inflating the predictive accuracy.

As was previously mentioned, sex was only a significant variable in the humerus model that excluded maximum glenoid cavity breadth and maximum breadth of the distal humerus. The univariate F-tests performed on the first model detected significant sex

differences in the minimum diameter of the humerus. A Bonferroni correction was used to assess the significance of the univariate F-tests performed on the variables in the models that contained glenoid cavity breadth, as well as glenoid cavity breadth and maximum breadth of the distal humerus. No significant sex differences were found for any of the measurements. The lack of a significant test for minimum diameter of the humerus in the second and third model can most likely be attributed to the reduction of the older subadult sample size. It is also likely that the reduction of the sample size caused glenoid cavity breadth to appear as if it was not sexually dimorphic because glenoid cavity breadth was sexually dimorphic in the young subadult group. It seems unlikely that glenoid cavity breadth would become less dimorphic as subadults age.

Logistic regressions were performed on the 3 humerus models previously mentioned. The final model chosen by the first logistic regression included age, maximum, and minimum diameters of the humerus. The overall predictive accuracy of this model was 84.2%. Difference in classification between the sexes was slight (80% male, 88.9% female). Accuracy increased to 94.4% with the addition of maximum glenoid cavity breadth in the second logistic regression. The increase in accuracy is due an increase in the accuracy of predicting males (100%), not females (87.5%). The most accurate model produced by the second logistic regression included age, maximum diameter of the humerus, minimum diameter of the humerus, and maximum glenoid cavity breadth. The increase in male predictive accuracy with the maximum glenoid cavity breadth suggests that glenoid cavity breadth is becoming more sexually dimorphic, although the size of the glenoid cavity may still be very variable in females. The hypothesis of an increase in the sexual dimorphism of the glenoid cavity is supported by a higher accuracy rate for the older subadults (~94%) and

adults (~89%) in comparison to the young subadults (82%). These results lend further support to the idea that small sample size caused sex differences in glenoid cavity breadth to be undetected in the older subadult data. This is also suggested by the glenoid cavity's important role in predicting sex in both subadult groups and the adult sample.

The third logistic regression selected a model from all of the Group 2 measurements. The final model was completely accurate at predicting sex and included age, maximum glenoid cavity breadth, and the humerus diameter ratio (maximum/minimum diameter). However, it is not likely that these results are valid because of the small sample size. The sample size used in the third logistic regression only included 5 females and 6 males. More testing with a larger sample size is necessary before it can be suggested that this model is highly accurate for predicting sex.

Sex was not a significant variable in the model constructed from radius measurements. Using a Bonferroni correction to evaluate significance, the results of the univariate F-tests did not reveal any further information. The small sample size is likely a factor in the insignificant results because sex was a significant variable in the radius models of both the young subadult and adult samples. It does not seem plausible that sexual dimorphism would be present in early life, decrease during adolescence, and then be present again during adulthood. However, the insignificant results in the older subadult sample are suggestive of the poor predictive capability of the radius measurements, but this could also be a factor of small sample size. The model selected from the radius measurements accurately classified ~73% of the older subadult sample. Fifty percent of the females and 85.7% of the males in the sample were correctly classified. This model consisted of maximum diameter, minimum diameter, and circumference of the radius. Yet, the adult

radius model was able to classify 84.8% of the adult sample, with nearly equal predictive accuracies between the sexes. Approximately 82% of the young subadult sample was accurately classified, but the difference in predictive accuracies between the sexes was highly skewed. Overall, it seems that Humphrey's (1998) conclusions regarding radius measurements are correct. Significant sex differences are detectable during early life and most of the radius growth appears to be completed by late adolescence to early adulthood. Only one radius measurement was significantly correlated with age and the amount of variation due to age was very small. Most likely the low predictive accuracies of the subadult samples are due to small sample size.

Results of the MANCOVA tests conducted on the ulna model indicate that sex is a significant variable in older subadults. In the young subadults, sex was not a significant variable in the ulna model. This could indicate that significant sexual dimorphism in ulna measurements is not detectable in subadults until puberty. The univariate F-tests of the ulna measurement taken on the older subadults found significant sex differences in minimum diameter and circumference of the ulna. A model containing the variables age, maximum diameter, minimum diameter, and circumference of the ulna accurately predicted the sex of 86.4% of the older subadult sample. Approximately 78% of females and 92% of males were accurately sexed. This accuracy is comparable to what was achieved in the adult sample (~89%) further indicating that a great deal of sexual dimorphism develops during the pubertal period. The most accurate model using the ulna measurements taken on the young subadults only achieved ~74% accuracy.

In the older subadult sample, sex was a significant variable in the model constructed from femur measurements. Tests of the between-subjects effects revealed the presence of

sexual dimorphism in the maximum diameter of the femur. This was not found to be the case in the younger subadult sample. Regarding the young subadult data, sex was not a significant variable in the femur model. However, examination of the univariate F-tests indicated significant sexual dimorphism in the circumference of the femur and maximum breadth of the distal femur of the young subadults. Nevertheless, the presence of sexual dimorphism in the young subadult sample is not certain because of the insignificant MANCOVA results. Overall, these results suggest that sexual dimorphism in the femur increases as subadults age and becomes detectable during puberty. Significant sexual dimorphism may be present in young subadults, but it may have been obscured by the small sample size.

Logistic regression results also support the idea that significant sexual dimorphism in the femur is present in the older subadults. A model including age, maximum diameter, minimum diameter, and circumference of the femur classified 83.3% of the older subadult sample. This was greater than the predictive accuracy achieved with the young subadult sample (73%), but less than in the adult sample (~89%). The steady increase in accuracy could suggest an increase in sexual dimorphism of the femur as age increases.

Univariate F-tests were performed on the tibia measurements of the older subadults after sex was found to be a significant variable in the tibia model. Maximum diameter, minimum diameter, and circumference were determined to be significantly sexually dimorphic. Significant sex differences were also detected in the maximum and minimum diameters of the tibia in the young subadult sample, but circumference was not significant. This suggests that the tibia is significantly sexually dimorphic during early childhood and continues to be significant throughout puberty and adulthood.

Due to a statistical problem with partial separation of the tibia measurements, all individual measurements could not be entered together into the first step of a logistic regression. In order to solve this problem, a ratio for maximum/minimum diameter of the tibia was used in place of the individual measurements. This allowed all tibia data to be entered into the first step. The most accurate model (100%) selected from the tibia measurements of the older subadults included age, circumference of the tibia, and maximum breadth of the proximal tibia. Although this model was completely accurate at predicting sex in the older subadults, the sample is small and uneven (8 females, 15 males). This accuracy is most certainly inflated. The model should be tested on a larger sample before any conclusions can be made.

Since partial separation was indicated, logistic regressions were also performed on separate models containing each tibia measurement to test how each tibia measurement would perform at predicting sex. The predictive accuracy for all models was considerably high. Age and maximum diameter of the tibia accurately classified ~79% of the older subadult sample. More specifically, the model accurately sexed ~78% of the females and ~80% of the males. The model including age and minimum diameter of the tibia correctly predicted the sex of 91.7% of the older subadult sample. The same degree of accuracy was achieved by a model containing age and circumference of the tibia. Both models correctly predicted the sex of ~89% of the females and ~93% of the males in the older subadult sample. The model containing age and maximum breadth of the proximal tibia performed poorly (69.6%) in comparison to the other tibia models. All males were accurately classified, but only ~13% of females were accurately sexed. The accuracy rates achieved by the separate models containing minimum diameter and circumference are comparable to the degree of

accuracy achieved by the most accurate adult model constructed from tibia measurements (~91%). Yet, the adult model constructed from tibia measurements required a combination of tibia measurements to achieve a high level of accuracy. The high predictive capabilities of the tibia measurements in the older subadult sample indicate a large increase in sexual dimorphism in tibia measurements during adolescence. This is also supported by the low predictive accuracy (~72%) of the tibia measurements in the young subadults in comparison to the older subadults. Furthermore, these results support Humphrey's (1998) conclusion that most tibia growth is completed by 18 years of age. Yet, it should be kept in mind that the sample size of the young subadult group is greater than that of the older subadult group, which probably affected predictive accuracy.

In older subadults, sex was a significant variable in the model constructed from fibula measurements. Sex was also a significant variable in young subadults and univariate F-tests revealed that minimum diameter and circumference of the fibula were significantly sexually dimorphic. Univariate F-tests of the fibula measurements taken on the older subadults also detected significant sexual dimorphism in the minimum diameter and circumference of the fibula. A model containing maximum diameter and circumference of the fibula accurately predicted the sex of 91.7% of the older subadult sample. This predictive accuracy was greater than what was achieved for the younger subadult sample (72.2%) and the adult sample (71.1%). Although the predictive accuracies of the young subadult and older subadult models are very different, the variables used in the model are almost identical. The young subadult fibula model was identical to the older subadult model, except the young subadult model included age. The most accurate adult fibula model contained minimum diameter and circumference of the fibula. The difference in accuracy between the samples suggests two

things. It could be an indication that sexual dimorphism in the fibula measurement increases during the pubertal period and then decreases at the onset of adulthood or it could mean that the high accuracy rate in the older subadult sample is simply inflated due to the small sample size. Most likely it is a problem with small sample size.

A model was constructed using measurements from several different bones of the body. The measurements were selected based on their ability to maximize the older subadult sample size. The variables entered into Step 1 of this regression included age, circumference of the clavicle, minimum diameter of the tibia, and maximum diameter of the femur. Approximately 91% of the older subadult sample was classified by a model including age and minimum diameter of the tibia. A second logistic regression was performed after maximum clavicle length was added to the variables used in Step 1 of the first logistic regression. The model chosen from the second logistic regression included maximum clavicle length, minimum diameter of the tibia, and maximum diameter of the femur. The model predicted sex with 100% accuracy in the older subadult sample. Although this model appears to be completely accurate for predicting sex, these results are probably not valid. The high degree of accuracy is most likely a factor of the small and uneven sample size. This model was tested on 9 females and 13 males. Testing the model on a larger sample size is necessary before predictive accuracy can be assessed. Yet, it is interesting that the best overall model chosen by the first logistic regression only included a single tibia measurement and age.

Overall, the results suggest that long bone measurements hold some promise for subadult sex determination. Before statements can be made with confidence regarding the level of accuracy that is possible for sex determination using long bone measurements, a

much larger sample size is necessary. As the National Museum of Natural History in Lisbon continues to add to the collection, this may be a possibility in the future. This research seems to suggest that clavicle, humerus, and tibia measurements have predictive capabilities in subadults, but this may be population specific. Also, it is not known if the degree of sexual dimorphism in this study's subadult sample is greater than the sexual dimorphism in other subadult samples. If this sample has a greater degree of sexual dimorphism than what is observed in other subadult samples, this research may not be a valid representation of the general existence of sexual dimorphism in subadults. Larger samples from other population will help address these issues. Investigators researching subadult sexual dimorphism should consider focusing their attention on long bone dimensions.

Although the subadult sample size is small, the results of this study are encouraging. More research on sexual dimorphism in long bone dimension of subadults should be conducted using a larger subadult sample. Utilizing the CAT Scans from living populations may solve the current problem of the small subadult sample sizes. Not only will the use of CAT Scans allow a larger data sample to be collected, but it will also allow the collection of data from different living populations. Utilizing data from living subjects or recently living subjects avoids the problems caused by developing standards from the remains of long deceased individuals. Due to secular change, the standards developed from long deceased individuals may not be valid on current populations. Furthermore, population variation in sexual dimorphism could be evaluated, while developing sex determination techniques.

Chapter 6

Conclusion

This research indicates that significant sexual dimorphism can be found in the long bone dimensions of subadults. As sexual dimorphism increases, accuracy should increase for predicting sex. In most cases, the probabilities for accurately predicting sex in the older subadult models were greater than the probabilities for the young subadult models, but accuracy varied greatly depending on the long bone used. Clavicle measurements proved to be fairly accurate predictors of sex for the subadults in this sample. Models constructed from clavicle measurements correctly sexed ~83% of the young subadult sample and ~95% of the older subadult sample. Regarding the older subadults, measurements of the humerus, tibia, and ulna were fairly accurate sex predictors. Humerus measurements correctly classified ~94% the older subadult sample. Approximately 92% of the older subadult sample was accurately sexed using age and the minimum diameter of the tibia or circumference of the tibia. Overall, the most accurate models for sexing adults and subadults were constructed from the measurements of several long bones.

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Appendix

Tables 9A-137A are the complete data from which the tables that appear in the body of the thesis are condensed.

Table 9A. Adult: Group 1 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Clavicle Length	8809.211 ^a	2	4404.605	58.484	.000
	Sag. Dia. of the Clavicle	154.195 ^b	2	77.098	51.445	.000
	Vert. Dia. of the Clavicle	131.027 ^c	2	65.514	53.459	.000
	Circ. of the Clavicle	1273.053 ^d	2	636.527	63.318	.000
Intercept	Max. Clavicle Length	384021.444	1	384021.444	5099.038	.000
	Sag. Dia. of the Clavicle	2457.764	1	2457.764	1639.981	.000
	Vert. Dia. of the Clavicle	1208.065	1	1208.065	985.787	.000
	Circ. of the Clavicle	19654.162	1	19654.162	1955.071	.000
Age	Max. Clavicle Length	112.244	1	112.244	1.490	.224
	Sag. Dia. of the Clavicle	.116	1	.116	.077	.781
	Vert. Dia. of the Clavicle	12.225	1	12.225	9.976	.002
	Circ. of the Clavicle	18.061	1	18.061	1.797	.182
Sex	Max. Clavicle Length	8627.318	1	8627.318	114.554	.000
	Sag. Dia. of the Clavicle	153.668	1	153.668	102.538	.000
	Vert. Dia. of the Clavicle	121.066	1	121.066	98.791	.000
	Circ. of the Clavicle	1263.149	1	1263.149	125.650	.000
Error	Max. Clavicle Length	14083.442	187	75.313		
	Sag. Dia. of the Clavicle	280.248	187	1.499		
	Vert. Dia. of the Clavicle	229.165	187	1.225		
	Circ. of the Clavicle	1879.895	187	10.053		
Total	Max. Clavicle Length	3795772.000	190			
	Sag. Dia. of the Clavicle	24995.918	190			
	Vert. Dia. of the Clavicle	15027.014	190			
	Circ. of the Clavicle	213808.750	190			
Corrected Total	Max. Clavicle Length	22892.653	189			
	Sag. Dia. of the Clavicle	434.443	189			
	Vert. Dia. of the Clavicle	360.193	189			
	Circ. of the Clavicle	3152.949	189			
a. R Squared = .385 (Adjusted R Squared = .378)						
b. R Squared = .355 (Adjusted R Squared = .348)						
c. R Squared = .364 (Adjusted R Squared = .357)						
d. R Squared = .404 (Adjusted R Squared = .397)						

Table 10A. Adult: Group 1 Correlations

		Age	Max. Clavicle Length	Sag. Dia. of the Clavicle	Vert. Dia. of the Clavicle	Circ. of the Clavicle
Age	Pearson Correlation	1.000	-.087	-.034	.176*	.060
	Sig. (2-tailed)		.230	.638	.013	.404
	N	204.000	191	196	197	197
Max. Clavicle Length	Pearson Correlation	-.087	1.000	.543**	.509**	.551**
	Sig. (2-tailed)	.230		.000	.000	.000
	N	191	191.000	190	191	191
Sag. Dia. of the Clavicle	Pearson Correlation	-.034	.543**	1.000	.488**	.838**
	Sig. (2-tailed)	.638	.000		.000	.000
	N	196	190	196.000	196	196
Vert. Dia. of the Clavicle	Pearson Correlation	.176*	.509**	.488**	1.000	.806**
	Sig. (2-tailed)	.013	.000	.000		.000
	N	197	191	196	197.000	197
Circ. of the Clavicle	Pearson Correlation	.060	.551**	.838**	.806**	1.000
	Sig. (2-tailed)	.404	.000	.000	.000	
	N	197	191	196	197	197.000
*. Correlation is significant at the 0.05 level (2-tailed).						
**. Correlation is significant at the 0.01 level (2-tailed).						

Table 11A. Adult: Group 2 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. breadth of the Glenoid Cavity	570.978 ^a	2	285.489	89.185	.000
	Max. Dia. of the Humerus	261.346 ^b	2	130.673	52.319	.000
	Min. Dia. of the Humerus	268.091 ^c	2	134.046	74.921	.000
	Circ. of the Humerus	2382.055 ^d	2	1191.027	65.412	.000
	Epicondylar Breadth o f the Humerus	2242.374 ^e	2	1121.187	89.585	.000
Intercept	Max. breadth of the Glenoid Cavity	8671.261	1	8671.261	2708.856	.000
	Max. Dia. of the Humerus	5581.989	1	5581.989	2234.911	.000
	Min. Dia. of the Humerus	3798.428	1	3798.428	2123.020	.000
	Circ. of the Humerus	49330.518	1	49330.518	2709.249	.000
	Epicondylar Breadth o f the Humerus	44475.450	1	44475.450	3553.692	.000
Age	Max. breadth of the Glenoid Cavity	26.779	1	26.779	8.366	.004
	Max. Dia. of the Humerus	40.943	1	40.943	16.393	.000
	Min. Dia. of the Humerus	4.232	1	4.232	2.365	.126
	Circ. of the Humerus	194.877	1	194.877	10.703	.001
	Epicondylar Breadth o f the Humerus	45.308	1	45.308	3.620	.059
Sex	Max. breadth of the Glenoid Cavity	553.324	1	553.324	172.855	.000
	Max. Dia. of the Humerus	227.976	1	227.976	91.277	.000
	Min. Dia. of the Humerus	266.185	1	266.185	148.776	.000
	Circ. of the Humerus	2237.915	1	2237.915	122.907	.000
	Epicondylar Breadth o f the Humerus	2219.535	1	2219.535	177.346	.000
Error	Max. breadth of the Glenoid Cavity	518.575	162	3.201		
	Max. Dia. of the Humerus	404.617	162	2.498		
	Min. Dia. of the Humerus	289.844	162	1.789		
	Circ. of the Humerus	2949.727	162	18.208		
	Epicondylar Breadth o f the Humerus	2027.475	162	12.515		

Table 11A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total	Max. breadth of the Glenoid Cavity	102391.185	165			
	Max. Dia. of the Humerus	69623.984	165			
	Min. Dia. of the Humerus	43139.744	165			
	Circ. of the Humerus	590187.250	165			
	Epicondylar Breadth o f the Humerus	502328.419	165			
Corrected Total	Max. breadth of the Glenoid Cavity	1089.553	164			
	Max. Dia. of the Humerus	665.963	164			
	Min. Dia. of the Humerus	557.936	164			
	Circ. of the Humerus	5331.782	164			
	Epicondylar Breadth o f the Humerus	4269.849	164			
a. R Squared = .524 (Adjusted R Squared = .518) b. R Squared = .392 (Adjusted R Squared = .385) c. R Squared = .481 (Adjusted R Squared = .474) d. R Squared = .447 (Adjusted R Squared = .440) e. R Squared = .525 (Adjusted R Squared = .519)						

Table 12A. Adult Group 2 Correlations

		Age	Max. Glenoid Cavity Breadth	Max. Dia. of the Humeru s	Min. Dia. of the Humerus	Circ. of the Humeru s	Epicondylar Breadth o f the Humerus
Age	Pearson Correlation	1.000	.153*	.255**	.114	.203**	.075
	Sig. (2-tailed)		.033	.000	.111	.004	.331
	N	204.000	193	197	197	197	172
Max. Glenoid Cavity breadth	Pearson Correlation	.153*	1.000	.681**	.764**	.753**	.801**
	Sig. (2-tailed)	.033		.000	.000	.000	.000
	N	193	193.000	189	189	189	165
Max. Dia. of the Humerus	Pearson Correlation	.255**	.681**	1.000	.752**	.941**	.708**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	197	189	197.000	197	197	172
Min. Dia. of the Humerus	Pearson Correlation	.114	.764**	.752**	1.000	.877**	.723**
	Sig. (2-tailed)	.111	.000	.000		.000	.000
	N	197	189	197	197.000	197	172
Circ. of the Humerus	Pearson Correlation	.203**	.753**	.941**	.877**	1.000	.748**
	Sig. (2-tailed)	.004	.000	.000	.000		.000
	N	197	189	197	197	197.000	172
Epicondylar Breadth of the Humerus	Pearson Correlation	.075	.801**	.708**	.723**	.748**	1.000
	Sig. (2-tailed)	.331	.000	.000	.000	.000	
	N	172	165	172	172	172	172.000
*. Correlation is significant at the 0.05 level (2-tailed).							
**. Correlation is significant at the 0.01 level (2-tailed).							

Table 13A. Adult Group 3 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Tran. Dia. of the Radius	135.390 ^a	2	67.695	39.157	.000
	Sag. Dia. of the Radius	161.381 ^b	2	80.691	96.109	.000
	Circ. of the Radius	1285.960 ^c	2	642.980	72.000	.000
Intercept	Tran. Dia. of the Radius	3451.741	1	3451.741	1996.589	.000
	Sag. Dia. of the Radius	1827.385	1	1827.385	2176.570	.000
	Circ. of the Radius	26989.402	1	26989.402	3022.218	.000
Age	Tran. Dia. of the Radius	5.050	1	5.050	2.921	.089
	Sag. Dia. of the Radius	10.713	1	10.713	12.760	.000
	Circ. of the Radius	67.380	1	67.380	7.545	.007
Sex	Tran. Dia. of the Radius	131.432	1	131.432	76.024	.000
	Sag. Dia. of the Radius	152.407	1	152.407	181.530	.000
	Circ. of the Radius	1230.901	1	1230.901	137.834	.000
Error	Tran. Dia. of the Radius	337.120	195	1.729		
	Sag. Dia. of the Radius	163.716	195	.840		
	Circ. of the Radius	1741.414	195	8.930		
Total	Tran. Dia. of the Radius	39202.988	198			
	Sag. Dia. of the Radius	22274.672	198			
	Circ. of the Radius	312352.000	198			
Corrected Total	Tran. Dia. of the Radius	472.510	197			
	Sag. Dia. of the Radius	325.098	197			
	Circ. of the Radius	3027.374	197			
a. R Squared = .287 (Adjusted R Squared = .279)						
b. R Squared = .496 (Adjusted R Squared = .491)						
c. R Squared = .425 (Adjusted R Squared = .419)						

Table 14A. Adult: Group 3 Correlations

		Age	Tran. Dia. of the Radius	Sag. Dia. of the Radius	Circ. of the Radius
Age	Pearson Correlation	1.000	.092	.166*	.135
	Sig. (2-tailed)		.200	.019	.058
	N	204.000	198	198	198
Tran. Dia. of the Radius	Pearson Correlation	.092	1.000	.690**	.913**
	Sig. (2-tailed)	.200		.000	.000
	N	198	198.000	198	198
Sag. Dia. of the Radius	Pearson Correlation	.166*	.690**	1.000	.857**
	Sig. (2-tailed)	.019	.000		.000
	N	198	198	198.000	198
Circ. of the Radius	Pearson Correlation	.135	.913**	.857**	1.000
	Sig. (2-tailed)	.058	.000	.000	
	N	198	198	198	198.000
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 15A. Adult: Group 4 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Tran. Dia. of the Ulna	321.229 ^a	2	160.614	95.448	.000
	Dorso-Volar Dia. of the Ulna	225.971 ^b	2	112.986	86.653	.000
	Min. Circ. of the Ulna	2652.355 ^c	2	1326.177	111.768	.000
Intercept	Tran. Dia. of the Ulna	3890.914	1	3890.914	2312.236	.000
	Dorso-Volar Dia. of the Ulna	2105.060	1	2105.060	1614.459	.000
	Min. Circ. of the Ulna	29901.221	1	29901.221	2520.028	.000
Age	Tran. Dia. of the Ulna	5.621	1	5.621	3.341	.069
	Dorso-Volar Dia. of the Ulna	5.700	1	5.700	4.372	.038
	Min. Circ. of the Ulna	140.198	1	140.198	11.816	.001
Sex	Tran. Dia. of the Ulna	317.797	1	317.797	188.856	.000
	Dorso-Volar Dia. of the Ulna	222.152	1	222.152	170.378	.000
	Min. Circ. of the Ulna	2544.692	1	2544.692	214.463	.000
Error	Tran. Dia. of the Ulna	323.088	192	1.683		
	Dorso-Volar Dia. of the Ulna	250.345	192	1.304		
	Min. Circ. of the Ulna	2278.163	192	11.865		
Total	Tran. Dia. of the Ulna	44585.942	195			
	Dorso-Volar Dia. of the Ulna	24848.046	195			
	Min. Circ. of the Ulna	361797.000	195			
Corrected Total	Tran. Dia. of the Ulna	644.317	194			
	Dorso-Volar Dia. of the Ulna	476.316	194			
	Min. Circ. of the Ulna	4930.518	194			
a. R Squared = .499 (Adjusted R Squared = .493)						
b. R Squared = .474 (Adjusted R Squared = .469)						
c. R Squared = .538 (Adjusted R Squared = .533)						

Table 16A. Adult: Group 4 Correlations

		Age	Tran. Dia. of the Ulna	Dorso-Volar Dia. of the Ulna	Min. Circ. of the Ulna
Age	Pearson Correlation	1.000	.073	.090	.148*
	Sig. (2-tailed)		.311	.213	.039
	N	204.000	195	195	195
Tran. Dia. of the Ulna	Pearson Correlation	.073	1.000	.804**	.951**
	Sig. (2-tailed)	.311		.000	.000
	N	195	195.000	195	195
Dorso-Volar Dia. of the Ulna	Pearson Correlation	.090	.804**	1.000	.907**
	Sig. (2-tailed)	.213	.000		.000
	N	195	195	195.000	195
Min. Circ. of the Ulna	Pearson Correlation	.148*	.951**	.907**	1.000
	Sig. (2-tailed)	.039	.000	.000	
	N	195	195	195	195.000
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 17A. Adult: Group 5 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Anterio-Posterior Dia. of the Femur	501.934 ^a	2	250.967	47.667	.000
	Tran. Dia. of the Femur	392.018 ^b	2	196.009	50.949	.000
	Circ. of the Femur	3887.063 ^c	2	1943.531	66.284	.000
	Epicondylar Breadth of the Femur	3834.937 ^d	2	1917.468	130.702	.000
Intercept	Anterio-Posterior Dia. of the Femur	13325.709	1	13325.709	2530.973	.000
	Tran. Dia. of the Femur	9974.275	1	9974.275	2592.635	.000
	Circ. of the Femur	116888.644	1	116888.644	3986.451	.000
	Epicondylar Breadth of the Femur	105214.948	1	105214.948	7171.861	.000
Age	Anterio-Posterior Dia. of the Femur	12.838	1	12.838	2.438	.120
	Tran. Dia. of the Femur	122.743	1	122.743	31.905	.000
	Circ. of the Femur	286.202	1	286.202	9.761	.002
	Epicondylar Breadth of the Femur	13.673	1	13.673	.932	.336
Sex	Anterio-Posterior Dia. of the Femur	492.016	1	492.016	93.449	.000
	Tran. Dia. of the Femur	276.334	1	276.334	71.828	.000
	Circ. of the Femur	3639.323	1	3639.323	124.118	.000
	Epicondylar Breadth of the Femur	3828.751	1	3828.751	260.983	.000
Error	Anterio-Posterior Dia. of the Femur	1010.890	192	5.265		
	Tran. Dia. of the Femur	738.654	192	3.847		
	Circ. of the Femur	5629.724	192	29.321		
	Epicondylar Breadth of the Femur	2816.740	192	14.671		

Table 17A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total	Anterio-Posterior Dia. of the Femur	146368.653	195			
	Tran. Dia. of the Femur	126269.739	195			
	Circ. of the Femur	1324471.500	195			
	Epicondylar Breadth of the Femur	1109217.539	195			
Corrected Total	Anterio-Posterior Dia. of the Femur	1512.825	194			
	Tran. Dia. of the Femur	1130.672	194			
	Circ. of the Femur	9516.787	194			
	Epicondylar Breadth of the Femur	6651.677	194			
a. R Squared = .332 (Adjusted R Squared = .325) b. R Squared = .347 (Adjusted R Squared = .340) c. R Squared = .408 (Adjusted R Squared = .402) d. R Squared = .577 (Adjusted R Squared = .572)						

Table 18A. Adult: Group 5 Correlations

		Age	Anterio- Posterior Dia. of the Femur	Tran. Dia. of the Femur	Circ. of the Femur	Epicondylar Breadth of the Femur
Age	Pearson Correlation	1.000	.086	.321**	.166*	.030
	Sig. (2-tailed)		.225	.000	.018	.672
	N	204.000	203	203	203	195
Anterio-Posterior Dia. of the Femur	Pearson Correlation	.086	1.000	.539**	.886**	.691**
	Sig. (2-tailed)	.225		.000	.000	.000
	N	203	203.000	203	203	195
Tran. Dia. of the Femur	Pearson Correlation	.321**	.539**	1.000	.828**	.619**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	203	203	203.000	203	195
Circ. of the Femur	Pearson Correlation	.166*	.886**	.828**	1.000	.758**
	Sig. (2-tailed)	.018	.000	.000		.000
	N	203	203	203	203.000	195
Epicondylar Breadth of the Femur	Pearson Correlation	.030	.691**	.619**	.758**	1.000
	Sig. (2-tailed)	.672	.000	.000	.000	
	N	195	195	195	195	195.000
**. Correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						

Table 19A. Adult: Group 6 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max Dia. of the Tibia at the Nutrient Foramen	1255.178 ^a	2	627.589	84.941	.000
	Tran. Dia. of the Tibia at the Nutrient Foramen	465.119 ^b	2	232.560	43.098	.000
	Circ. of the Tibia at the Nutrient Foramen	7366.802 ^c	2	3683.401	76.939	.000
	Max. Epiphysis Breadth of the Proximal Tibia	3167.124 ^d	2	1583.562	123.970	.000
Intercept	Max Dia. of the Tibia at the Nutrient Foramen	17600.018	1	17600.018	2382.072	.000
	Tran. Dia. of the Tibia at the Nutrient Foramen	9538.952	1	9538.952	1767.745	.000
	Circ. of the Tibia at the Nutrient Foramen	135317.766	1	135317.766	2826.535	.000
	Max. Epiphysis Breadth of the Proximal Tibia	83854.679	1	83854.679	6564.604	.000
Age	Max Dia. of the Tibia at the Nutrient Foramen	34.451	1	34.451	4.663	.032
	Tran. Dia. of the Tibia at the Nutrient Foramen	.000	1	.000	.000	.995
	Circ. of the Tibia at the Nutrient Foramen	41.250	1	41.250	.862	.355
	Max. Epiphysis Breadth of the Proximal Tibia	53.596	1	53.596	4.196	.042
Sex	Max Dia. of the Tibia at the Nutrient Foramen	1211.686	1	1211.686	163.995	.000
	Tran. Dia. of the Tibia at the Nutrient Foramen	464.906	1	464.906	86.156	.000
	Circ. of the Tibia at the Nutrient Foramen	7299.541	1	7299.541	152.474	.000
	Max. Epiphysis Breadth of the Proximal Tibia	3095.217	1	3095.217	242.311	.000
Error	Max Dia. of the Tibia at the Nutrient Foramen	1344.713	182	7.389		
	Tran. Dia. of the Tibia at the Nutrient Foramen	982.092	182	5.396		
	Circ. of the Tibia at the Nutrient Foramen	8713.084	182	47.874		
	Max. Epiphysis Breadth of the Proximal Tibia	2324.824	182	12.774		

Table 19A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total	Max Dia. of the Tibia at the Nutrient Foramen	199806.218	185			
	Tran. Dia. of the Tibia at the Nutrient Foramen	99935.120	185			
	Circ. of the Tibia at the Nutrient Foramen	1459476.000	185			
	Max. Epiphysis Breadth of the Proximal Tibia	913448.533	185			
Corrected Total	Max Dia. of the Tibia at the Nutrient Foramen	2599.891	184			
	Tran. Dia. of the Tibia at the Nutrient Foramen	1447.212	184			
	Circ. of the Tibia at the Nutrient Foramen	16079.886	184			
	Max. Epiphysis Breadth of the Proximal Tibia	5491.948	184			
a. R Squared = .483 (Adjusted R Squared = .477) b. R Squared = .321 (Adjusted R Squared = .314) c. R Squared = .458 (Adjusted R Squared = .452) d. R Squared = .577 (Adjusted R Squared = .572)						

Table 20A. Adult: Group 7 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Fibula	69.206 ^a	2	34.603	15.257	.000
	Min. Dia. of the Fibula	77.625 ^b	2	38.813	25.309	.000
	Cir. of the Fibula	688.601 ^c	2	344.301	25.917	.000
Intercept	Max. Dia. of the Fibula	3658.014	1	3658.014	1612.853	.000
	Min. Dia. of the Fibula	1881.368	1	1881.368	1226.780	.000
	Cir. of the Fibula	29100.404	1	29100.404	2190.523	.000
Age	Max. Dia. of the Fibula	.006	1	.006	.002	.960
	Min. Dia. of the Fibula	2.411	1	2.411	1.572	.211
	Cir. of the Fibula	16.347	1	16.347	1.230	.269
Sex	Max. Dia. of the Fibula	69.086	1	69.086	30.461	.000
	Min. Dia. of the Fibula	76.016	1	76.016	49.568	.000
	Cir. of the Fibula	678.399	1	678.399	51.066	.000
Error	Max. Dia. of the Fibula	440.000	194	2.268		
	Min. Dia. of the Fibula	297.515	194	1.534		
	Cir. of the Fibula	2577.228	194	13.285		
Total	Max. Dia. of the Fibula	38459.902	197			
	Min. Dia. of the Fibula	21261.071	197			
	Cir. of the Fibula	319578.810	197			
Corrected Total	Max. Dia. of the Fibula	509.206	196			
	Min. Dia. of the Fibula	375.140	196			
	Cir. of the Fibula	3265.829	196			
a. R Squared = .136 (Adjusted R Squared = .127)						
b. R Squared = .207 (Adjusted R Squared = .199)						
c. R Squared = .211 (Adjusted R Squared = .203)						

Table 22A. Adult: Group 1 Classification Tablea

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Step 1	Sex	F	88	11	88.9
		M	13	78	85.7
		Overall Percentage			87.4
Step 2	Sex	F	88	11	88.9
		M	13	78	85.7
		Overall Percentage			87.4
a. The cut value is .500					

Table 23A. Adult: Group 1 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Max. Clav. Length	.119	.030	16.089	1	.000	1.127
	Sag. Dia. of the Clavicle	.809	.373	4.701	1	.030	2.246
	Vert. Dia. of the Clavicle	.914	.365	6.276	1	.012	2.494
	Circ. of the Clavicle	-.059	.193	.094	1	.759	.942
	Constant	-32.219	4.800	45.060	1	.000	.000
Step 2 ^a	Max. Clav. Length	.121	.030	16.585	1	.000	1.128
	Sag. Dia. of the Clavicle	.711	.196	13.145	1	.000	2.037
	Vert. Dia. of the Clavicle	.823	.209	15.484	1	.000	2.276
	Constant	-32.445	4.765	46.362	1	.000	.000
a. Variable(s) entered on step 1: Max. Clav. Length, Sag. Dia. of the Clavicle, Vert. Dia. of the Clavicle, Circ. of the Clavicle.							

Table 24A. Adult: Group 2 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	79	9	89.8
		M	10	67	87.0
		Overall Percentage			88.5
Step 2	Sex	F	79	9	89.8
		M	10	67	87.0
		Overall Percentage			88.5
Step 3	Sex	F	79	9	89.8
		M	10	67	87.0
		Overall Percentage			88.5

a. The cut value is .500

Table 25A. Adult: Group 2 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Glenoid Cavity Breadth	.363	.197	3.387	1	.066	1.437
	Max. Dia. of the Humerus	-.128	.418	.094	1	.759	.880
	Min. Dia. of the Humerus	.862	.386	5.001	1	.025	2.368
	Circ. of the Humerus	-.037	.219	.028	1	.866	.964
	Epicondylar Breadth of the Humerus	.316	.095	11.118	1	.001	1.372
	Constant	-35.690	5.493	42.209	1	.000	.000
Step 2 ^a	Glenoid Cavity Breadth	.358	.195	3.372	1	.066	1.431
	Max. Dia. of the Humerus	-.190	.208	.827	1	.363	.827
	Min. Dia. of the Humerus	.818	.281	8.488	1	.004	2.266
	Epicondylar Breadth of the Humerus	.316	.095	11.117	1	.001	1.372
	Constant	-35.816	5.452	43.152	1	.000	.000
Step 3 ^a	Glenoid Cavity Breadth	.334	.194	2.947	1	.086	1.396
	Min. Dia. of the Humerus	.725	.257	7.975	1	.005	2.064
	Epicondylar Breadth of the Humerus	.296	.092	10.422	1	.001	1.344
	Constant	-36.456	5.428	45.109	1	.000	.000

a. Variable(s) entered on step 1: Glenoid Cavity Breadth, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Epicondylar Breadth of the Humerus.

Table 26A. Adult: Group 3 Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	87	14	86.1
		M	16	81	83.5
		Overall Percentage			84.8
Step 2	Sex	F	87	14	86.1
		M	16	81	83.5
		Overall Percentage			84.8
Step 3	Sex	F	85	16	84.2
		M	17	80	82.5
		Overall Percentage			83.3
a. The cut value is .500					

Table 27A Adult: Group 3 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Tran. Dia. of the Radius	.038	.347	.012	1	.914	1.038
	Sag. Dia. of the Radius	1.732	.399	18.883	1	.000	5.651
	Circ. of the Radius	.109	.183	.350	1	.554	1.115
	Constant	-22.977	3.202	51.497	1	.000	.000
Step 2 ^a	Sag. Dia. of the Radius	1.716	.374	21.044	1	.000	5.565
	Circ. of the Radius	.126	.097	1.663	1	.197	1.134
	Constant	-22.960	3.196	51.608	1	.000	.000
Step 3 ^a	Sag. Dia. of the Radius	2.055	.282	52.937	1	.000	7.807
	Constant	-21.538	2.945	53.486	1	.000	.000
a. Variable(s) entered on step 1: Tran. Dia. of the Radius, Sag. Dia. of the Radius, Circ. of the Radius.							

Table 30A. Adult: Group 5 Classification Table^a

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	92	10	90.2
		M	11	82	88.2
		Overall Percentage			89.2
Step 2	Sex	F	92	10	90.2
		M	11	82	88.2
		Overall Percentage			89.2
Step 3	Sex	F	92	10	90.2
		M	13	80	86.0
		Overall Percentage			88.2
Step 4	Sex	F	92	10	90.2
		M	15	78	83.9
		Overall Percentage			87.2

a. The cut value is .500

Table 31A. Adult: Group 5 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Anterior-Posterior Dia. of the Femur	.030	.259	.013	1	.909	1.030
	Tran. Dia. of the Femur	-.165	.266	.384	1	.535	.848
	Circ. of the Femur	.087	.164	.281	1	.596	1.091
	Epicondylar Breadth of the Femur	.461	.080	33.392	1	.000	1.586
	Constant	-38.486	5.077	57.454	1	.000	.000
Step 2 ^a	Tran. Dia. of the Femur	-.187	.182	1.056	1	.304	.829
	Circ. of the Femur	.103	.077	1.811	1	.178	1.109
	Epicondylar Breadth of the Femur	.461	.080	33.433	1	.000	1.586
	Constant	-38.482	5.073	57.548	1	.000	.000
Step 3 ^a	Circ. of the Femur	.047	.053	.783	1	.376	1.048
	Epicondylar Breadth of the Femur	.458	.079	33.753	1	.000	1.580
	Constant	-38.293	5.025	58.077	1	.000	.000
Step 4 ^a	Epicondylar Breadth of the Femur	.500	.066	58.099	1	.000	1.649
	Constant	-37.677	4.927	58.470	1	.000	.000

a. Variable(s) entered on step 1: Anterior-Posterior Dia. of the Femur, Tran. Dia. of the Femur, Circ. of the Femur, Epicondylar Breadth of the Femur.

Table 32A. Adult: Group 6 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Step 1	Sex	F	86	8	91.5
		M	10	81	89.0
		Overall Percentage			90.3
Step 2	Sex	F	86	8	91.5
		M	9	82	90.1
		Overall Percentage			90.8
Step 3	Sex	F	85	9	90.4
		M	10	81	89.0
		Overall Percentage			89.7
a. The cut value is .500					

Table 33A. Adult: Group 6 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Max. Dia. of the Tibia at the Nutrient Foramen	.149	.250	.353	1	.552	1.160
	Tran. Dia. of the Tibia at the Nutrient Foramen	.036	.208	.031	1	.861	1.037
	Circ. of the Tibia at the Nutrient Foramen	.076	.140	.293	1	.588	1.079
	Max. Epiphysis Breadth of the Proximal Tibia	.406	.081	25.129	1	.000	1.500
	Constant	-40.838	5.894	48.002	1	.000	.000
Step 2 ^a	Max. Dia. of the Tibia at the Nutrient Foramen	.125	.208	.359	1	.549	1.133
	Circ. of the Tibia at the Nutrient Foramen	.095	.089	1.128	1	.288	1.099
	Max. Epiphysis Breadth of the Proximal Tibia	.406	.081	25.242	1	.000	1.501
	Constant	-40.908	5.889	48.253	1	.000	.000
Step 3 ^a	Circ. of the Tibia at the Nutrient Foramen	.141	.046	9.469	1	.002	1.151
	Max. Epiphysis Breadth of the Proximal Tibia	.416	.080	27.101	1	.000	1.516
	Constant	-41.606	5.849	50.606	1	.000	.000
a. Variable(s) entered on step 1: Max. Dia. of the Tibia at the Nutrient Foramen, Tran. Dia. of the Tibia at the Nutrient Foramen, Circ. of the Tibia at the Nutrient Foramen, Max. Epiphysis Breadth of the Proximal Tibia.							

Table 36A. Adult: All Measurements Classification Table^a

	Observed		Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	71	3	95.9
		M	2	60	96.8
		Overall Percentage			96.3
Step 2	Sex	F	71	3	95.9
		M	2	60	96.8
		Overall Percentage			96.3
Step 3	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 4	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 5	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 6	Sex	F	71	3	95.9
		M	5	57	91.9
		Overall Percentage			94.1
Step 7	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 8	Sex	F	71	3	95.9
		M	4	58	93.5
		Overall Percentage			94.9
Step 9	Sex	F	71	3	95.9
		M	4	58	93.5
		Overall Percentage			94.9

Table 36A, cont.

	Observed		F	M	Percentage Correct
Step 10	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 11	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 12	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 13	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 14	Sex	F	71	3	95.9
		M	3	59	95.2
		Overall Percentage			95.6
Step 15	Sex	F	71	3	95.9
		M	4	58	93.5
		Overall Percentage			94.9
Step 16	Sex	F	71	3	95.9
		M	4	58	93.5
		Overall Percentage			94.9
Step 17	Sex	F	71	3	95.9
		M	4	58	93.5
		Overall Percentage			94.9
Step 18	Sex	F	71	3	95.9
		M	5	57	91.9
		Overall Percentage			94.1
Step 19	Sex	F	71	3	95.9
		M	5	57	91.9
		Overall Percentage			94.1

Table 36A, cont.

	Observed		F	M	Percentage correct
Step 20	Sex	F	71	3	95.9
		M	5	57	91.9
		Overall Percentage			94.1
a. The cut value is .500					

Table 37A. Adult: All Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Max. Clavicle Length	.213	.130	2.674	1	.102	1.238
	Sag. Dia. of the Clavicle	.707	1.311	.291	1	.590	2.028
	Vert. Dia. of the Clavicle	2.649	1.657	2.555	1	.110	14.146
	Circ. of the Clavicle	-.481	.712	.457	1	.499	.618
	Glenoid Cavity Breadth	-.937	.608	2.370	1	.124	.392
	Max. Dia. of the Humerus	-1.290	1.262	1.045	1	.307	.275
	Min. Dia. of the Humerus	-1.121	1.057	1.125	1	.289	.326
	Circ. of the Humerus	.592	.676	.767	1	.381	1.807
	Epicondylar Breadth of the Humerus	-.288	.300	.920	1	.337	.750
	Tran. Dia. of the Ulna	1.292	1.317	.962	1	.327	3.640
	Dorso-Volar Dia. of the Ulna	.417	.948	.193	1	.660	1.517
	Min. Circ. of the Ulna	.838	.808	1.077	1	.299	2.313
	Tran. Dia. of the Radius	2.668	2.318	1.325	1	.250	14.418
	Sag. Dia. of the Radius	2.172	2.374	.837	1	.360	8.779
	Circ. of the Radius	-1.651	1.566	1.112	1	.292	.192
	Anterio-Posterior Dia. of the Femur	-2.103	1.578	1.777	1	.183	.122
	Tran. Dia. of the Femur	-.210	1.188	.031	1	.860	.810
	Circ. of the Femur	.148	.864	.029	1	.864	1.160
	Epicondylar Breadth of the Femur	1.258	.711	3.127	1	.077	3.517
	Max. Dia. of the Tibia at the Nutrient Foramen	.361	.590	.374	1	.541	1.434
	Tran. Dia. of the Tibia at the Nutrient Foramen	-.172	.561	.094	1	.760	.842
	Circ. of the Tibia at the Nutrient Foramen	.077	.347	.049	1	.825	1.080
	Max. Epiphysis Breadth of the Proximal Tibia	-.290	.433	.449	1	.503	.748
	Max. Dia. of the Fibula	-.206	1.050	.038	1	.845	.814
	Min. Dia. of the Fibula	-2.398	1.611	2.217	1	.136	.091
	Circ. of the Fibula	.755	.710	1.131	1	.288	2.127
	Constant	-93.574	33.899	7.620	1	.006	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2 ^a	Max. Clavicle Length	.212	.130	2.664	1	.103	1.236
	Sag. Dia. of the Clavicle	.702	1.299	.292	1	.589	2.017
	Vert. Dia. of the Clavicle	2.649	1.669	2.519	1	.112	14.135
	Circ. of the Clavicle	-.463	.693	.446	1	.504	.630
	Glenoid Cavity Breadth	-.961	.600	2.564	1	.109	.382
	Max. Dia. of the Humerus	-1.312	1.260	1.085	1	.298	.269
	Min. Dia. of the Humerus	-1.124	1.057	1.129	1	.288	.325
	Circ. of the Humerus	.588	.678	.752	1	.386	1.800
	Epicondylar Breadth of the Humerus	-.289	.294	.963	1	.326	.749
	Tran. Dia. of the Ulna	1.299	1.307	.987	1	.320	3.665
	Dorso-Volar Dia. of the Ulna	.377	.917	.169	1	.681	1.457
	Min. Circ. of the Ulna	.850	.805	1.113	1	.291	2.339
	Tran. Dia. of the Radius	2.725	2.358	1.335	1	.248	15.257
	Sag. Dia. of the Radius	2.207	2.367	.870	1	.351	9.086
	Circ. of the Radius	-1.664	1.604	1.076	1	.300	.189
	Anterio-Posterior Dia. of the Femur	-1.886	.916	4.240	1	.039	.152
	Tran. Dia. of the Femur	-.020	.412	.002	1	.961	.980
	Epicondylar Breadth of the Femur	1.285	.700	3.373	1	.066	3.615
	Max. Dia. of the Tibia at the Nutrient Foramen	.353	.588	.360	1	.549	1.423
	Tran. Dia. of the Tibia at the Nutrient Foramen	-.218	.486	.202	1	.653	.804
	Circ. of the Tibia at the Nutrient Foramen	.096	.329	.086	1	.770	1.101
	Max. Epiphysis Breadth of the Proximal Tibia	-.298	.427	.488	1	.485	.742
	Max. Dia. of the Fibula	-.220	1.056	.043	1	.835	.803
	Min. Dia. of the Fibula	-2.526	1.468	2.959	1	.085	.080
	Circ. of the Fibula	.805	.659	1.492	1	.222	2.236
	Constant	-94.301	33.868	7.753	1	.005	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 3 ^a	Max. Clavicle Length	.212	.129	2.697	1	.101	1.236
	Sag. Dia. of the Clavicle	.696	1.283	.295	1	.587	2.007
	Vert. Dia. of the Clavicle	2.643	1.660	2.536	1	.111	14.057
	Circ. of the Clavicle	-.455	.670	.462	1	.497	.634
	Glenoid Cavity Breadth	-.963	.599	2.584	1	.108	.382
	Max. Dia. of the Humerus	-1.294	1.199	1.164	1	.281	.274
	Min. Dia. of the Humerus	-1.099	.933	1.389	1	.239	.333
	Circ. of the Humerus	.571	.583	.958	1	.328	1.769
	Epicondylar Breadth of the Humerus	-.284	.278	1.048	1	.306	.753
	Tran. Dia. of the Ulna	1.304	1.307	.995	1	.318	3.684
	Dorso-Volar Dia. of the Ulna	.373	.913	.167	1	.683	1.453
	Min. Circ. of the Ulna	.842	.785	1.149	1	.284	2.320
	Tran. Dia. of the Radius	2.696	2.269	1.411	1	.235	14.814
	Sag. Dia. of the Radius	2.170	2.227	.950	1	.330	8.759
	Circ. of the Radius	-1.637	1.493	1.202	1	.273	.195
	Anterio-Posterior Dia. of the Femur	-1.883	.913	4.259	1	.039	.152
	Epicondylar Breadth of the Femur	1.280	.686	3.475	1	.062	3.595
	Max. Dia. of the Tibia at the Nutrient Foramen	.348	.580	.360	1	.548	1.417
	Tran. Dia. of the Tibia at the Nutrient Foramen	-.212	.468	.205	1	.651	.809
	Circ. of the Tibia at the Nutrient Foramen	.092	.318	.084	1	.771	1.097
	Max. Epiphysis Breadth of the Proximal Tibia	-.298	.426	.488	1	.485	.743
	Max. Dia. of the Fibula	-.212	1.051	.041	1	.840	.809
	Min. Dia. of the Fibula	-2.513	1.444	3.030	1	.082	.081
	Circ. of the Fibula	.802	.659	1.481	1	.224	2.230
	Constant	-94.456	33.714	7.849	1	.005	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 4 ^a	Max. Clavicle Length	.209	.129	2.655	1	.103	1.233
	Sag. Dia. of the Clavicle	.705	1.263	.311	1	.577	2.023
	Vert. Dia. of the Clavicle	2.570	1.578	2.652	1	.103	13.064
	Circ. of the Clavicle	-.436	.651	.448	1	.503	.647
	Glenoid Cavity Breadth	-.943	.583	2.614	1	.106	.389
	Max. Dia. of the Humerus	-1.342	1.156	1.347	1	.246	.261
	Min. Dia. of the Humerus	-1.079	.919	1.379	1	.240	.340
	Circ. of the Humerus	.586	.569	1.058	1	.304	1.796
	Epicondylar Breadth of the Humerus	-.285	.276	1.067	1	.302	.752
	Tran. Dia. of the Ulna	1.208	1.184	1.042	1	.307	3.348
	Dorso-Volar Dia. of the Ulna	.379	.904	.176	1	.675	1.461
	Min. Circ. of the Ulna	.861	.766	1.262	1	.261	2.365
	Tran. Dia. of the Radius	2.586	2.171	1.419	1	.234	13.273
	Sag. Dia. of the Radius	2.172	2.217	.960	1	.327	8.772
	Circ. of the Radius	-1.594	1.456	1.199	1	.274	.203
	Anterio-Posterior Dia. of the Femur	-1.887	.911	4.290	1	.038	.152
	Epicondylar Breadth of the Femur	1.279	.682	3.511	1	.061	3.592
	Max. Dia. of the Tibia at the Nutrient Foramen	.351	.588	.357	1	.550	1.421
	Tran. Dia. of the Tibia at the Nutrient Foramen	-.228	.465	.241	1	.624	.796
	Circ. of the Tibia at the Nutrient Foramen	.099	.321	.095	1	.758	1.104
	Max. Epiphysis Breadth of the Proximal Tibia	-.309	.419	.544	1	.461	.734
	Min. Dia. of the Fibula	-2.405	1.327	3.284	1	.070	.090
	Circ. of the Fibula	.696	.390	3.176	1	.075	2.005
	Constant	-93.552	33.040	8.017	1	.005	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 5 ^a	Max. Clavicle Length	.224	.129	3.004	1	.083	1.251
	Sag. Dia. of the Clavicle	.643	1.234	.271	1	.603	1.902
	Vert. Dia. of the Clavicle	2.657	1.577	2.839	1	.092	14.258
	Circ. of the Clavicle	-.399	.631	.400	1	.527	.671
	Glenoid Cavity Breadth	-.968	.576	2.824	1	.093	.380
	Max. Dia. of the Humerus	-1.303	1.140	1.306	1	.253	.272
	Min. Dia. of the Humerus	-1.031	.890	1.342	1	.247	.357
	Circ. of the Humerus	.576	.565	1.039	1	.308	1.779
	Epicondylar Breadth of the Humerus	-.274	.268	1.043	1	.307	.760
	Tran. Dia. of the Ulna	1.314	1.158	1.287	1	.257	3.720
	Dorso-Volar Dia. of the Ulna	.418	.918	.207	1	.649	1.519
	Min. Circ. of the Ulna	.818	.750	1.192	1	.275	2.266
	Tran. Dia. of the Radius	2.586	2.163	1.430	1	.232	13.272
	Sag. Dia. of the Radius	1.973	2.085	.895	1	.344	7.190
	Circ. of the Radius	-1.547	1.424	1.180	1	.277	.213
	Anterio-Posterior Dia. of the Femur	-1.952	.930	4.404	1	.036	.142
	Epicondylar Breadth of the Femur	1.259	.675	3.477	1	.062	3.520
	Max. Dia. of the Tibia at the Nutrient Foramen	.502	.351	2.048	1	.152	1.652
	Tran. Dia. of the Tibia at the Nutrient Foramen	-.130	.339	.147	1	.702	.878
	Max. Epiphysis Breadth of the Proximal Tibia	-.280	.406	.476	1	.490	.756
	Min. Dia. of the Fibula	-2.443	1.342	3.314	1	.069	.087
	Circ. of the Fibula	.725	.397	3.334	1	.068	2.065
	Constant	-95.709	33.846	7.996	1	.005	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 6 ^a	Max. Clavicle Length	.216	.122	3.163	1	.075	1.241
	Sag. Dia. of the Clavicle	.528	1.115	.225	1	.636	1.696
	Vert. Dia. of the Clavicle	2.446	1.379	3.147	1	.076	11.543
	Circ. of the Clavicle	-.346	.570	.369	1	.544	.708
	Glenoid Cavity Breadth	-.933	.575	2.631	1	.105	.394
	Max. Dia. of the Humerus	-1.161	1.071	1.175	1	.278	.313
	Min. Dia. of the Humerus	-1.011	.881	1.317	1	.251	.364
	Circ. of the Humerus	.507	.529	.920	1	.338	1.661
	Epicondylar Breadth of the Humerus	-.239	.244	.965	1	.326	.787
	Tran. Dia. of the Ulna	1.193	1.120	1.134	1	.287	3.297
	Dorso-Volar Dia. of the Ulna	.364	.908	.161	1	.688	1.439
	Min. Circ. of the Ulna	.826	.752	1.206	1	.272	2.284
	Tran. Dia. of the Radius	2.544	2.117	1.444	1	.229	12.737
	Sag. Dia. of the Radius	1.727	1.872	.851	1	.356	5.625
	Circ. of the Radius	-1.520	1.380	1.215	1	.270	.219
	Anterio-Posterior Dia. of the Femur	-1.825	.814	5.021	1	.025	.161
	Epicondylar Breadth of the Femur	1.147	.583	3.876	1	.049	3.150
	Max. Dia. of the Tibia at the Nutrient Foramen	.451	.323	1.948	1	.163	1.569
	Max. Epiphysis Breadth of the Proximal Tibia	-.207	.350	.349	1	.555	.813
	Min. Dia. of the Fibula	-2.242	1.178	3.625	1	.057	.106
	Circ. of the Fibula	.673	.357	3.556	1	.059	1.961
	Constant	-92.535	32.108	8.306	1	.004	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 7 ^a	Max. Clavicle Length	.229	.120	3.639	1	.056	1.257
	Sag. Dia. of the Clavicle	.475	1.114	.182	1	.670	1.609
	Vert. Dia. of the Clavicle	2.400	1.373	3.055	1	.080	11.022
	Circ. of the Clavicle	-.323	.575	.316	1	.574	.724
	Glenoid Cavity Breadth	-.988	.578	2.921	1	.087	.372
	Max. Dia. of the Humerus	-1.144	1.036	1.220	1	.269	.318
	Min. Dia. of the Humerus	-.959	.843	1.294	1	.255	.383
	Circ. of the Humerus	.506	.508	.994	1	.319	1.659
	Epicondylar Breadth of the Humerus	-.224	.234	.918	1	.338	.799
	Tran. Dia. of the Ulna	1.064	1.058	1.013	1	.314	2.899
	Min. Circ. of the Ulna	1.011	.583	3.001	1	.083	2.747
	Tran. Dia. of the Radius	2.677	2.106	1.616	1	.204	14.539
	Sag. Dia. of the Radius	1.480	1.655	.799	1	.371	4.391
	Circ. of the Radius	-1.568	1.366	1.318	1	.251	.208
	Anterio-Posterior Dia. of the Femur	-1.844	.820	5.063	1	.024	.158
	Epicondylar Breadth of the Femur	1.148	.587	3.832	1	.050	3.153
	Max. Dia. of the Tibia at the Nutrient Foramen	.506	.297	2.905	1	.088	1.658
	Max. Epiphysis Breadth of the Proximal Tibia	-.193	.349	.308	1	.579	.824
	Min. Dia. of the Fibula	-2.322	1.167	3.959	1	.047	.098
	Circ. of the Fibula	.695	.358	3.773	1	.052	2.004
	Constant	-96.310	32.613	8.721	1	.003	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 8 ^a	Max. Clavicle Length	.242	.119	4.129	1	.042	1.274
	Vert. Dia. of the Clavicle	2.081	1.089	3.653	1	.056	8.015
	Circ. of the Clavicle	-.131	.279	.222	1	.637	.877
	Glenoid Cavity Breadth	-1.042	.568	3.361	1	.067	.353
	Max. Dia. of the Humerus	-1.152	1.049	1.207	1	.272	.316
	Min. Dia. of the Humerus	-.873	.832	1.101	1	.294	.418
	Circ. of the Humerus	.524	.517	1.029	1	.310	1.689
	Epicondylar Breadth of the Humerus	-.195	.222	.770	1	.380	.823
	Tran. Dia. of the Ulna	1.162	1.055	1.212	1	.271	3.197
	Min. Circ. of the Ulna	1.023	.595	2.955	1	.086	2.782
	Tran. Dia. of the Radius	2.725	2.122	1.650	1	.199	15.259
	Sag. Dia. of the Radius	1.361	1.603	.721	1	.396	3.899
	Circ. of the Radius	-1.633	1.368	1.425	1	.233	.195
	Anterio-Posterior Dia. of the Femur	-1.860	.836	4.953	1	.026	.156
	Epicondylar Breadth of the Femur	1.124	.599	3.521	1	.061	3.076
	Max. Dia. of the Tibia at the Nutrient Foramen	.524	.294	3.177	1	.075	1.689
	Max. Epiphysis Breadth of the Proximal Tibia	-.162	.351	.214	1	.644	.850
	Min. Dia. of the Fibula	-2.281	1.160	3.866	1	.049	.102
	Circ. of the Fibula	.705	.366	3.707	1	.054	2.024
	Constant	-99.047	33.157	8.923	1	.003	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 9 ^a	Max. Clavicle Length	.231	.114	4.105	1	.043	1.260
	Vert. Dia. of the Clavicle	1.985	1.050	3.578	1	.059	7.280
	Circ. of the Clavicle	-.108	.277	.151	1	.698	.898
	Glenoid Cavity Breadth	-1.089	.568	3.681	1	.055	.336
	Max. Dia. of the Humerus	-1.079	1.037	1.084	1	.298	.340
	Min. Dia. of the Humerus	-.822	.821	1.000	1	.317	.440
	Circ. of the Humerus	.479	.510	.881	1	.348	1.615
	Epicondylar Breadth of the Humerus	-.157	.202	.603	1	.437	.855
	Tran. Dia. of the Ulna	1.207	1.041	1.343	1	.246	3.343
	Min. Circ. of the Ulna	.933	.543	2.956	1	.086	2.543
	Tran. Dia. of the Radius	2.551	2.009	1.613	1	.204	12.825
	Sag. Dia. of the Radius	1.276	1.552	.676	1	.411	3.582
	Circ. of the Radius	-1.518	1.313	1.337	1	.248	.219
	Anterio-Posterior Dia. of the Femur	-1.733	.759	5.215	1	.022	.177
	Epicondylar Breadth of the Femur	.943	.414	5.201	1	.023	2.569
	Max. Dia. of the Tibia at the Nutrient Foramen	.476	.271	3.078	1	.079	1.610
	Min. Dia. of the Fibula	-2.122	1.083	3.838	1	.050	.120
	Circ. of the Fibula	.655	.340	3.698	1	.054	1.924
	Constant	-95.297	30.389	9.834	1	.002	.000
Step 10 ^a	Max. Clavicle Length	.232	.115	4.043	1	.044	1.261
	Vert. Dia. of the Clavicle	1.848	.957	3.732	1	.053	6.348
	Glenoid Cavity Breadth	-1.026	.536	3.667	1	.055	.359
	Max. Dia. of the Humerus	-1.008	1.100	.840	1	.359	.365
	Min. Dia. of the Humerus	-.754	.824	.836	1	.361	.471
	Circ. of the Humerus	.448	.540	.689	1	.406	1.565
	Epicondylar Breadth of the Humerus	-.168	.204	.677	1	.411	.846
	Tran. Dia. of the Ulna	1.080	.970	1.238	1	.266	2.943
	Min. Circ. of the Ulna	.944	.546	2.988	1	.084	2.570
	Tran. Dia. of the Radius	2.561	2.001	1.638	1	.201	12.945
	Sag. Dia. of the Radius	1.199	1.566	.586	1	.444	3.316
	Circ. of the Radius	-1.567	1.323	1.402	1	.236	.209
	Anterio-Posterior Dia. of the Femur	-1.778	.756	5.530	1	.019	.169
	Epicondylar Breadth of the Femur	.935	.413	5.128	1	.024	2.548
	Max. Dia. of the Tibia at the Nutrient Foramen	.514	.260	3.918	1	.048	1.672
	Min. Dia. of the Fibula	-2.220	1.086	4.180	1	.041	.109
	Circ. of the Fibula	.665	.345	3.715	1	.054	1.945
	Constant	-94.194	30.000	9.858	1	.002	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 11 ^a	Max. Clavicle Length	.231	.112	4.216	1	.040	1.259
	Vert. Dia. of the Clavicle	1.859	.941	3.899	1	.048	6.416
	Glenoid Cavity Breadth	-.988	.538	3.375	1	.066	.372
	Max. Dia. of the Humerus	-.215	.475	.206	1	.650	.806
	Min. Dia. of the Humerus	-.258	.570	.204	1	.651	.773
	Epicondylar Breadth of the Humerus	-.166	.196	.721	1	.396	.847
	Tran. Dia. of the Ulna	1.042	.916	1.294	1	.255	2.835
	Min. Circ. of the Ulna	.880	.526	2.797	1	.094	2.412
	Tran. Dia. of the Radius	2.177	1.785	1.488	1	.223	8.822
	Sag. Dia. of the Radius	1.009	1.391	.526	1	.468	2.744
	Circ. of the Radius	-1.290	1.179	1.197	1	.274	.275
	Anterio-Posterior Dia. of the Femur	-1.704	.744	5.241	1	.022	.182
	Epicondylar Breadth of the Femur	.901	.403	5.009	1	.025	2.463
	Max. Dia. of the Tibia at the Nutrient Foramen	.481	.248	3.758	1	.053	1.617
	Min. Dia. of the Fibula	-2.226	1.122	3.932	1	.047	.108
	Circ. of the Fibula	.701	.349	4.035	1	.045	2.016
	Constant	-92.863	29.621	9.828	1	.002	.000
Step 12 ^a	Max. Clavicle Length	.228	.112	4.137	1	.042	1.256
	Vert. Dia. of the Clavicle	1.820	.941	3.741	1	.053	6.170
	Glenoid Cavity Breadth	-.974	.526	3.420	1	.064	.378
	Max. Dia. of the Humerus	-.216	.478	.204	1	.651	.806
	Epicondylar Breadth of the Humerus	-.138	.183	.571	1	.450	.871
	Tran. Dia. of the Ulna	.964	.900	1.147	1	.284	2.622
	Min. Circ. of the Ulna	.863	.525	2.705	1	.100	2.370
	Tran. Dia. of the Radius	2.263	1.806	1.570	1	.210	9.607
	Sag. Dia. of the Radius	1.053	1.398	.567	1	.451	2.866
	Circ. of the Radius	-1.401	1.173	1.427	1	.232	.246
	Anterio-Posterior Dia. of the Femur	-1.714	.752	5.195	1	.023	.180
	Epicondylar Breadth of the Femur	.895	.408	4.812	1	.028	2.446
	Max. Dia. of the Tibia at the Nutrient Foramen	.476	.250	3.628	1	.057	1.610
	Min. Dia. of the Fibula	-2.213	1.133	3.814	1	.051	.109
	Circ. of the Fibula	.684	.354	3.735	1	.053	1.981
	Constant	-91.919	29.716	9.568	1	.002	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 13 ^a	Max. Clavicle Length	.227	.111	4.178	1	.041	1.254
	Vert. Dia. of the Clavicle	1.794	.929	3.727	1	.054	6.013
	Glenoid Cavity Breadth	-1.028	.517	3.950	1	.047	.358
	Epicondylar Breadth of the Humerus	-.136	.181	.569	1	.451	.873
	Tran. Dia. of the Ulna	1.044	.865	1.456	1	.228	2.842
	Min. Circ. of the Ulna	.861	.520	2.738	1	.098	2.366
	Tran. Dia. of the Radius	2.176	1.763	1.524	1	.217	8.815
	Sag. Dia. of the Radius	.859	1.309	.430	1	.512	2.360
	Circ. of the Radius	-1.377	1.140	1.459	1	.227	.252
	Anterio-Posterior Dia. of the Femur	-1.757	.738	5.670	1	.017	.173
	Epicondylar Breadth of the Femur	.930	.396	5.515	1	.019	2.534
	Max. Dia. of the Tibia at the Nutrient Foramen	.469	.250	3.527	1	.060	1.598
	Min. Dia. of the Fibula	-2.247	1.116	4.051	1	.044	.106
	Circ. of the Fibula	.685	.352	3.784	1	.052	1.983
	Constant	-94.520	29.128	10.530	1	.001	.000
Step 14 ^a	Max. Clavicle Length	.248	.107	5.324	1	.021	1.281
	Vert. Dia. of the Clavicle	1.745	.893	3.819	1	.051	5.724
	Glenoid Cavity Breadth	-1.019	.509	4.001	1	.045	.361
	Epicondylar Breadth of the Humerus	-.124	.170	.531	1	.466	.884
	Tran. Dia. of the Ulna	1.067	.860	1.537	1	.215	2.905
	Min. Circ. of the Ulna	.819	.498	2.708	1	.100	2.269
	Tran. Dia. of the Radius	1.475	1.247	1.400	1	.237	4.373
	Circ. of the Radius	-.867	.756	1.314	1	.252	.420
	Anterio-Posterior Dia. of the Femur	-1.737	.717	5.878	1	.015	.176
	Epicondylar Breadth of the Femur	.833	.348	5.722	1	.017	2.301
	Max. Dia. of the Tibia at the Nutrient Foramen	.502	.242	4.320	1	.038	1.652
	Min. Dia. of the Fibula	-2.046	1.059	3.736	1	.053	.129
	Circ. of the Fibula	.686	.352	3.803	1	.051	1.986
	Constant	-94.345	28.371	11.058	1	.001	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 15 ^a	Max. Clavicle Length	.235	.104	5.154	1	.023	1.265
	Vert. Dia. of the Clavicle	1.678	.862	3.791	1	.052	5.352
	Glenoid Cavity Breadth	-1.019	.488	4.364	1	.037	.361
	Tran. Dia. of the Ulna	1.059	.881	1.445	1	.229	2.883
	Min. Circ. of the Ulna	.691	.447	2.392	1	.122	1.996
	Tran. Dia. of the Radius	1.431	1.192	1.442	1	.230	4.185
	Circ. of the Radius	-.813	.722	1.265	1	.261	.444
	Anterio-Posterior Dia. of the Femur	-1.607	.664	5.865	1	.015	.200
	Epicondylar Breadth of the Femur	.754	.317	5.655	1	.017	2.124
	Max. Dia. of the Tibia at the Nutrient Foramen	.464	.229	4.087	1	.043	1.590
	Min. Dia. of the Fibula	-1.837	.975	3.547	1	.060	.159
	Circ. of the Fibula	.621	.327	3.596	1	.058	1.861
	Constant	-90.516	26.538	11.634	1	.001	.000
Step 16 ^a	Max. Clavicle Length	.205	.092	4.965	1	.026	1.227
	Vert. Dia. of the Clavicle	1.341	.763	3.090	1	.079	3.825
	Glenoid Cavity Breadth	-.930	.466	3.981	1	.046	.395
	Tran. Dia. of the Ulna	1.182	.900	1.726	1	.189	3.262
	Min. Circ. of the Ulna	.392	.361	1.179	1	.278	1.480
	Tran. Dia. of the Radius	.133	.512	.068	1	.794	1.143
	Anterio-Posterior Dia. of the Femur	-1.338	.548	5.972	1	.015	.262
	Epicondylar Breadth of the Femur	.564	.223	6.405	1	.011	1.757
	Max. Dia. of the Tibia at the Nutrient Foramen	.424	.223	3.611	1	.057	1.527
	Min. Dia. of the Fibula	-1.398	.833	2.816	1	.093	.247
	Circ. of the Fibula	.459	.285	2.599	1	.107	1.582
	Constant	-78.144	20.484	14.554	1	.000	.000
Step 17 ^a	Max. Clavicle Length	.201	.091	4.937	1	.026	1.223
	Vert. Dia. of the Clavicle	1.300	.734	3.142	1	.076	3.670
	Glenoid Cavity Breadth	-.933	.462	4.079	1	.043	.393
	Tran. Dia. of the Ulna	1.117	.856	1.704	1	.192	3.055
	Min. Circ. of the Ulna	.431	.329	1.719	1	.190	1.538
	Anterio-Posterior Dia. of the Femur	-1.326	.540	6.031	1	.014	.266
	Epicondylar Breadth of the Femur	.568	.224	6.437	1	.011	1.765
	Max. Dia. of the Tibia at the Nutrient Foramen	.444	.212	4.395	1	.036	1.559
	Min. Dia. of the Fibula	-1.420	.838	2.871	1	.090	.242
	Circ. of the Fibula	.467	.284	2.706	1	.100	1.596
	Constant	-77.453	20.146	14.780	1	.000	.000

Table 37A, cont.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 18 ^a	Max. Clavicle Length	.213	.092	5.317	1	.021	1.237
	Vert. Dia. of the Clavicle	1.435	.744	3.722	1	.054	4.199
	Glenoid Cavity Breadth	-.840	.443	3.593	1	.058	.432
	Tran. Dia. of the Ulna	1.925	.658	8.569	1	.003	6.853
	Anterio-Posterior Dia. of the Femur	-1.232	.544	5.134	1	.023	.292
	Epicondylar Breadth of the Femur	.509	.212	5.743	1	.017	1.663
	Max. Dia. of the Tibia at the Nutrient Foramen	.434	.206	4.428	1	.035	1.543
	Min. Dia. of the Fibula	-1.192	.807	2.181	1	.140	.304
	Circ. of the Fibula	.481	.304	2.504	1	.114	1.618
	Constant	-77.075	20.903	13.596	1	.000	.000
Step 19 ^a	Max. Clavicle Length	.181	.081	5.064	1	.024	1.199
	Vert. Dia. of the Clavicle	1.015	.612	2.745	1	.098	2.758
	Glenoid Cavity Breadth	-.760	.407	3.496	1	.062	.468
	Tran. Dia. of the Ulna	1.706	.566	9.075	1	.003	5.507
	Anterio-Posterior Dia. of the Femur	-.788	.387	4.149	1	.042	.455
	Epicondylar Breadth of the Femur	.358	.161	4.961	1	.026	1.430
	Max. Dia. of the Tibia at the Nutrient Foramen	.381	.203	3.516	1	.061	1.463
	Circ. of the Fibula	.111	.156	.508	1	.476	1.117
	Constant	-63.941	14.995	18.182	1	.000	.000
Step 20 ^a	Max. Clavicle Length	.158	.069	5.223	1	.022	1.171
	Vert. Dia. of the Clavicle	.827	.520	2.530	1	.112	2.286
	Glenoid Cavity Breadth	-.642	.353	3.312	1	.069	.526
	Tran. Dia. of the Ulna	1.615	.534	9.162	1	.002	5.030
	Anterio-Posterior Dia. of the Femur	-.648	.302	4.605	1	.032	.523
	Epicondylar Breadth of the Femur	.352	.160	4.831	1	.028	1.422
	Max. Dia. of the Tibia at the Nutrient Foramen	.381	.203	3.514	1	.061	1.463
	Constant	-59.390	12.426	22.844	1	.000	.000

a. Variable(s) entered on step 1: Max. Clavicle Length, Sag. Dia. of the Clavicle, Vert. Dia. of the Clavicle, Circ. of the Clavicle, Glenoid Cavity Breadth, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Epicondylar Breadth of the Humerus, Tran. Dia. of the Ulna, Dorso-Volar Dia. of the Ulna, Min. Circ. of the Ulna, Tran. Dia. of the Radius, Sag. Dia. of the Radius, Circ. of the Radius, Anterio-Posterior Dia. of the Femur, Tran. Dia. of the Femur, Circ. of the Femur, Epicondylar Breadth of the Femur, Max. Dia. of the Tibia at the Nutrient Foramen, Tran. Dia. of the Tibia at the Nutrient Foramen, Circ. of the Tibia at the Nutrient Foramen, Max. Epiphysis Breadth of the Proximal Tibia, Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula.

Table 41A. Young Subadult: Group 1 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Clavicle Length	9581.681 ^a	3	3193.894	72.044	.000
	Max. Dia. of the Clavicle	68.731 ^b	3	22.910	30.934	.000
	Min. Dia. of the Clavicle	25.710 ^c	3	8.570	24.140	.000
	Circ. of the Clavicle	561.338 ^d	3	187.113	32.778	.000
Intercept	Max. Clavicle Length	12964.660	1	12964.660	292.439	.000
	Max. Dia. of the Clavicle	100.759	1	100.759	136.049	.000
	Min. Dia. of the Clavicle	48.745	1	48.745	137.308	.000
	Circ. of the Clavicle	718.710	1	718.710	125.900	.000
AgeSquare	Max. Clavicle Length	73.753	1	73.753	1.664	.209
	Max. Dia. of the Clavicle	.058	1	.058	.079	.781
	Min. Dia. of the Clavicle	.055	1	.055	.156	.696
	Circ. of the Clavicle	1.103	1	1.103	.193	.664
Age	Max. Clavicle Length	930.499	1	930.499	20.989	.000
	Max. Dia. of the Clavicle	2.526	1	2.526	3.411	.077
	Min. Dia. of the Clavicle	1.894	1	1.894	5.335	.029
	Circ. of the Clavicle	18.278	1	18.278	3.202	.086
Sex	Max. Clavicle Length	240.314	1	240.314	5.421	.028
	Max. Dia. of the Clavicle	9.170	1	9.170	12.382	.002
	Min. Dia. of the Clavicle	1.118	1	1.118	3.148	.088
	Circ. of the Clavicle	47.742	1	47.742	8.363	.008
Error	Max. Clavicle Length	1108.321	25	44.333		
	Max. Dia. of the Clavicle	18.515	25	.741		
	Min. Dia. of the Clavicle	8.875	25	.355		
	Circ. of the Clavicle	142.714	25	5.709		
Total	Max. Clavicle Length	193191.047	29			
	Max. Dia. of the Clavicle	1310.287	29			
	Min. Dia. of the Clavicle	631.867	29			
	Circ. of the Clavicle	9743.500	29			
Corrected Total	Max. Clavicle Length	10690.002	28			
	Max. Dia. of the Clavicle	87.246	28			
	Min. Dia. of the Clavicle	34.585	28			
	Circ. of the Clavicle	704.052	28			
a. R Squared = .896 (Adjusted R Squared = .884) b. R Squared = .788 (Adjusted R Squared = .762) c. R Squared = .743 (Adjusted R Squared = .713) d. R Squared = .797 (Adjusted R Squared = .773) e. Males (n=14), Females (n=15)						

Table 42A. Young Subadult: Group 2 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Humerus	174.872 ^a	3	58.291	34.696	.000
	Min. Dia. of the Humerus	114.641 ^b	3	38.214	33.737	.000
	Circ. of the Humerus	1407.885 ^c	3	469.295	32.870	.000
	Max. Glenoid cavity breadth	309.482 ^d	3	103.161	60.257	.000
Intercept	Max. Dia. of the Humerus	230.009	1	230.009	136.907	.000
	Min. Dia. of the Humerus	180.548	1	180.548	159.396	.000
	Circ. of the Humerus	2137.900	1	2137.900	149.742	.000
	Max. Glenoid cavity breadth	242.698	1	242.698	141.763	.000
AgeSquare	Max. Dia. of the Humerus	1.352	1	1.352	.805	.381
	Min. Dia. of the Humerus	.127	1	.127	.112	.742
	Circ. of the Humerus	15.158	1	15.158	1.062	.316
	Max. Glenoid cavity breadth	10.774	1	10.774	6.293	.022
Age	Max. Dia. of the Humerus	17.398	1	17.398	10.356	.005
	Min. Dia. of the Humerus	7.716	1	7.716	6.812	.018
	Circ. of the Humerus	152.695	1	152.695	10.695	.004
	Max. Glenoid cavity breadth	51.331	1	51.331	29.983	.000
Sex	Max. Dia. of the Humerus	6.623	1	6.623	3.942	.063
	Min. Dia. of the Humerus	8.396	1	8.396	7.413	.014
	Circ. of the Humerus	70.082	1	70.082	4.909	.040
	Max. Glenoid cavity breadth	14.906	1	14.906	8.707	.009
Error	Max. Dia. of the Humerus	30.241	18	1.680		
	Min. Dia. of the Humerus	20.389	18	1.133		
	Circ. of the Humerus	256.990	18	14.277		
	Max. Glenoid cavity breadth	30.816	18	1.712		
Total	Max. Dia. of the Humerus	3094.179	22			
	Min. Dia. of the Humerus	2153.153	22			
	Circ. of the Humerus	27472.250	22			
	Max. Glenoid cavity breadth	4332.806	22			
Corrected Total	Max. Dia. of the Humerus	205.113	21			
	Min. Dia. of the Humerus	135.030	21			
	Circ. of the Humerus	1664.875	21			
	Max. Glenoid cavity breadth	340.298	21			
a. R Squared = .853 (Adjusted R Squared = .828) b. R Squared = .849 (Adjusted R Squared = .824) c. R Squared = .846 (Adjusted R Squared = .820) d. R Squared = .909 (Adjusted R Squared = .894) e. Males (n=9), Females (n=13)						

Table 43A. Young Subadult: Group 2 Tests of Between-Subjects Effects^f

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Humerus	148.338 ^a	3	49.446	18.960	.000
	Min. Dia. of the Humerus	102.057 ^b	3	34.019	21.993	.000
	Circ. of the Humerus	1249.233 ^c	3	416.411	20.449	.000
	Max. Glenoid cavity breadth	243.737 ^d	3	81.246	38.640	.000
	Max. breadth of the distal Humerus	1170.760 ^e	3	390.253	23.852	.000
Intercept	Max. Dia. of the Humerus	169.781	1	169.781	65.102	.000
	Min. Dia. of the Humerus	131.254	1	131.254	84.854	.000
	Circ. of the Humerus	1566.945	1	1566.945	76.951	.000
	Max. Glenoid cavity breadth	203.446	1	203.446	96.757	.000
	Max. breadth of the distal Humerus	1155.781	1	1155.781	70.642	.000
AgeSquare	Max. Dia. of the Humerus	.923	1	.923	.354	.567
	Min. Dia. of the Humerus	.171	1	.171	.110	.747
	Circ. of the Humerus	10.217	1	10.217	.502	.497
	Max. Glenoid cavity breadth	2.308	1	2.308	1.098	.322
	Max. breadth of the distal Humerus	1.580	1	1.580	.097	.763
Age	Max. Dia. of the Humerus	11.630	1	11.630	4.460	.064
	Min. Dia. of the Humerus	5.788	1	5.788	3.742	.085
	Circ. of the Humerus	104.389	1	104.389	5.126	.050
	Max. Glenoid cavity breadth	21.299	1	21.299	10.130	.011
	Max. breadth of the distal Humerus	71.007	1	71.007	4.340	.067
Sex	Max. Dia. of the Humerus	6.570	1	6.570	2.519	.147
	Min. Dia. of the Humerus	7.058	1	7.058	4.563	.061
	Circ. of the Humerus	69.405	1	69.405	3.408	.098
	Max. Glenoid cavity breadth	13.709	1	13.709	6.520	.031
	Max. breadth of the distal Humerus	13.642	1	13.642	.834	.385
Error	Max. Dia. of the Humerus	23.471	9	2.608		
	Min. Dia. of the Humerus	13.921	9	1.547		
	Circ. of the Humerus	183.267	9	20.363		
	Max. Glenoid cavity breadth	18.924	9	2.103		
	Max. breadth of the distal Humerus	147.251	9	16.361		

Table 43A, cont.

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Total	Max. Dia. of the Humerus	1851.499	13			
	Min. Dia. of the Humerus	1300.847	13			
	Circ. of the Humerus	16460.500	13			
	Max. Glenoid cavity breadth	2523.295	13			
	Max. breadth of the distal Humerus	13379.562	13			
Corrected Total	Max. Dia. of the Humerus	171.809	12			
	Min. Dia. of the Humerus	115.978	12			
	Circ. of the Humerus	1432.500	12			
	Max. Glenoid cavity breadth	262.661	12			
	Max. breadth of the distal Humerus	1318.011	12			
a. R Squared = .863 (Adjusted R Squared = .818) b. R Squared = .880 (Adjusted R Squared = .840) c. R Squared = .872 (Adjusted R Squared = .829) d. R Squared = .928 (Adjusted R Squared = .904) e. R Squared = .888 (Adjusted R Squared = .851) f. Males (n=5), Females (n=8)						

Table 44A. Young Subadult: Group 3 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Radius	114.613 ^a	3	38.204	29.545	.000
	Min. Dia. of the Radius	58.063 ^b	3	19.354	36.019	.000
	Circ. of the Radius	860.854 ^c	3	286.951	33.132	.000
Intercept	Max. Dia. of the Radius	147.335	1	147.335	113.941	.000
	Min. Dia. of the Radius	89.315	1	89.315	166.217	.000
	Circ. of the Radius	1138.581	1	1138.581	131.463	.000
AgeSquare	Max. Dia. of the Radius	.899	1	.899	.696	.412
	Min. Dia. of the Radius	.109	1	.109	.204	.656
	Circ. of the Radius	10.422	1	10.422	1.203	.284
Age	Max. Dia. of the Radius	12.370	1	12.370	9.566	.005
	Min. Dia. of the Radius	4.500	1	4.500	8.375	.008
	Circ. of the Radius	103.087	1	103.087	11.903	.002
Sex	Max. Dia. of the Radius	2.070	1	2.070	1.601	.218
	Min. Dia. of the Radius	3.533	1	3.533	6.575	.017
	Circ. of the Radius	28.014	1	28.014	3.235	.085
Error	Max. Dia. of the Radius	31.034	24	1.293		
	Min. Dia. of the Radius	12.896	24	.537		
	Circ. of the Radius	207.861	24	8.661		
Total	Max. Dia. of the Radius	1937.967	28			
	Min. Dia. of the Radius	1039.630	28			
	Circ. of the Radius	14886.000	28			
Corrected Total	Max. Dia. of the Radius	145.647	27			
	Min. Dia. of the Radius	70.959	27			
	Circ. of the Radius	1068.714	27			

Table 44A, cont.

a. R Squared = .787 (Adjusted R Squared = .760)
 b. R Squared = .818 (Adjusted R Squared = .796)
 c. R Squared = .806 (Adjusted R Squared = .781)
 d. Males (n=13), Females (n=15)

Table 45A. Young Subadult: Group 4 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Ulna	143.007 ^a	3	47.669	38.387	.000
	Min. Dia. of the Ulna	60.905 ^b	3	20.302	35.250	.000
	Circ. of the Ulna	1117.579 ^c	3	372.526	41.150	.000
Intercept	Max. Dia. of the Ulna	144.442	1	144.442	116.318	.000
	Min. Dia. of the Ulna	85.024	1	85.024	147.627	.000
	Circ. of the Ulna	1130.025	1	1130.025	124.825	.000
AgeSquare	Max. Dia. of the Ulna	.027	1	.027	.022	.884
	Min. Dia. of the Ulna	1.324	1	1.324	2.299	.143
	Circ. of the Ulna	3.116	1	3.116	.344	.563
Age	Max. Dia. of the Ulna	10.203	1	10.203	8.217	.009
	Min. Dia. of the Ulna	8.993	1	8.993	15.615	.001
	Circ. of the Ulna	101.333	1	101.333	11.193	.003
Sex	Max. Dia. of the Ulna	3.371	1	3.371	2.715	.113
	Min. Dia. of the Ulna	4.244	1	4.244	7.369	.012
	Circ. of the Ulna	45.216	1	45.216	4.995	.035
Error	Max. Dia. of the Ulna	28.561	23	1.242		
	Min. Dia. of the Ulna	13.247	23	.576		
	Circ. of the Ulna	208.217	23	9.053		
Total	Max. Dia. of the Ulna	2097.578	27			
	Min. Dia. of the Ulna	1162.478	27			
	Circ. of the Ulna	16710.250	27			
Corrected Total	Max. Dia. of the Ulna	171.569	26			
	Min. Dia. of the Ulna	74.152	26			
	Circ. of the Ulna	1325.796	26			

a. R Squared = .834 (Adjusted R Squared = .812)
 b. R Squared = .821 (Adjusted R Squared = .798)
 c. R Squared = .843 (Adjusted R Squared = .822)
 d. Males (n=12), Females (n=15)

Table 46A. Young Subadult: Group 5 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Femur	666.775 ^a	3	222.258	60.259	.000
	Min. Dia. of the Femur	563.643 ^b	3	187.881	81.369	.000
	Circ. of the Femur	5989.498 ^c	3	1996.499	69.820	.000
Intercept	Max. Dia. of the Femur	697.940	1	697.940	189.227	.000
	Min. Dia. of the Femur	517.900	1	517.900	224.297	.000
	Circ. of the Femur	6387.751	1	6387.751	223.389	.000
AgeSquare	Max. Dia. of the Femur	9.460	1	9.460	2.565	.116
	Min. Dia. of the Femur	12.118	1	12.118	5.248	.027
	Circ. of the Femur	120.414	1	120.414	4.211	.046
Age	Max. Dia. of the Femur	87.542	1	87.542	23.734	.000
	Min. Dia. of the Femur	85.152	1	85.152	36.878	.000
	Circ. of the Femur	882.147	1	882.147	30.850	.000
Sex	Max. Dia. of the Femur	22.450	1	22.450	6.087	.018
	Min. Dia. of the Femur	13.191	1	13.191	5.713	.021
	Circ. of the Femur	181.215	1	181.215	6.337	.016
Error	Max. Dia. of the Femur	162.289	44	3.688		
	Min. Dia. of the Femur	101.595	44	2.309		
	Circ. of the Femur	1258.169	44	28.595		
Total	Max. Dia. of the Femur	9410.197	48			
	Min. Dia. of the Femur	7515.457	48			
	Circ. of the Femur	86629.000	48			
Corrected Total	Max. Dia. of the Femur	829.064	47			
	Min. Dia. of the Femur	665.238	47			
	Circ. of the Femur	7247.667	47			
a. R Squared = .804 (Adjusted R Squared = .791)						
b. R Squared = .847 (Adjusted R Squared = .837)						
c. R Squared = .826 (Adjusted R Squared = .815)						
d. Males (n=25), Females (n=23)						

Table 47A. Young Subadult: Group 5 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Femur	613.967 ^a	3	204.656	47.559	.000
	Min. Dia. of the Femur	518.431 ^b	3	172.810	65.157	.000
	Circ. of the Femur	5519.019 ^c	3	1839.673	55.226	.000
	Max. breadth of the distal Femur	5375.992 ^d	3	1791.997	81.390	.000
Intercept	Max. Dia. of the Femur	627.507	1	627.507	145.823	.000
	Min. Dia. of the Femur	465.767	1	465.767	175.614	.000
	Circ. of the Femur	5753.047	1	5753.047	172.705	.000
	Max. breadth of the distal Femur	5469.715	1	5469.715	248.426	.000
AgeSquare	Max. Dia. of the Femur	3.780	1	3.780	.878	.355
	Min. Dia. of the Femur	6.390	1	6.390	2.409	.130
	Circ. of the Femur	53.175	1	53.175	1.596	.215
	Max. breadth of the distal Femur	400.752	1	400.752	18.202	.000
Age	Max. Dia. of the Femur	60.566	1	60.566	14.074	.001
	Min. Dia. of the Femur	62.349	1	62.349	23.508	.000
	Circ. of the Femur	613.383	1	613.383	18.414	.000
	Max. breadth of the distal Femur	1315.895	1	1315.895	59.766	.000
Sex	Max. Dia. of the Femur	27.349	1	27.349	6.355	.017
	Min. Dia. of the Femur	13.241	1	13.241	4.992	.032
	Circ. of the Femur	209.780	1	209.780	6.298	.017
	Max. breadth of the distal Femur	174.476	1	174.476	7.924	.008
Error	Max. Dia. of the Femur	142.006	33	4.303		
	Min. Dia. of the Femur	87.523	33	2.652		
	Circ. of the Femur	1099.278	33	33.311		
	Max. breadth of the distal Femur	726.576	33	22.017		
Total	Max. Dia. of the Femur	7412.027	37			
	Min. Dia. of the Femur	5945.721	37			
	Circ. of the Femur	68120.250	37			
	Max. breadth of the distal Femur	72046.830	37			
Corrected Total	Max. Dia. of the Femur	755.973	36			
	Min. Dia. of the Femur	605.955	36			
	Circ. of the Femur	6618.297	36			
	Max. breadth of the distal Femur	6102.568	36			

Table 47A, cont.

a. R Squared = .812 (Adjusted R Squared = .795)
 b. R Squared = .856 (Adjusted R Squared = .842)
 c. R Squared = .834 (Adjusted R Squared = .819)
 d. R Squared = .881 (Adjusted R Squared = .870)
 e. Males (n=20), Females (n=17)

Table 48A. Young Subadult: Group 6 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Tibia	778.440 ^a	3	259.480	60.330	.000
	Min. Dia. of the Tibia	433.368 ^b	3	144.456	71.617	.000
	Circ. of the Tibia	6124.826 ^c	3	2041.609	67.685	.000
Intercept	Max. Dia. of the Tibia	617.292	1	617.292	143.522	.000
	Min. Dia. of the Tibia	388.008	1	388.008	192.363	.000
	Circ. of the Tibia	4976.068	1	4976.068	164.969	.000
AgeSquare	Max. Dia. of the Tibia	2.705	1	2.705	.629	.433
	Min. Dia. of the Tibia	6.819	1	6.819	3.381	.074
	Circ. of the Tibia	66.847	1	66.847	2.216	.145
Age	Max. Dia. of the Tibia	67.002	1	67.002	15.578	.000
	Min. Dia. of the Tibia	55.190	1	55.190	27.361	.000
	Circ. of the Tibia	696.664	1	696.664	23.096	.000
Sex	Max. Dia. of the Tibia	27.417	1	27.417	6.375	.016
	Min. Dia. of the Tibia	14.025	1	14.025	6.953	.012
	Circ. of the Tibia	183.926	1	183.926	6.098	.018
Error	Max. Dia. of the Tibia	159.138	37	4.301		
	Min. Dia. of the Tibia	74.631	37	2.017		
	Circ. of the Tibia	1116.052	37	30.164		
Total	Max. Dia. of the Tibia	8313.212	41			
	Min. Dia. of the Tibia	5182.208	41			
	Circ. of the Tibia	68592.000	41			
Corrected Total	Max. Dia. of the Tibia	937.578	40			
	Min. Dia. of the Tibia	507.999	40			
	Circ. of the Tibia	7240.878	40			

a. R Squared = .830 (Adjusted R Squared = .817)
 b. R Squared = .853 (Adjusted R Squared = .841)
 c. R Squared = .846 (Adjusted R Squared = .833)
 d. Males (n=19), Females (n=22)

Table 49A. Young Subadult: Group 6 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Tibia	639.833 ^a	3	213.278	42.478	.000
	Min. Dia. of the Tibia	327.810 ^b	3	109.270	47.809	.000
	Circ. of the Tibia	4831.318 ^c	3	1610.439	45.479	.000
	Max. breadth of the proximal Tibia	3386.823 ^d	3	1128.941	58.838	.000
Intercept	Max. Dia. of the Tibia	444.366	1	444.366	88.503	.000
	Min. Dia. of the Tibia	287.821	1	287.821	125.932	.000
	Circ. of the Tibia	3615.426	1	3615.426	102.101	.000
	Max. breadth of the proximal Tibia	2446.463	1	2446.463	127.504	.000
AgeSquare	Max. Dia. of the Tibia	2.361	1	2.361	.470	.498
	Min. Dia. of the Tibia	7.403	1	7.403	3.239	.083
	Circ. of the Tibia	68.414	1	68.414	1.932	.175
	Max. breadth of the proximal Tibia	285.440	1	285.440	14.876	.001
Age	Max. Dia. of the Tibia	58.827	1	58.827	11.716	.002
	Min. Dia. of the Tibia	49.314	1	49.314	21.577	.000
	Circ. of the Tibia	621.623	1	621.623	17.555	.000
	Max. breadth of the proximal Tibia	900.288	1	900.288	46.921	.000
Sex	Max. Dia. of the Tibia	23.339	1	23.339	4.648	.040
	Min. Dia. of the Tibia	10.396	1	10.396	4.548	.042
	Circ. of the Tibia	140.892	1	140.892	3.979	.056
	Max. breadth of the proximal Tibia	117.941	1	117.941	6.147	.019
Error	Max. Dia. of the Tibia	140.586	28	5.021		
	Min. Dia. of the Tibia	63.995	28	2.286		
	Circ. of the Tibia	991.487	28	35.410		
	Max. breadth of the proximal Tibia	537.247	28	19.187		
Total	Max. Dia. of the Tibia	6922.895	32			
	Min. Dia. of the Tibia	4248.421	32			
	Circ. of the Tibia	56583.750	32			
	Max. breadth of the proximal Tibia	42969.523	32			
Corrected Total	Max. Dia. of the Tibia	780.419	31			
	Min. Dia. of the Tibia	391.805	31			
	Circ. of the Tibia	5822.805	31			
	Max. breadth of the proximal Tibia	3924.070	31			

Table 49A, cont.

a. R Squared = .820 (Adjusted R Squared = .801)
b. R Squared = .837 (Adjusted R Squared = .819)
c. R Squared = .830 (Adjusted R Squared = .811)
d. R Squared = .863 (Adjusted R Squared = .848)
e. Males (n=15), Females (n=17)

Table 50A. Young Subadult: Group 7 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Fibula	169.596 ^a	3	56.532	44.352	.000
	Min. Dia. of the Fibula	97.719 ^b	3	32.573	42.714	.000
	Circ. of the Fibula	1455.994 ^c	3	485.331	54.734	.000
Intercept	Max. Dia. of the Fibula	126.949	1	126.949	99.596	.000
	Min. Dia. of the Fibula	80.525	1	80.525	105.594	.000
	Circ. of the Fibula	979.084	1	979.084	110.417	.000
AgeSquare	Max. Dia. of the Fibula	2.050	1	2.050	1.608	.214
	Min. Dia. of the Fibula	.022	1	.022	.029	.865
	Circ. of the Fibula	16.596	1	16.596	1.872	.181
Age	Max. Dia. of the Fibula	20.236	1	20.236	15.876	.000
	Min. Dia. of the Fibula	6.184	1	6.184	8.110	.008
	Circ. of the Fibula	168.795	1	168.795	19.036	.000
Sex	Max. Dia. of the Fibula	3.074	1	3.074	2.412	.130
	Min. Dia. of the Fibula	3.482	1	3.482	4.567	.040
	Circ. of the Fibula	42.993	1	42.993	4.849	.035
Error	Max. Dia. of the Fibula	40.788	32	1.275		
	Min. Dia. of the Fibula	24.403	32	.763		
	Circ. of the Fibula	283.749	32	8.867		
Total	Max. Dia. of the Fibula	2012.811	36			
	Min. Dia. of the Fibula	1119.840	36			
	Circ. of the Fibula	16119.750	36			
Corrected Total	Max. Dia. of the Fibula	210.384	35			
	Min. Dia. of the Fibula	122.122	35			
	Circ. of the Fibula	1739.743	35			

Table 50A, cont.

a. R Squared = .806 (Adjusted R Squared = .788)
b. R Squared = .800 (Adjusted R Squared = .781)
c. R Squared = .837 (Adjusted R Squared = .822)
d. Males (n=16), Females (n=20)

Table 52A. Older Subadult: Group 1 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Clavicle Length	1473.432 ^a	3	491.144	4.840	.012
	Max. Dia. of the Clavicle	29.430 ^b	3	9.810	11.286	.000
	Min. Dia. of the Clavicle	24.935 ^c	3	8.312	8.485	.001
	Circ. of the Clavicle	278.101 ^d	3	92.700	15.901	.000
Intercept	Max. Clavicle Length	42.136	1	42.136	.415	.527
	Max. Dia. of the Clavicle	.832	1	.832	.958	.341
	Min. Dia. of the Clavicle	1.993	1	1.993	2.035	.171
	Circ. of the Clavicle	20.447	1	20.447	3.507	.077
AgeSquare	Max. Clavicle Length	82.810	1	82.810	.816	.378
	Max. Dia. of the Clavicle	1.170	1	1.170	1.346	.261
	Min. Dia. of the Clavicle	2.037	1	2.037	2.079	.167
	Circ. of the Clavicle	23.952	1	23.952	4.109	.058
Age	Max. Clavicle Length	120.305	1	120.305	1.186	.291
	Max. Dia. of the Clavicle	1.577	1	1.577	1.814	.195
	Min. Dia. of the Clavicle	2.581	1	2.581	2.634	.122
	Circ. of the Clavicle	29.560	1	29.560	5.070	.037
Sex	Max. Clavicle Length	21.620	1	21.620	.213	.650
	Max. Dia. of the Clavicle	12.401	1	12.401	14.267	.001
	Min. Dia. of the Clavicle	7.577	1	7.577	7.735	.012
	Circ. of the Clavicle	107.002	1	107.002	18.354	.000

Table 52A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Error	Max. Clavicle Length	1826.481	18	101.471		
	Max. Dia. of the Clavicle	15.646	18	.869		
	Min. Dia. of the Clavicle	17.633	18	.980		
	Circ. of the Clavicle	104.937	18	5.830		
Total	Max. Clavicle Length	364073.106	22			
	Max. Dia. of the Clavicle	2510.217	22			
	Min. Dia. of the Clavicle	1350.338	22			
	Circ. of the Clavicle	19931.840	22			
Corrected Total	Max. Clavicle Length	3299.913	21			
	Max. Dia. of the Clavicle	45.076	21			
	Min. Dia. of the Clavicle	42.568	21			
	Circ. of the Clavicle	383.038	21			
a. R Squared = .447 (Adjusted R Squared = .354) b. R Squared = .653 (Adjusted R Squared = .595) c. R Squared = .586 (Adjusted R Squared = .517) d. R Squared = .726 (Adjusted R Squared = .680) e. Males (n=13), Females (n=9)						

Table 53A. Older Subadult: Group 2 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Humerus	52.479 ^a	3	17.493	3.366	.047
	Min. Dia. of the Humerus	49.534 ^b	3	16.511	7.674	.002
	Circ. of the Humerus	486.585 ^c	3	162.195	4.543	.019
Intercept	Max. Dia. of the Humerus	2.850	1	2.850	.548	.470
	Min. Dia. of the Humerus	1.185	1	1.185	.551	.469
	Circ. of the Humerus	33.237	1	33.237	.931	.350
AgeSquare	Max. Dia. of the Humerus	3.272	1	3.272	.630	.440
	Min. Dia. of the Humerus	1.462	1	1.462	.679	.423
	Circ. of the Humerus	39.086	1	39.086	1.095	.312
Age	Max. Dia. of the Humerus	4.507	1	4.507	.867	.366
	Min. Dia. of the Humerus	2.087	1	2.087	.970	.340
	Circ. of the Humerus	50.536	1	50.536	1.415	.253
Sex	Max. Dia. of the Humerus	4.263	1	4.263	.820	.379
	Min. Dia. of the Humerus	15.738	1	15.738	7.314	.016
	Circ. of the Humerus	77.559	1	77.559	2.172	.161
Error	Max. Dia. of the Humerus	77.944	15	5.196		
	Min. Dia. of the Humerus	32.275	15	2.152		
	Circ. of the Humerus	535.546	15	35.703		
Total	Max. Dia. of the Humerus	6246.886	19			
	Min. Dia. of the Humerus	3908.994	19			
	Circ. of the Humerus	53548.500	19			
Corrected Total	Max. Dia. of the Humerus	130.423	18			
	Min. Dia. of the Humerus	81.809	18			
	Circ. of the Humerus	1022.132	18			
a. R Squared = .402 (Adjusted R Squared = .283) b. R Squared = .605 (Adjusted R Squared = .527) c. R Squared = .476 (Adjusted R Squared = .371) d. Males (n=10), Females (n=9)						

Table 54A. Older Subadult: Group 2 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Humerus	52.595 ^a	3	17.532	3.250	.054
	Min. Dia. of the Humerus	42.117 ^b	3	14.039	6.092	.007
	Circ. of the Humerus	466.520 ^c	3	155.507	4.165	.026
	Max. Glenoid cavity breadth	62.812 ^d	3	20.937	5.786	.009
Intercept	Max. Dia. of the Humerus	3.544	1	3.544	.657	.431
	Min. Dia. of the Humerus	1.193	1	1.193	.518	.484
	Circ. of the Humerus	38.361	1	38.361	1.027	.328
	Max. Glenoid cavity breadth	.166	1	.166	.046	.834
AgeSquare	Max. Dia. of the Humerus	3.800	1	3.800	.704	.415
	Min. Dia. of the Humerus	1.472	1	1.472	.639	.438
	Circ. of the Humerus	43.085	1	43.085	1.154	.301
	Max. Glenoid cavity breadth	.347	1	.347	.096	.761
Age	Max. Dia. of the Humerus	5.225	1	5.225	.969	.342
	Min. Dia. of the Humerus	2.093	1	2.093	.908	.357
	Circ. of the Humerus	55.768	1	55.768	1.494	.242
	Max. Glenoid cavity breadth	.908	1	.908	.251	.624
Sex	Max. Dia. of the Humerus	5.282	1	5.282	.979	.339
	Min. Dia. of the Humerus	15.423	1	15.423	6.692	.022
	Circ. of the Humerus	86.186	1	86.186	2.308	.151
	Max. Glenoid cavity breadth	10.348	1	10.348	2.860	.113
Error	Max. Dia. of the Humerus	75.509	14	5.394		
	Min. Dia. of the Humerus	32.265	14	2.305		
	Circ. of the Humerus	522.758	14	37.340		
	Max. Glenoid cavity breadth	50.657	14	3.618		
Total	Max. Dia. of the Humerus	5975.955	18			
	Min. Dia. of the Humerus	3775.822	18			
	Circ. of the Humerus	51339.500	18			
	Max. Glenoid cavity breadth	9003.246	18			
Corrected Total	Max. Dia. of the Humerus	128.104	17			
	Min. Dia. of the Humerus	74.382	17			
	Circ. of the Humerus	989.278	17			
	Max. Glenoid cavity breadth	113.468	17			
a. R Squared = .411 (Adjusted R Squared = .284) b. R Squared = .566 (Adjusted R Squared = .473) c. R Squared = .472 (Adjusted R Squared = .358) d. R Squared = .554 (Adjusted R Squared = .458) e. Males (n=10), Females (n=8)						

Table 55A. Group 2 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Humerus	17.461 ^a	3	5.820	.693	.585
	Min. Dia. of the Humerus	16.314 ^b	3	5.438	1.838	.228
	Circ. of the Humerus	131.491 ^c	3	43.830	.735	.563
	Max. Glenoid cavity breadth	39.286 ^d	3	13.095	3.596	.074
	Max. breadth of the distal Humerus	137.018 ^e	3	45.673	1.780	.238
Intercept	Max. Dia. of the Humerus	2.215	1	2.215	.264	.623
	Min. Dia. of the Humerus	2.543	1	2.543	.859	.385
	Circ. of the Humerus	16.619	1	16.619	.279	.614
	Max. Glenoid cavity breadth	2.754	1	2.754	.756	.413
	Max. breadth of the distal Humerus	1.281	1	1.281	.050	.830
AgeSquare	Max. Dia. of the Humerus	2.058	1	2.058	.245	.636
	Min. Dia. of the Humerus	2.313	1	2.313	.782	.406
	Circ. of the Humerus	14.542	1	14.542	.244	.636
	Max. Glenoid cavity breadth	2.737	1	2.737	.752	.415
	Max. breadth of the distal Humerus	1.594	1	1.594	.062	.810
Age	Max. Dia. of the Humerus	1.692	1	1.692	.201	.667
	Min. Dia. of the Humerus	2.050	1	2.050	.693	.433
	Circ. of the Humerus	12.074	1	12.074	.203	.666
	Max. Glenoid cavity breadth	2.135	1	2.135	.586	.469
	Max. breadth of the distal Humerus	2.744	1	2.744	.107	.753
Sex	Max. Dia. of the Humerus	.021	1	.021	.002	.962
	Min. Dia. of the Humerus	1.418	1	1.418	.479	.511
	Circ. of the Humerus	2.587	1	2.587	.043	.841
	Max. Glenoid cavity breadth	1.023	1	1.023	.281	.612
	Max. breadth of the distal Humerus	11.081	1	11.081	.432	.532
Error	Max. Dia. of the Humerus	58.780	7	8.397		
	Min. Dia. of the Humerus	20.714	7	2.959		
	Circ. of the Humerus	417.236	7	59.605		
	Max. Glenoid cavity breadth	25.494	7	3.642		
	Max. breadth of the distal Humerus	179.652	7	25.665		

Table 55A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total	Max. Dia. of the Humerus	3910.872	11			
	Min. Dia. of the Humerus	2404.620	11			
	Circ. of the Humerus	33167.000	11			
	Max. Glenoid cavity breadth	5807.213	11			
	Max. breadth of the distal Humerus	31102.354	11			
Corrected Total	Max. Dia. of the Humerus	76.241	10			
	Min. Dia. of the Humerus	37.028	10			
	Circ. of the Humerus	548.727	10			
	Max. Glenoid cavity breadth	64.779	10			
	Max. breadth of the distal Humerus	316.670	10			
a. R Squared = .229 (Adjusted R Squared = -.101) b. R Squared = .441 (Adjusted R Squared = .201) c. R Squared = .240 (Adjusted R Squared = -.086) d. R Squared = .606 (Adjusted R Squared = .438) e. R Squared = .433 (Adjusted R Squared = .190) f. Males (n=6), Females (n=5)						

Table 56A. Older Subadult: Group 3 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Radius	33.719 ^a	3	11.240	5.261	.009
	Min. Dia. of the Radius	20.043 ^b	3	6.681	7.678	.002
	Circ. of the Radius	249.729 ^c	3	83.243	6.954	.003
Intercept	Max. Dia. of the Radius	1.277	1	1.277	.598	.449
	Min. Dia. of the Radius	.422	1	.422	.485	.495
	Circ. of the Radius	1.043	1	1.043	.087	.771
AgeSquare	Max. Dia. of the Radius	1.227	1	1.227	.574	.458
	Min. Dia. of the Radius	.412	1	.412	.473	.500
	Circ. of the Radius	.713	1	.713	.060	.810
Age	Max. Dia. of the Radius	.667	1	.667	.312	.583
	Min. Dia. of the Radius	.184	1	.184	.211	.652
	Circ. of the Radius	.008	1	.008	.001	.979
Sex	Max. Dia. of the Radius	.036	1	.036	.017	.898
	Min. Dia. of the Radius	.346	1	.346	.398	.536
	Circ. of the Radius	6.884	1	6.884	.575	.458
Error	Max. Dia. of the Radius	38.456	18	2.136		
	Min. Dia. of the Radius	15.662	18	.870		
	Circ. of the Radius	215.464	18	11.970		
Total	Max. Dia. of the Radius	3738.357	22			
	Min. Dia. of the Radius	1944.442	22			
	Circ. of the Radius	28725.750	22			
Corrected Total	Max. Dia. of the Radius	72.175	21			
	Min. Dia. of the Radius	35.705	21			
	Circ. of the Radius	465.193	21			

Table 56A, cont.

a. R Squared = .467 (Adjusted R Squared = .378)
 b. R Squared = .561 (Adjusted R Squared = .488)
 c. R Squared = .537 (Adjusted R Squared = .460)
 d. Males (n=14), Females (n=8)

Table 57A. Older Subadult: Group 4 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Ulna	27.863 ^a	3	9.288	6.034	.005
	Min. Dia. of the Ulna	23.666 ^b	3	7.889	7.570	.002
	Circ. of the Ulna	253.467 ^c	3	84.489	8.188	.001
Intercept	Max. Dia. of the Ulna	2.762	1	2.762	1.794	.197
	Min. Dia. of the Ulna	.258	1	.258	.247	.625
	Circ. of the Ulna	8.490	1	8.490	.823	.376
AgeSquare	Max. Dia. of the Ulna	3.598	1	3.598	2.338	.144
	Min. Dia. of the Ulna	.526	1	.526	.505	.486
	Circ. of the Ulna	13.330	1	13.330	1.292	.271
Age	Max. Dia. of the Ulna	4.439	1	4.439	2.884	.107
	Min. Dia. of the Ulna	.735	1	.735	.705	.412
	Circ. of the Ulna	17.704	1	17.704	1.716	.207
Sex	Max. Dia. of the Ulna	5.879	1	5.879	3.819	.066
	Min. Dia. of the Ulna	14.062	1	14.062	13.494	.002
	Circ. of the Ulna	99.199	1	99.199	9.614	.006
Error	Max. Dia. of the Ulna	27.706	18	1.539		
	Min. Dia. of the Ulna	18.758	18	1.042		
	Circ. of the Ulna	185.726	18	10.318		
Total	Max. Dia. of the Ulna	3761.358	22			
	Min. Dia. of the Ulna	2082.058	22			
	Circ. of the Ulna	30298.750	22			
Corrected Total	Max. Dia. of the Ulna	55.568	21			
	Min. Dia. of the Ulna	42.424	21			
	Circ. of the Ulna	439.193	21			

a. R Squared = .501 (Adjusted R Squared = .418)
 b. R Squared = .558 (Adjusted R Squared = .484)
 c. R Squared = .577 (Adjusted R Squared = .507)
 d. Males (n=13), Females (n=9)

Table 58A. Older Subadult: Group 5 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Femur	127.834 ^a	3	42.611	14.851	.000
	Min. Dia. of the Femur	74.981 ^b	3	24.994	6.228	.004
	Circ. of the Femur	796.000 ^c	3	265.333	6.548	.003
	Max. breadth of the distal Femur	637.225 ^d	3	212.408	7.784	.001
Intercept	Max. Dia. of the Femur	1.188	1	1.188	.414	.527
	Min. Dia. of the Femur	.770	1	.770	.192	.666
	Circ. of the Femur	42.564	1	42.564	1.050	.318
	Max. breadth of the distal Femur	4.322	1	4.322	.158	.695
AgeSquare	Max. Dia. of the Femur	1.920	1	1.920	.669	.423
	Min. Dia. of the Femur	1.550	1	1.550	.386	.541
	Circ. of the Femur	63.974	1	63.974	1.579	.223
	Max. breadth of the distal Femur	.881	1	.881	.032	.859
Age	Max. Dia. of the Femur	3.461	1	3.461	1.206	.285
	Min. Dia. of the Femur	2.546	1	2.546	.634	.435
	Circ. of the Femur	83.387	1	83.387	2.058	.167
	Max. breadth of the distal Femur	.055	1	.055	.002	.964
Sex	Max. Dia. of the Femur	29.945	1	29.945	10.437	.004
	Min. Dia. of the Femur	20.305	1	20.305	5.060	.036
	Circ. of the Femur	185.062	1	185.062	4.567	.045
	Max. breadth of the distal Femur	78.544	1	78.544	2.878	.105
Error	Max. Dia. of the Femur	57.384	20	2.869		
	Min. Dia. of the Femur	80.260	20	4.013		
	Circ. of the Femur	810.459	20	40.523		
	Max. breadth of the distal Femur	545.768	20	27.288		
Total	Max. Dia. of the Femur	14637.805	24			
	Min. Dia. of the Femur	10706.087	24			
	Circ. of the Femur	129356.500	24			
	Max. breadth of the distal Femur	113831.245	24			
Corrected Total	Max. Dia. of the Femur	185.218	23			
	Min. Dia. of the Femur	155.241	23			
	Circ. of the Femur	1606.458	23			
	Max. breadth of the distal Femur	1182.992	23			

Table 58A, cont.

a. R Squared = .690 (Adjusted R Squared = .644)
 b. R Squared = .483 (Adjusted R Squared = .405)
 c. R Squared = .495 (Adjusted R Squared = .420)
 d. R Squared = .539 (Adjusted R Squared = .469)
 e. Males (n=15), Females (n=9)

Table 59A. Older Subadult: Group 6 Tests of Between-Subjects Effects^c

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Tibia	132.627 ^a	3	44.209	5.828	.005
	Min. Dia. of the Tibia	77.432 ^b	3	25.811	9.273	.001
	Circ. of the Tibia	1015.206 ^c	3	338.402	8.467	.001
	Max. breadth of the proximal Tibia	1047.440 ^d	3	349.147	8.468	.001
Intercept	Max. Dia. of the Tibia	.478	1	.478	.063	.804
	Min. Dia. of the Tibia	.925	1	.925	.332	.571
	Circ. of the Tibia	.002	1	.002	.000	.994
	Max. breadth of the proximal Tibia	.083	1	.083	.002	.965
AgeSquare	Max. Dia. of the Tibia	1.831	1	1.831	.241	.629
	Min. Dia. of the Tibia	.294	1	.294	.105	.749
	Circ. of the Tibia	3.170	1	3.170	.079	.781
	Max. breadth of the proximal Tibia	.243	1	.243	.006	.940
Age	Max. Dia. of the Tibia	2.736	1	2.736	.361	.555
	Min. Dia. of the Tibia	.091	1	.091	.033	.858
	Circ. of the Tibia	6.979	1	6.979	.175	.681
	Max. breadth of the proximal Tibia	1.333	1	1.333	.032	.859
Sex	Max. Dia. of the Tibia	79.575	1	79.575	10.491	.004
	Min. Dia. of the Tibia	45.671	1	45.671	16.407	.001
	Circ. of the Tibia	600.780	1	600.780	15.031	.001
	Max. breadth of the proximal Tibia	4.044	1	4.044	.098	.758
Error	Max. Dia. of the Tibia	144.117	19	7.585		
	Min. Dia. of the Tibia	52.888	19	2.784		
	Circ. of the Tibia	759.403	19	39.969		
	Max. breadth of the proximal Tibia	783.365	19	41.230		

Table 59A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total	Max. Dia. of the Tibia	15203.438	23			
	Min. Dia. of the Tibia	7812.308	23			
	Circ. of the Tibia	114055.000	23			
	Max. breadth of the proximal Tibia	91344.857	23			
Corrected Total	Max. Dia. of the Tibia	276.744	22			
	Min. Dia. of the Tibia	130.320	22			
	Circ. of the Tibia	1774.609	22			
	Max. breadth of the proximal Tibia	1830.804	22			
a. R Squared = .479 (Adjusted R Squared = .397) b. R Squared = .594 (Adjusted R Squared = .530) c. R Squared = .572 (Adjusted R Squared = .505) d. R Squared = .572 (Adjusted R Squared = .505) e. Males (n=15), Females (n=8)						

Table 60A. Older Subadult: Group 7 Tests of Between-Subjects Effects^d

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Max. Dia. of the Fibula	37.071 ^a	3	12.357	3.150	.048
	Min. Dia. of the Fibula	29.443 ^b	3	9.814	5.201	.008
	Circ. of the Fibula	320.984 ^c	3	106.995	5.923	.005
Intercept	Max. Dia. of the Fibula	.296	1	.296	.076	.786
	Min. Dia. of the Fibula	4.682	1	4.682	2.481	.131
	Circ. of the Fibula	8.954	1	8.954	.496	.490
AgeSquare	Max. Dia. of the Fibula	.621	1	.621	.158	.695
	Min. Dia. of the Fibula	5.753	1	5.753	3.049	.096
	Circ. of the Fibula	14.222	1	14.222	.787	.385
Age	Max. Dia. of the Fibula	.978	1	.978	.249	.623
	Min. Dia. of the Fibula	6.358	1	6.358	3.369	.081
	Circ. of the Fibula	18.429	1	18.429	1.020	.325
Sex	Max. Dia. of the Fibula	17.247	1	17.247	4.397	.049
	Min. Dia. of the Fibula	16.064	1	16.064	8.513	.009
	Circ. of the Fibula	171.802	1	171.802	9.511	.006
Error	Max. Dia. of the Fibula	78.453	20	3.923		
	Min. Dia. of the Fibula	37.739	20	1.887		
	Circ. of the Fibula	361.255	20	18.063		

Table 60A, cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Total	Max. Dia. of the Fibula	4000.466	24			
	Min. Dia. of the Fibula	2178.432	24			
	Circ. of the Fibula	31534.750	24			
Corrected Total	Max. Dia. of the Fibula	115.524	23			
	Min. Dia. of the Fibula	67.181	23			
	Circ. of the Fibula	682.240	23			
a. R Squared = .321 (Adjusted R Squared = .219) b. R Squared = .438 (Adjusted R Squared = .354) c. R Squared = .470 (Adjusted R Squared = .391) d. Males (n=15), Females (n=9)						

Table 61A. Young Subadult: Group 1 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
Observed					
Step 1	Sex	F	13	2	86.7
		M	3	11	78.6
		Overall Percentage			82.8
Step 2	Sex	F	13	2	86.7
		M	3	11	78.6
		Overall Percentage			82.8
Step 3	Sex	F	13	2	86.7
		M	3	11	78.6
		Overall Percentage			82.8
Step 4	Sex	F	12	3	80.0
		M	4	10	71.4
		Overall Percentage			75.9
a. The cut value is .500					

Table 62A. Young Subadult: Group 1 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-1.382	.613	5.090	1	.024	.251
	Max. Clavicle Length	.118	.092	1.666	1	.197	1.126
	Max. Dia. of the Clavicle	2.861	2.041	1.966	1	.161	17.484
	Min. Dia. of the Clavicle	.780	1.932	.163	1	.686	2.182
	Circ. of the Clavicle	-.553	1.012	.298	1	.585	.575
	Constant	-15.337	6.535	5.507	1	.019	.000
Step 2 ^a	Age	-1.409	.616	5.232	1	.022	.244
	Max. Clavicle Length	.125	.091	1.903	1	.168	1.134
	Max. Dia. of the Clavicle	2.333	1.509	2.391	1	.122	10.307
	Circ. of the Clavicle	-.210	.534	.154	1	.695	.811
	Constant	-14.846	6.444	5.309	1	.021	.000
Step 3 ^a	Age	-1.462	.609	5.756	1	.016	.232
	Max. Clavicle Length	.125	.091	1.905	1	.168	1.133
	Max. Dia. of the Clavicle	1.846	.809	5.208	1	.022	6.332
	Constant	-15.116	6.364	5.642	1	.018	.000
Step 4 ^a	Age	-.848	.332	6.515	1	.011	.428
	Max. Dia. of the Clavicle	1.966	.783	6.309	1	.012	7.142
	Constant	-8.767	3.658	5.744	1	.017	.000

a. Variable(s) entered on step 1: Age, Max. Clavicle Length, Max. Dia. of the Clavicle, Min. Dia. of the Clavicle, Circ. of the Clavicle.

Table 63A. Young Subadult: Group 2 Classification Table^a

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 1	Sex	F	14	4	77.8
		M	6	6	50.0
		Overall Percentage			66.7
Step 2	Sex	F	14	4	77.8
		M	6	6	50.0
		Overall Percentage			66.7
Step 3	Sex	F	15	3	83.3
		M	6	6	50.0
		Overall Percentage			70.0

a. The cut value is .500

Table 64A. Young Subadult: Group 2 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-.381	.276	1.908	1	.167	.683
	Max. Dia. of the Humerus	-1.482	1.826	.659	1	.417	.227
	Min. Dia. of the Humerus	1.634	1.385	1.391	1	.238	5.124
	Circ. of the Humerus	.250	.842	.088	1	.767	1.284
	Constant	-5.620	2.980	3.557	1	.059	.004
Step 2 ^a	Age	-.397	.270	2.157	1	.142	.672
	Max. Dia. of the Humerus	-.988	.725	1.855	1	.173	.372
	Min. Dia. of the Humerus	1.948	.923	4.454	1	.035	7.013
	Constant	-5.616	2.953	3.617	1	.057	.004
Step 3 ^a	Age	-.505	.260	3.781	1	.052	.603
	Min. Dia. of the Humerus	.900	.414	4.721	1	.030	2.458
	Constant	-6.413	2.861	5.023	1	.025	.002
a. Variable(s) entered on step 1: Age, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus.							

Table 65A. Young Subadult: Group 2 Classification Table^a

		Predicted			
		Sex			
	Observed	F	M	Percentage Correct	
Step 1	Sex	F	11	2	84.6
		M	3	6	66.7
		Overall Percentage			77.3
Step 2	Sex	F	11	2	84.6
		M	3	6	66.7
		Overall Percentage			77.3
Step 3	Sex	F	10	3	76.9
		M	4	5	55.6
		Overall Percentage			68.2
Step 4	Sex	F	10	3	76.9
		M	4	5	55.6
		Overall Percentage			68.2
a. The cut value is .500					

Table 66A. Young Subadult: Group 2 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-2.023	1.139	3.157	1	.076	.132
	Max. Dia. of the Humerus	2.250	4.157	.293	1	.588	9.488
	Min. Dia. of the Humerus	4.096	2.657	2.376	1	.123	60.083
	Circ. of the Humerus	-1.867	1.974	.895	1	.344	.155
	Glenoid Cavity Breadth	1.676	1.103	2.307	1	.129	5.345
	Constant	-15.002	8.292	3.273	1	.070	.000
Step 2 ^a	Age	-1.909	1.125	2.879	1	.090	.148
	Min. Dia. of the Humerus	3.215	1.938	2.752	1	.097	24.909
	Circ. of the Humerus	-.885	.648	1.864	1	.172	.413
	Glenoid Cavity Breadth	1.701	1.127	2.278	1	.131	5.479
	Constant	-15.380	8.843	3.025	1	.082	.000
Step 3 ^a	Age	-1.435	.835	2.953	1	.086	.238
	Min. Dia. of the Humerus	.968	.768	1.588	1	.208	2.633
	Glenoid Cavity Breadth	.829	.736	1.269	1	.260	2.291
	Constant	-14.572	7.848	3.448	1	.063	.000
Step 4 ^a	Age	-.824	.411	4.024	1	.045	.439
	Min. Dia. of the Humerus	1.362	.639	4.534	1	.033	3.902
	Constant	-9.719	4.567	4.530	1	.033	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Glenoid Cavity Breadth.							

Table 67A. Young Subadult: Group 2 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
Observed					
Step 1	Sex	F	8	0	100.0
		M	0	5	100.0
		Overall Percentage			100.0
Step 2	Sex	F	8	0	100.0
		M	0	5	100.0
		Overall Percentage			100.0
Step 3	Sex	F	8	0	100.0
		M	0	5	100.0
		Overall Percentage			100.0
Step 4	Sex	F	8	0	100.0
		M	0	5	100.0
		Overall Percentage			100.0
a. The cut value is .500					

Table 68A. Young Subadult: Group 2 Variables in the Equation^c

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-35.347	3711.640	.000	1	.992	.000
	Max. Dia. of the Humerus	1164.616	116390.025	.000	1	.992	.
	Min. Dia. of the Humerus	437.493	46247.337	.000	1	.992	1.002E190
	Circ. of the Humerus	-416.004	41641.295	.000	1	.992	.000
	Glenoid Cavity Breadth	47.045	10738.901	.000	1	.997	2.701E20
	Max. Breadth the Distal Humerus	-126.207	12190.656	.000	1	.992	.000
	Constant	39.762	30654.629	.000	1	.999	1.854E17
Step 2 ^a	Age	-111.926	9679.886	.000	1	.991	.000
	Max. Dia. of the Humerus	348.931	60193.483	.000	1	.995	3.457E151
	Circ. of the Humerus	-119.007	25696.635	.000	1	.996	.000
	Glenoid Cavity Breadth	309.994	28077.592	.000	1	.991	4.253E134
	Max. Breadth the Distal Humerus	-93.244	7815.821	.000	1	.990	.000
	Constant	-794.790	110948.343	.000	1	.994	.000
Step 3 ^a	Age	-127.756	9460.450	.000	1	.989	.000
	Max. Dia. of the Humerus	88.810	7852.730	.000	1	.991	3.713E38
	Glenoid Cavity Breadth	249.423	18409.054	.000	1	.989	2.104E108
	Max. Breadth the Distal Humerus	-87.468	6541.193	.000	1	.989	.000
	Constant	-1251.265	93278.796	.000	1	.989	.000
Step 4 ^b	Age	-126.206	1961081.187	.000	1	1.000	.000
	Max. Dia. of the Humerus	101.724	9491737.307	.000	1	1.000	1.507E44
	Min. Dia. of the Humerus	32.592	24687890.925	.000	1	1.000	1.428E14
	Glenoid Cavity Breadth	221.191	23111272.988	.000	1	1.000	1.153E96
	Max. Breadth the Distal Humerus	-89.678	1137890.237	.000	1	1.000	.000
	Constant	-1285.316	18493798.934	.000	1	1.000	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus, Glenoid Cavity Breadth, Max. Breadth the Distal Humerus.							
b. Variable(s) entered on step 4: Min. Dia. of the Humerus.							
c. Stepwise procedure stopped because removing the least significant variable result in a previously fitted model.							

Table 69A. Young Subadult: Group 3 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Step 1	Sex	F	14	1	93.3
		M	5	8	61.5
		Overall Percentage			78.6
Step 2	Sex	F	15	0	100.0
		M	5	8	61.5
		Overall Percentage			82.1
a. The cut value is .500					

Table 70A. Young Subadult: Group 3 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-.593	.386	2.356	1	.125	.553
	Max. Dia. of the Radius	-. 1.912	1.543	1.535	1	.215	.148
	Min. Dia. of the Radius	3.731	2.159	2.986	1	.084	41.737
	Circ. of the Radius	.175	.715	.060	1	.806	1.192
	Constant	-. 7.807	3.818	4.180	1	.041	.000
Step 2 ^a	Age	-.606	.387	2.444	1	.118	.546
	Max. Dia. of the Radius	-. 1.623	.979	2.747	1	.097	.197
	Min. Dia. of the Radius	4.037	1.810	4.973	1	.026	56.643
	Constant	-. 7.938	3.814	4.332	1	.037	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Radius, Min. Dia. of the Radius, Circ. of the Radius.							

Table 71A. Young Subadult: Group 4 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Step 1	Sex	F	11	4	73.3
		M	4	8	66.7
		Overall Percentage			70.4
Step 2	Sex	F	12	3	80.0
		M	4	8	66.7
		Overall Percentage			74.1
Step 3	Sex	F	11	4	73.3
		M	4	8	66.7
		Overall Percentage			70.4
a. The cut value is .500					

Table 72A. Young Subadult: Group 4 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.463	.328	1.987	1	.159	.629
	Max. Dia. of the Ulna	-1.442	1.582	.831	1	.362	.236
	Min. Dia. of the Ulna	1.450	1.713	.716	1	.397	4.262
	Circ. of the Ulna	.524	.838	.391	1	.532	1.689
	Constant	-7.662	3.695	4.300	1	.038	.000
Step 2 ^a	Age	-.413	.312	1.755	1	.185	.662
	Max. Dia. of the Ulna	-.623	.816	.584	1	.445	.536
	Min. Dia. of the Ulna	2.259	1.233	3.359	1	.067	9.578
	Constant	-7.403	3.471	4.548	1	.033	.001
Step 3 ^a	Age	-.540	.293	3.386	1	.066	.583
	Min. Dia. of the Ulna	1.552	.709	4.794	1	.029	4.720
	Constant	-7.549	3.425	4.857	1	.028	.001
a. Variable(s) entered on step 1: Age, Max. Dia. of the Ulna, Min. Dia. of the Ulna, Circ. of the Ulna.							

Table 73A. Young Subadult: Group 5 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
	Observed				
Step 1	Sex	F	13	10	56.5
		M	7	18	72.0
		Overall Percentage			64.6
Step 2	Sex	F	12	11	52.2
		M	7	18	72.0
		Overall Percentage			62.5
Step 3	Sex	F	12	11	52.2
		M	7	18	72.0
		Overall Percentage			62.5
a. The cut value is .500					

Table 74A. Young Subadult: Group 5 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.475	.245	3.762	1	.052	.622
	Max. Dia. of the Femur	.139	.922	.023	1	.880	1.149
	Min. Dia. of the Femur	-.219	.955	.053	1	.818	.803
	Circ. of the Femur	.155	.494	.099	1	.753	1.168
	Constant	-3.522	1.898	3.446	1	.063	.030
Step 2 ^a	Age	-.472	.243	3.765	1	.052	.623
	Min. Dia. of the Femur	-.280	.866	.105	1	.746	.756
	Circ. of the Femur	.220	.248	.785	1	.376	1.246
	Constant	-3.570	1.873	3.633	1	.057	.028
Step 3 ^a	Age	-.500	.230	4.709	1	.030	.607
	Circ. of the Femur	.143	.065	4.753	1	.029	1.153
	Constant	-3.657	1.864	3.849	1	.050	.026
a. Variable(s) entered on step 1: Age, Max. Dia. of the Femur, Min. Dia. of the Femur, Circ. of the Femur.							

Table 75A. Young Subadult: Group 5 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
Observed					
Step 1	Sex	F	11	6	64.7
		M	4	16	80.0
		Overall Percentage			73.0
Step 2	Sex	F	11	6	64.7
		M	4	16	80.0
		Overall Percentage			73.0
Step 3	Sex	F	10	7	58.8
		M	7	13	65.0
		Overall Percentage			62.2
Step 4	Sex	F	9	8	52.9
		M	5	15	75.0
		Overall Percentage			64.9
a. The cut value is .500					

Table 76A. Young Subadult: Group 5 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-.431	.270	2.556	1	.110	.650
	Max. Dia. of the Femur	.150	1.091	.019	1	.890	1.162
	Min. Dia. of the Femur	-1.297	1.338	.939	1	.332	.273
	Circ. of the Femur	.383	.639	.360	1	.549	1.467
	Max. Breadth of the Distal Femur	.103	.112	.851	1	.356	1.108
	Constant	-4.305	2.131	4.082	1	.043	.013
Step 2 ^a	Age	-.429	.269	2.550	1	.110	.651
	Min. Dia. of the Femur	-1.363	1.250	1.189	1	.276	.256
	Circ. of the Femur	.457	.354	1.662	1	.197	1.579
	Max. Breadth of the Distal Femur	.099	.108	.840	1	.359	1.104
	Constant	-4.334	2.121	4.176	1	.041	.013
Step 3 ^a	Age	-.413	.276	2.234	1	.135	.662
	Min. Dia. of the Femur	-1.216	1.232	.974	1	.324	.296
	Circ. of the Femur	.501	.352	2.033	1	.154	1.651
	Constant	-3.811	2.050	3.456	1	.063	.022
Step 4 ^a	Age	-.543	.256	4.490	1	.034	.581
	Circ. of the Femur	.166	.074	5.046	1	.025	1.181
	Constant	-4.203	2.051	4.200	1	.040	.015
a. Variable(s) entered on step 1: Age, Max. Dia. of the Femur, Min. Dia. of the Femur, Circ. of the Femur, Max. Breadth of the Distal Femur.							

Table 81A. Young Subadult: Group 7 Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	16	4	80.0
		M	6	10	62.5
		Overall Percentage			72.2
Step 2	Sex	F	16	4	80.0
		M	6	10	62.5
		Overall Percentage			72.2
a. The cut value is .500					

Table 82A. Young Subadult: Group 7 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.536	.303	3.122	1	.077	.585
	Max. Dia. of the Fibula	-2.900	1.631	3.160	1	.075	.055
	Min. Dia. of the Fibula	.006	.761	.000	1	.993	1.006
	Circ. of the Fibula	1.339	.713	3.524	1	.060	3.815
	Constant	-4.170	2.206	3.574	1	.059	.015
Step 2 ^a	Age	-.535	.294	3.321	1	.068	.585
	Max. Dia. of the Fibula	-2.906	1.492	3.792	1	.052	.055
	Circ. of the Fibula	1.342	.597	5.048	1	.025	3.828
	Constant	-4.166	2.140	3.789	1	.052	.016
a. Variable(s) entered on step 1: Age, Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula.							

Table 85A. Older Subadult: Group 1 Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	7	2	77.8
		M	0	13	100.0
		Overall Percentage			90.9
Step 2	Sex	F	7	2	77.8
		M	0	13	100.0
		Overall Percentage			90.9
Step 3	Sex	F	8	1	88.9
		M	0	13	100.0
		Overall Percentage			95.5
Step 4	Sex	F	8	1	88.9
		M	1	12	92.3
		Overall Percentage			90.9
a. The cut value is .500					

Table 86A. Older Subadult: Group 1 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.407	.591	.473	1	.492	.666
	Max. Clavicle Length	-.112	.106	1.118	1	.290	.894
	Max. Dia. of the Clavicle	.660	2.265	.085	1	.771	1.934
	Min. Dia. of the Clavicle	-.296	2.477	.014	1	.905	.744
	Circ. of the Clavicle	.750	1.407	.284	1	.594	2.118
	Constant	-5.923	10.500	.318	1	.573	.003
Step 2 ^a	Age	-.389	.568	.468	1	.494	.678
	Max. Clavicle Length	-.118	.097	1.471	1	.225	.889
	Max. Dia. of the Clavicle	.859	1.547	.308	1	.579	2.360
	Circ. of the Clavicle	.601	.616	.949	1	.330	1.823
	Constant	-5.404	9.490	.324	1	.569	.004
Step 3 ^a	Age	-.425	.562	.571	1	.450	.654
	Max. Clavicle Length	-.132	.093	2.008	1	.156	.876
	Circ. of the Clavicle	.895	.389	5.277	1	.022	2.446
	Constant	-2.826	7.936	.127	1	.722	.059
Step 4 ^a	Age	-.657	.502	1.713	1	.191	.518
	Circ. of the Clavicle	.640	.265	5.804	1	.016	1.896
	Constant	-8.452	6.584	1.648	1	.199	.000
a. Variable(s) entered on step 1: Max. Clavicle Length, Max. Dia. of the Clavicle, Min. Dia. of the Clavicle, Circ. of the Clavicle.							

Table 87A. Older Subadult: Group 2 Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	8	1	88.9
		M	2	8	80.0
		Overall Percentage			84.2
Step 2	Sex	F	8	1	88.9
		M	2	8	80.0
		Overall Percentage			84.2
a. The cut value is .500					

Table 88A. Older Subadult: Group 2 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.133	.907	.022	1	.883	.875
	Max. Dia. of the Humerus	-1.632	2.190	.556	1	.456	.195
	Min. Dia. of the Humerus	2.423	1.666	2.117	1	.146	11.284
	Circ. of the Humerus	.227	1.017	.050	1	.823	1.255
	Constant	-14.826	14.994	.978	1	.323	.000
Step 2 ^a	Age	-.239	.789	.092	1	.762	.787
	Max. Dia. of the Humerus	-1.173	.650	3.254	1	.071	.309
	Min. Dia. of the Humerus	2.681	1.243	4.648	1	.031	14.597
	Constant	-13.173	12.542	1.103	1	.294	.000
a. Variable(s) entered on step 1: Max. Dia. of the Humerus, Min. Dia. of the Humerus, Circ. of the Humerus.							

Table 89A. Older Subadult: Group 2 Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	7	1	87.5
		M	1	9	90.0
		Overall Percentage			88.9
Step 2	Sex	F	7	1	87.5
		M	0	10	100.0
		Overall Percentage			94.4
a. The cut value is .500					

Table 90A. Older Subadult: Group 2 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-4.476	10.953	.167	1	.683	.011
	Max. Dia. of the Humerus	-2.629	3.847	.467	1	.494	.072
	Min. Dia. of the Humerus	8.717	17.115	.259	1	.611	6107.231
	Circ. of the Humerus	-.742	2.847	.068	1	.794	.476
	Glenoid Cavity Breadth	2.350	4.428	.282	1	.596	10.484
	Constant	-21.480	26.978	.634	1	.426	.000
Step 2 ^a	Age	-2.435	3.176	.588	1	.443	.088
	Max. Dia. of the Humerus	-3.003	2.740	1.201	1	.273	.050
	Min. Dia. of the Humerus	5.700	5.468	1.087	1	.297	299.016
	Glenoid Cavity Breadth	1.625	1.616	1.011	1	.315	5.078
	Constant	-25.931	23.122	1.258	1	.262	.000
a. Variable(s) entered on step 1: Max. Dia. of the Humerus, Hmin, Circ. of the Humerus, Glenoid Cavity Breadth.							

Table 91A. Older Subadult: Group 2 Classification Table^a

			Predicted		
			Sex		Percentage Correct
	Observed		F	M	
Step 1	Sex	F	5	0	100.0
		M	0	6	100.0
		Overall Percentage			100.0
Step 2	Sex	F	5	0	100.0
		M	0	6	100.0
		Overall Percentage			100.0
Step 3	Sex	F	5	0	100.0
		M	0	6	100.0
		Overall Percentage			100.0
a. The cut value is .500					

Table 92A. Older Subadult: Group 2 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-23.670	45109.578	.000	1	1.000	.000
	Circ. of the Humerus	-.851	8696.547	.000	1	1.000	.427
	Glenoid Cavity Breadth	46.334	25065.003	.000	1	.999	1.326E20
	Humerus Ratio	-439.755	288555.301	.000	1	.999	.000
	Max. Breadth of the Distal Humerus	-3.707	6692.811	.000	1	1.000	.025
	Constant	121.601	103160.118	.000	1	.999	6.468E52
Step 2 ^a	Age	-19.238	11018.371	.000	1	.999	.000
	Glenoid Cavity Breadth	44.193	11593.844	.000	1	.997	1.558E19
	Humerus Ratio	-467.347	126407.821	.000	1	.997	.000
	Max. Breadth of the Distal Humerus	-4.324	2309.455	.000	1	.999	.013
	Constant	125.050	95686.830	.000	1	.999	2.034E54
Step 3 ^a	Age	-31.843	9493.921	.000	1	.997	.000
	Glenoid Cavity Breadth	49.234	10399.642	.000	1	.996	2.411E21
	Humerus Ratio	-672.161	140647.464	.000	1	.996	.000
	Constant	235.136	74269.620	.000	1	.997	1.312E10 ₂
a. Variable(s) entered on step 1: Circ. of the Humerus, Glenoid Cavity Breadth, Humerus Ratio, Max. Breadth of the Distal Humerus.							

Table 93A. Older Subadult: Group 3 Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	4	4	50.0
		M	2	12	85.7
		Overall Percentage			72.7
Step 2	Sex	F	4	4	50.0
		M	3	11	78.6
		Overall Percentage			68.2
a. The cut value is .500					

Table 94A. Older Subadult: Group 3 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-.154	.565	.074	1	.785	.857
	Max. Dia. of the Radius	-4.471	2.417	3.422	1	.064	.011
	Min. Dia. of the Radius	-1.559	1.841	.716	1	.397	.210
	Circ. of the Radius	2.383	1.352	3.106	1	.078	10.838
	Constant	-9.549	6.739	2.007	1	.157	.000
Step 2 ^a	Age	-.189	.556	.115	1	.734	.828
	Max. Dia. of the Radius	-3.423	1.964	3.037	1	.081	.033
	Circ. of the Radius	1.551	.861	3.242	1	.072	4.715
	Constant	-7.468	5.641	1.753	1	.186	.001
a. Variable(s) entered on step 1: Max. Dia. of the Radius, Min. Dia. of the Radius, Circ. of the Radius.							

Table 97A. Older Subadult: Group 5 Classification Table^a

			Predicted		
			Sex		
			F	M	Percentage Correct
Observed					
Step 1	Sex	F	7	2	77.8
		M	2	13	86.7
		Overall Percentage			83.3
Step 2	Sex	F	7	2	77.8
		M	2	13	86.7
		Overall Percentage			83.3
Step 3	Sex	F	6	3	66.7
		M	3	12	80.0
		Overall Percentage			75.0
Step 4	Sex	F	6	3	66.7
		M	2	13	86.7
		Overall Percentage			79.2
a. The cut value is .500					

Table 98A. Older Subadult: Group 5 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-1.455	.758	3.681	1	.055	.233
	Max. Dia. of the Femur	2.089	1.127	3.435	1	.064	8.078
	Min. Dia. of the Femur	.759	.865	.770	1	.380	2.137
	Circ. of the Femur	-.473	.389	1.476	1	.224	.623
	Max. Breadth of the Distal Femur	-.033	.175	.035	1	.852	.968
	Constant	-7.294	8.106	.810	1	.368	.001
Step 2 ^a	Age	-1.461	.751	3.782	1	.052	.232
	Max. Dia. of the Femur	2.030	1.045	3.774	1	.052	7.617
	Min. Dia. of the Femur	.713	.818	.760	1	.383	2.040
	Circ. of the Femur	-.462	.365	1.597	1	.206	.630
	Constant	-7.846	7.626	1.059	1	.304	.000
Step 3 ^a	Age	-1.506	.775	3.779	1	.052	.222
	Max. Dia. of the Femur	2.073	.993	4.362	1	.037	7.952
	Circ. of the Femur	-.265	.196	1.829	1	.176	.767
	Constant	-7.636	7.422	1.058	1	.304	.000
Step 4 ^a	Age	-1.034	.601	2.959	1	.085	.356
	Max. Dia. of the Femur	1.022	.460	4.944	1	.026	2.778
	Constant	-8.562	6.407	1.786	1	.181	.000
a. Variable(s) entered on step 1: Age, Max. Dia. of the Femur, Min. Dia. of the Femur, Circ. of the Femur, Max. Breadth of the Distal Femur.							

Table 107A. Older Subadult: Group 6 Classification Table^a

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 1	Sex	F	8	0	100.0
		M	0	15	100.0
		Overall Percentage			100.0
Step 2	Sex	F	8	0	100.0
		M	0	15	100.0
		Overall Percentage			100.0
a. The cut value is .500					

Table 108A. Older Subadult: Group 6 Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 ^a	Age	-58.574	2149.514	.001	1	.978	.000
	Tibia ratio	-984.081	58855.741	.000	1	.987	.000
	Circ. of the Tibia	102.611	3196.831	.001	1	.974	3.658E44
	Max. Breadth of the Proximal Tibia	-10.584	381.357	.001	1	.978	.000
	Constant	-3889.144	146694.913	.001	1	.979	.000
Step 2 ^a	Age	-88.574	2380.381	.001	1	.970	.000
	Circ. of the Tibia	135.786	3376.926	.002	1	.968	9.360E58
	Max. Breadth of the Proximal Tibia	-18.521	444.330	.002	1	.967	.000
	Constant	-6518.682	162369.226	.002	1	.968	.000
a. Variable(s) entered on step 1: Age, Tibia ratio, Circ. of the Tibia, Max. Breadth of the Proximal Tibia.							

Table 109A. Older Subadult: Group 7 Classification Table^a

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 1	Sex	F	7	2	77.8
		M	1	14	93.3
		Overall Percentage			87.5
Step 2	Sex	F	8	1	88.9
		M	1	14	93.3
		Overall Percentage			91.7
a. The cut value is .500					

Table 110A. Older Subadult: Group 7 Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-.303	.470	.417	1	.519	.738
	Max. Dia. of the Fibula	-2.790	1.437	3.771	1	.052	.061
	Min. Dia. of the Fibula	-1.771	1.261	1.972	1	.160	.170
	Circ. of the Fibula	2.238	1.080	4.291	1	.038	9.372
	Constant	-22.531	12.958	3.023	1	.082	.000
Step 2 ^a	Age	-.267	.400	.447	1	.504	.765
	Max. Dia. of the Fibula	-1.458	.918	2.524	1	.112	.233
	Circ. of the Fibula	1.032	.485	4.521	1	.033	2.806
	Constant	-13.487	8.913	2.290	1	.130	.000
a. Variable(s) entered on step 1: Max. Dia. of the Fibula, Min. Dia. of the Fibula, Circ. of the Fibula.							

Table 111A. Older Subadult: Best Model Classification Table^a

Observed			Predicted		
			Sex		
			F	M	Percentage Correct
Step 1	Sex	F	8	1	88.9
		M	1	13	92.9
		Overall Percentage			91.3
Step 2	Sex	F	8	1	88.9
		M	1	13	92.9
		Overall Percentage			91.3
Step 3	Sex	F	8	1	88.9
		M	1	13	92.9
		Overall Percentage			91.3
a. The cut value is .500					

Table 112A. Older Subadult: Best Model Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-2.019	2.689	.564	1	.453	.133
	Circ. of the Clavicle	.086	.476	.032	1	.857	1.090
	Min. Dia. of the Tibia	5.305	6.045	.770	1	.380	201.326
	Max. Dia. of the Femur	.103	.800	.017	1	.898	1.108
	Constant	-66.882	69.047	.938	1	.333	.000
Step 2 ^a	Age	-1.836	2.063	.792	1	.373	.159
	Circ. of the Clavicle	.128	.342	.139	1	.709	1.136
	Min. Dia. of the Tibia	4.972	4.972	1.000	1	.317	144.293
	Constant	-62.648	55.897	1.256	1	.262	.000
Step 3 ^a	Age	-2.127	2.290	.863	1	.353	.119
	Min. Dia. of the Tibia	6.056	5.007	1.463	1	.226	426.822
	Constant	-73.288	56.839	1.663	1	.197	.000
a. Variable(s) entered on step 1: Age, Circ. of the Clavicle, Min. Dia. of the Tibia, Max. Dia. of the Femur.							

Table 113A. Older Subadult: Best Model Classification Table^a

			Predicted		
			Sex		
	Observed		F	M	Percentage Correct
Step 1	Sex	F	9	0	100.0
		M	0	13	100.0
		Overall Percentage			100.0
Step 2	Sex	F	9	0	100.0
		M	0	13	100.0
		Overall Percentage			100.0
a. The cut value is .500					

Table 114A. Older Subadult: Best Model Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Age	-23.263	2310.285	.000	1	.992	.000
	Circ. of the Clavicle	-1.295	912.601	.000	1	.999	.274
	Min. Dia. of the Tibia	73.694	6560.442	.000	1	.991	1.011E32
	Max. Dia. of the Femur	43.538	5436.417	.000	1	.994	8.095E18
	Max. Clavicle Length	-5.848	891.278	.000	1	.995	.003
	Constant	-1194.674	103025.534	.000	1	.991	.000
Step 2 ^a	Age	-24.643	2360.602	.000	1	.992	.000
	Min. Dia. of the Tibia	70.461	6023.602	.000	1	.991	3.989E30
	Max. Dia. of the Femur	50.795	4969.939	.000	1	.992	1.148E22
	Max. Clavicle Length	-7.185	753.153	.000	1	.992	.001
	Constant	-1158.899	97732.981	.000	1	.991	.000
a. Variable(s) entered on step 1: Age, Circ. of the Clavicle, Min. Dia. of the Tibia, Max. Dia. of the Femur, Max. Clavicle Length.							

Vita

Miriam E. Soto was born in Houston, Texas, on April 14, 1982. She attended a Baptist private school from the age of 2 until the 6th grade. She also attended Johnston Middle School and Bellaire High school. In December of 2004, she graduated cum laude with a Bachelor of Science in Anthropology from the University of Houston. Miriam began graduate school at the University of Tennessee, Knoxville in August 2005. In August 2008, Miriam Soto earned her Master of Arts degree in Anthropology. She plans to continue her education at the University of Tennessee, Knoxville, to earn her Doctor of Philosophy degree in Anthropology with a concentration in Forensic Anthropology.

While at the University of Tennessee, Miriam E. Soto has volunteered her time at the Forensic Anthropology Center. She has also conducted research in Lisbon, Portugal at the National Museum of Natural History and hopes to return to Lisbon someday and for further research and recreation. At the moment, Miriam's research interests include forensic anthropology and craniometrics for purposes of investigating admixture.

Now that Miriam has finished her master's degree, she plans to return to Houston for the summer for some much needed relaxation and to spend time with her beloved family.