Comparative study of pelvic variability in relation to sexual dimorphism and geography in both modern and pre-historic populations

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A COMPARATIVE STUDY OF PELVIC VARIABILITY IN RELATION TO SEXUAL DIMORPHISM AND GEOGRAPHY IN BOTH MODERN AND PRE-HISTORIC POPULATIONS

by

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B.Sc. State University of New York at Binghamton, USA, 2003

presented in partial fulfillment of the requirements for the degree of

Master of Arts

The University of Montana

May 2005

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A Comparative Study of Pelvic Variability in Relation to Sexual Dimorphism and Geography in Both Modern and Pre-historic Populations

Chairperson; Noriko Seguchi

This project is an attempt to document pelvic variation based on geography and sexual dimorphism. The pelvis has received little attention with respect to population variability around the world, in comparison to the thorough documentation on the human crania. The methods employed repeat those utilized by both Wu et al. (1982) and Davivongs (1963), in order to ensure comparability with their results on populations of the Han and the Australian Aborigines. Twelve variables (ischial length, sciatic notch breadth, sciatic notch depth, OB of greater sciatic notch, acetabular vertical height, horizontal diameter of acetabulum, maximum length of os coxae, iliac breadth, length of pubic symphysis, pubic length, as well as pelvic and sacral chilotic lines) were measured on four different populations, with some repeated due to different measuring techniques. These include prehistoric populations from New Mexico, Utah, and Colorado and a modern day population from New York. Indices were calculated from this data, including the ischio-pubic index, the coxal index, greater sciatic notch index, the chilotic index and an OB index for efficient population comparability. SPSS was used to perform statistical analysis of these results, including One-Way ANOVA and Post Hoc tests. Results show a clear deviation of means between sexes when considering areas of the pelvis related to the greater sciatic notch as well as the ischium; but overlap exists in every case. The modern collection was the only group showing statistically significant differences to the other groups. Differences in measuring techniques alone are not sufficient to explain the observed variation.
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x
This study focuses on the os coxae as a means to document, compare, and discuss sexual dimorphism. There are few reasons why the os coxae was the skeletal unit chosen for such a study. The os coxae has been documented as one of the most accurate tools in sexing the human skeleton. "As far as the sex differences and sex determination of skeletons are concerned, it has been universally accepted that the pelvic girdle is the most important part (Davivongs 1963:443). It is accepted by researchers that the majority of skeletal attributes that help distinguish sex have to do with the robusticity of the particular feature. Examples of such features include the size, shape, and robustness of the mastoid process on the crania; a male often has a thicker and wider mastoid process than women. Tuberosities on the femur and tibia can be looked at for robusticity and prominence; if the areas of muscle attachment are very well-defined and robust, these are indications of a male individual. The nuchal crest is often more prominent and robust in males as well. In respect to the os coxae, a researcher often takes into consideration the size and robustness. For example, the hip joint is thought to be larger in males than females, therefore creating a larger acetabulum in male os coxae. Such sexual differences in the pelvis are often created due to the functional purpose a female’s capacity to have children, and the influence of sex hormones. Washburn (1948) reveals that the pubic bone is the most influenced portion of the pelvis by female sex hormones, and is therefore the best sex indicator of the skeleton. These differences can be detected in the pelvis as early on as fetal life, and continue to develop into adulthood (Krogman 1962:122). Studies have been done that detect sexual differences in the fetus, infants,
and/or children (Thomson 1899; Reynolds 1945, 1947). Sexual differences are often easier and more reliable in the adult form, after fusion has occurred at every epiphysis. This study will only use fully developed os coxae. I chose not to account for body size differences between the female and male sexes, which can be done by dividing the os coxae measurements by a measure of body size such as femur length or femur head diameter. The reason for not doing this was explained by Tague (1992); he claims that "there are marked differences among the pelvic dimensions in the proportion to which each scales with femoral size (Tague 1992)."

It is a goal of this paper to discuss the Morphology and Southwest samples in great detail concerning various aspects of os coxae morphology. I want to know how these pelvic attributes describe an individual population and how they relate to other populations. I also want to compare, whenever possible, previous studies done concerning sexual dimorphism of the pelvis. It will be shown that while each population does have its own range of variation, and significant differences are present between populations, a large degree of overlap does exist among all compared populations. Variations in the mosaic patterns of pelvic variation can be detected by geographic region, and temporally as well.

In order to achieve a thorough description of human skeletal morphology around the globe, a database comparable to present documented cranial variation should be achieved for the human pelvis. Difficulties in sexing prehistoric and modern skeletons, whether realized or unbeknownst to a researcher, do exist. Karen Rosenberg acknowledges the occurrence and states, "that confusion over the os coxae reflects a real (but hitherto poorly documented) pattern of regional variation in sexual dimorphism in
the human pelvis” (Rosenberg 2002). The need for an increase in understanding of os coxae variation is put into perspective by Hanna and Washburn (1953) when they present the fact that, “If there were very few cases of doubtful sex, this might not be a matter of practical concern, but Howells ('41) estimates that here may be disagreement among experts in 15% of the cases, and this is more than enough to cause a major difficulty in the study of race, sex, and variability of prehistoric populations” (Hanna and Washburn 1953:21). By mapping out geographic os coxae variation, and eventually quantifying to what degree these populations vary, efforts to sexing skeletons from the pelvis will be better understood and more accurate. There has been significant documentation on the regional variation of cranial morphology in respect to sexual dimorphism (Howells 1973; Frayer and Wolpoff 1985), and a similar effort needs to be made in the documentation of os coxae regional variation. Most literature discussing postcranial morphology has focused on body proportions (such as Ruff 1993), and the true extent of postcranial elements having potential for documentable regional variation has not been explored (Rosenberg 2002).

There are concerns expressed by researchers for a standardization of pelvic measurements (Hanna and Washburn 1953; Rosenberg 2002). This concern is validated from past studies that have been reevaluated, and have been determined to possess some very subjective judgments, with no supportable data, and are possibly tainted by a “western perspective” (Rosenberg 2002). Examples of such instances are publications discussing the sex of the Luijiang fossils by Coon (1962), and Woo (1959). In order to alleviate future subjective judgments, it is necessary to establish repeatable measurements that can be taught and performed by anyone trained to do so. This effort would provide
systematic means of comparing results and observing os coxae variations around the world. Hanna and Washburn (1953) feel that all subjectivity should be removed from pelvic studies with the use of a “quantitative method which will divide a series automatically into those probably male and those probably female and which will allow some estimate of error” (Hanna and Washburn 1953:22). Although Hanna and Washburn (1953) had great success with this type of method for sexing an Eskimo population, there needs to be more quantification of regional variation and the accuracy of the pelvic aspects they chose for quantitative analysis. I will show in this study that some pelvic measurements are more accurate at sexing an individual than others, and that this may vary from population to population. In addition, this study attempts to conform to a documentable and repeatable process by using measurements described and utilized in articles by Wu et al. (1982) and Davivongs (1963).

In addition to genetic factors, it has been shown that the morphology of the os coxae is influenced by environmental stimuli, in particular diet (Krukierek 1951). Diet and environment are two factors that must be considered when applying a standard to individuals from different regions and circumstances (Hanna and Washburn 1953:22). Chapter 2 is a background chapter that will provide a thorough characterization of the individuals I collected data on from the prehistoric Southwest skeletal collection. Diet, lifestyle, construction, religion, and burials are a few of the topics in Chapter 2. This will provide a basic understanding of the daily environmental influences and stresses that these people lived and coped with, and better explain how serious the damaging effects of diseases like rickets could be to a person living during this time. In addition, the effects that vitamin D deficiency can have on pelvic morphology will be discussed.
Chapter 2: Background to Southwest Sample

In order to address particular questions posed, it is imperative to provide a description of the culture and environment of the composite Southwest Sample. Although the studied individuals did not inhabit the same pueblo, sufficient archaeological data has provided a database of knowledge linking each individual to a common spatial and temporal existence. Cultures were extremely similar, if not the same; survival in unforgiving environmental conditions were suffered equally, and the magnificent architectural ruins are reminders of a people whose legacy will never cease to amaze.

Of main interest here is under what circumstances were the burials excavated, what type of subsistence was employed by the Pueblo Indians, what was the extent of their existence in the Southwest, and what may have it entailed both physically and culturally. In turn, this information will help us to understand the possible morphological influences such a lifestyle may have had, particularly in reference to the human pelvis. In addition, the recorded data in this study is a tool to be able to better recognize and understand a particular geographic population. Although certain sites have received more attention from full-scale archaeological endeavors than others, these well-documented projects will shed light on all of the represented individuals used in this study.
Chaco Canyon was created by the Chaco Wash, a waterway that once terminated into the San Juan River. Encompassed by mesa cliffs on the north and south side, Chaco Canyon is an expanse of dry land approximately fifteen miles long and one mile wide (Noble 1991:120). The eastern border of the Chaco Canyon is located at latitude $35^\circ\,56'\,27''$ and longitude $107^\circ\,46'$ (Pepper 1920:13). In a one-mile distance of the canon bottom, over forty small ruins can be located, and a total of 12 large ruins over the entire expanse (Pepper 1920:13). Here was the setting of what was to be a great hub of Anasazi
culture, with a population that would exceed a thousand and influence hundreds of miles of pueblo culture in all directions (Noble 1991:120). Over the years there has been no consensus on what type of climate existed during the period of thriving Anasazi culture, and only recently has more sophisticated paleoenvironmental research provided an accurate depiction. (refer to figure 2.a)

One example of a past assumption was made by Fisher (1934), who believed it would have been impossible for climatic conditions witnessed today to be the same in the past. He thought the Chaco Wash contained water at the time of Pueblo inhabitance; it must have in order to support such a large population. Fisher (1934) estimated a population size of thirty thousand individuals. According to this estimate, he believed the Chaco Wash must have been able to irrigate up to six hundred thousand acres of land. Brand (1937) did not think such a fertile land ever existed, but merely a cold desert that may have supported some local Douglas fir and ponderosa, which were commonly used in construction. Judd (1954) agreed with Fisher on the thought that timber had to be located within the nearby vicinity, but believed a better climate and constant water supply is indicated in the tree-ring record (Akins 1986:1-2).

Although all of these ideas could have been possible, only one was proven to be true. The following is one of the earliest recorded descriptions of Chaco Canyon, made by Kidder in 1924; it is remarkably similar to how the climate may have actually been during prehistoric times.

To begin with, the district is little better than a desert; many parts of it, indeed, are absolutely barren wastes of sand and rock which do not even support the usual dry country flora of the Southwest. It is almost devoid of springs, has no permanent streams, is subject to severe sandstorms, and is blistering hot in summer and bitterly cold in winter. It is hard to see how life in Chaco could have been anything but a continual struggle for bare existence. Yet in this harsh and difficult environment Pueblo Culture reached its highest development. The towns are large, excellently constructed, and lie in close proximity to each other. If all of them had been inhabited at the same time, they might well have housed more than
10,000 people. But how so large a population could have supplied itself with the mere necessities of life, and still had time and energy left for the development of so remarkable a civilization, has puzzled every observer who has visited Chaco country [Kidder 1924:179].

A generally warm and wet climate at Chaco Canyon existed between A.D. 900 and A.D. 1130, however, in the course of this time range many periods of drought occurred. Droughts occurred during the following inclusive years, A.D. 900 to 910; A.D. 1030 to 1050, A.D. 1080 to 1100, and most harsh during the years A.D. 1130 to 1180 (Akins 1986:2; Hogan 1983). The lush Douglas fir and ponderosa pine forests of previous theories were proven to be a rarity among the Chaco landscape before the Anasazi culture arrived, as indicated by packrat midden studies (Gillespie 1985).

**Excavations**

Originally from Pennsylvania, but a newly established as a freight train operator and pothunter in the San Jan Basin area, Scott N. Morris was one of the first to ponder over the dead of Chaco Canyon. Scott Morris’s interest led him to dig one of the first exploratory trenches associated with the Pueblo Bonito ruins (Lister and Lister 1968:7).

Pueblo Bonito was one of the first Southwest sites to undergo an official archaeological excavation, respective to the knowledge present at the time. Archaeologist Richard Wetherill, who did pioneering work at Mesa Verde and Grand Gulch, saw promise in the site when he informally dug around there in 1896 (Lister and Lister 1983:110). Wetherill presented an excavation opportunity at Pueblo Bonito to sponsors of his work at Grand Gulch, brothers B. Talbot B. Hyde and Frederick E. Hyde Pepper 1920:1; Lister and Lister1968:8). Impressed with the knowledge acquired so far, the Hyde Brothers decided to fully fund the expedition, which came to be known as the Hyde Exploring Expedition. Director of the expedition was the Curator of Anthropology at the American Museum of Natural History, Professor F. W. Putnam, field director was
George H. Pepper, and Richard Wetherill was his assistant (Lister and Lister 1968:9; Pepper 1920:1). Professor F.W. Putnam is believed to have only visited the site maybe two times in the course of excavations (Lister and Lister 1983:110). Excavations have been said to have occurred there during the summer seasons of 1897 to 1900 (Lister and Lister 1968:9) and from 1896 to 1899 (Pepper 1920:1, Noble 1991:120).

What made this excavation unique was the particular care the parties involved took to provide one of the most descriptive and knowledge producing endeavors ever made in archaeology. In order to do this a methodology was introduced that included provenience records of the rooms and objects, measurements of each specimen, in situ photographs, and a geological survey (Pepper 1920:1). There was planning for future interpretation of the data based on the correlation of the geological survey with the cultural data obtained from the excavation.

**Pueblo Bonito Excavations**

About one hundred Navajos assisted in the Hyde excavations at Pueblo Bonito, aiding in the excavations of one hundred ninety eight rooms. This totaled to be a slim amount less than half of the total rooms present (Lister and Lister 1968:9, Pepper 1920:2). The first tasks involved the excavation of two refuse mounds located in the south front of Pueblo Bonito, and then burial mounds located on the southern side of the canyon. It was of interest to try and determine where the burials were located, although this was not a main objective of the expedition (Pepper 1920:26). Many excavations have provided incomplete, wrong, inconsistent, and/or unclear descriptions of prehistoric burials found in Chaco Canyon (Akins 1986:12). As an exception, George Pepper did record descriptions and take photographs of about thirty burials encountered at Pueblo Bonito (Pepper 1920:339-351). In the year 1906 some changes in the practice of archaeology were mandated with the passing of the Lacey Law by the federal
government, which made it a federal offense to excavate without permission from the proper authorities on public land. Chaco Canyon was deemed a national monument in 1907, under the tenure of Teddy Roosevelt (Lister and Lister 1983:109). It became subject to the Lacey Law, which caused an end to the Hyde expedition at Pueblo Bonito (Lister and Lister 1968:11).

Chronology of Occupation

It is known that Paleoindians hunted and gathered in the Chaco Canyon area as long as ten thousand years ago, before the settlement of more permanent cultures. The earliest of such a permanent culture were the Basketmakers. The term Basketmakers originated when Richard Wetherill excavated in the Grand Gulch area and encountered a culture that preceded the ‘Cliff Dwellers’. Among the artifacts recovered were finely woven baskets, panniers, baskets, and no inclination of pottery being made or used; for this reason Richard Wetherill named them the Basketmakers (Lister and Lister 1968:8). Beginning in about A.D. 900 the Basketmakers inhabited sites such as Atlatl Cave and Shabik’eshchee Village. Between A.D. 700 and A.D. 850 this culture settled in Chaco Canyon, before the existence of pueblos in the area (Noble 1991:120, Sofaer 1999). They lived on a small scale, inhabiting simple one-story masonry and modest earth shelters. They are believed to have practiced subsistence farming, but left very little trace of their existence (Sofaer 1999).

A.D. 900 marked the beginning of a significant population increase compared to what existed in the past. The Anasazi were taking the first steps toward becoming a more established presence in the canyon, with the introduction of larger and more delineated pueblos. The first of such inhabitants occupied a small row of rooms that is now a section of the elaborate Pueblo Bonito (Noble 1991:120).
The next couple of centuries endured a striking increase in population. This population growth marked the beginning of Pueblo Bonito's structural expansion around A.D. 1030, resulting in 10 enormous buildings that reached four to five stories high, containing approximately three thousand rooms (Sofaer 1999; Noble 1991:120). Pueblo Bonito was now one of the largest buildings in the world, and represented the center of the Anasazi culture system. Eventually this Anasazi kingdom covered a total of three acres; upon completion it was the size of the Roman Coliseum (Sofaer 1999).

By A.D. 1115 seventy pueblos of unknown purpose occupied the land surrounding Pueblo Bonito, all within 25,000 square miles of the San Juan Basin. Theories of their purpose include trading post locations, taxing overlords, and places of religious activity. What is known by the presence of over two hundred miles of interconnecting, well engineered roads, all leading at some point back to Chaco Canyon, is that these surrounding pueblos did have relationships with the Chaco Canyon pueblos (Noble 1991:122). These roads eventually reached communities that spanned ninety five thousand square miles across the Southwest of the United States (Sofaer 1999).

The drought that occurred between the years A.D. 1130 to A.D. 1150 first effected the populations of Chaco Canyon's outlying populations, and eventually caused a period of abandonment at Chaco Canyon itself (Noble 1991:122). The last chapter of Chaco Canyon occurred only a century later, when in A.D. 1200 the abandoned pueblos of Chaco Canyon began their long exposure to environmental conditions. After twelve generations of habitation, Chaco took its first steps to becoming the magnificent ruins we see there today (Noble 1991:124). It is said by Lister and Lister (1983:49) that after the people left Chaco Canyon they began to travel southward.
The ‘Chaco Phenomenon’

Roads and Trade

Although the true purpose of the road network has not been discerned from the archaeology, there are many possible reasons that these roads were built. They linked people together who lived in diverse environmental regions of the Southwest; in some areas people were more likely to be successful in particular areas of production than at others. These roads provided an organized way to transport goods to and from communities. Some believe that the influences of the Southwest stretched all the way down to Mexico (Lister and Lister 1983:48). Some of these roads were up to sixty miles long, ranged from twenty five to forty feet wide, and are surprisingly very straight (Noble 1991:122, Sofaer 1999).

Construction

Due to the almost barren location of Chaco Canyon, many people think that two of the main items possibly transported on those roads were food and lumber. Walls of the pueblo structures were created from thousands of tons of sandstone, which were cut from mesa tops above. Perhaps most remarkable was the importation of two hundred twenty thousand timbers. This lumber was actually carried by foot from mountain ranges and locations as far as seventy miles away; they were used as roof beams for kivas and other structures (Sofaer 1999; Noble 1991:124) (refer to figure 2.b).
Trade

Because of the remote location that the pueblos of Chaco Canyon were built in, and the presence of such a magnificent road network, trade has been hypothesized as one of the main functions of Chaco Canyon. Chaco cultures traded with people who lived up to three thousand miles to the south in northern Mexico, shown by the recovery of Meso-American artifacts in Chaco's buildings (Sofaer 1999). Mexicans traded material goods as well as cultural practices in exchange for items, such as the much-desired turquoise stone. Macaw birds were one such trade item found in Chaco. Religious and cultural practices that diffused from Mexico include astronomical observations, communication methods, as well as certain economic and architectural practices (Lister and Lister 1983:47; 1968, Sofaer 1999). Whatever knowledge was attained from outside parties,
there are many unique achievements that are only exhibited in Chaco Canyon. Mostly, they relate to the manipulation of water in order to perform agriculture, ceremonial constructions such as kivas, and a layout of pueblos that seemed to be in accordance with the sun and moon.

‘Impressive’ Buildings

There have been many population estimates for Chaco Canyon over the years; most of these estimations assume the best possible environmental conditions possible for the time of habitation. Fisher (1934) postulated a population of ten thousand people if only the greathouses were occupied; Pierson (1949) used the number of rooms to estimate a population of four thousand four hundred people; Drager (1976) used more recent surveys to estimate six thousand, Hayes (1981) used a more complex methodology to estimate two thousand eight hundred eighty nine residents for smaller sites and two thousand seven hundred sixty three people for greathouses; Windes (1984) believed only two thousand people could have lived in the entire canyon; and lastly Lekson (1984) was more ambitious with a total of four thousand one hundred inhabitants for the entire canyon (Akins 1986:4).

Recently, however, the massive structure called Pueblo Bonito is seen as having a much more spiritual role instead of mere residential use. Archaeologists John Stein and Mike Marshall both observe that the structural technique used was built to impress and overwhelm an individual. They make comparisons to the pyramids of Egypt, in the sense that something monumental was built for ritual more than practical purposes. It is interesting to consider that six hundred of the rooms at Pueblo Bonito may have been used as support structures for the massive exteriors. These rooms provided little if any light, very poor ventilation, making fire an impossibility, and revealed slim evidence of occupation. Supporting this idea of non-residential use is evidence provided by infrared aerial technology. With this technology, geologist Rich Friedman was able to determine
that the ratio of organic material that should have been present for a continuous occupation of many people was very off. There was not nearly enough evidence of refuse mounds that would have indicatively been the result of supporting thousands of dwellers. With no written record left, archaeologists were left to interpret the signs, symbols, and architecture itself as a means of communicating with the past. If these massive buildings were not intended for residential inhabitance, then what purpose did they serve?

**Solstice Project (Anna Sofaer 1999)**

It was not until 1977, when Anna Sofaer began her ongoing research at Chaco Canyon, that new light was literally shed on the lives of the inhabitants who created this astonishing prehistoric society. It may have been chance or fate, but when Anna Sofaer curiously peered behind three slabs of sandstone a dagger of light pierced a large spiral drawing right in its center point (refer to figure 2.c). Channeled between the sandstone rocks, this light was marking the highest point of the sun’s path in both year and day. It was later observed that equinox days, or midpoints in the sun’s year, were also marked on this spiral drawing by bracketing light rays. After this first discovery, Anna Sofaer created the Solstice Project, whose job it was to study the ruins for signs such as this. With great success, the Solstice Project found that Fajada Butte at Pueblo Bonito revealed similar sun markings of the equinox, this time in the form of a snake and a double spiral. It was now known that Chaco Canyon’s inhabitants were very aware of the solar cycle, but what was learned next displayed more than common awareness.
A symbol on Fajada Butte showed Pueblo Bonito, the center of Chaco Canyon, as a half circle with an arrow pointing south extending from the midwall of the building toward the sun. This was reason to start exploring the structural layout of Pueblo Bonito in respect to the solar cycle. It was learned that the two longest walls of Pueblo Bonito point straight in both the north-south and east-west directions; both of these directions have a relationship to the sun. At noon, a shadow disappears behind the north-south wall at the Pueblo (refer to figure 2.d). The sun rises in line with the east-west wall and sets on this wall only on equinox days, but it also separates day and night equally. Pueblo Bonito was turning out to be more than the center of Chaco Canyon culture, but a center of time as well. In addition to Pueblo Bonito, three other pueblo sites have been found to share a structural relationship with the solar cycle.
What comes next is a discovery that has not been observed in any other culture’s structural design in the world. The Solstice Project now learned that buildings at Chaco were also in accordance with the lunar cycle. What is amazing about this is the fact that it takes eighteen and a half years to observe the moon at its maximum extreme, and nine and one quarter years to observe a full lunar cycle. Somehow, the twelve generations that occupied Chaco Canyon kept track of this cycle in the form of shadows and light on the spiral rock carving (refer to figure 2.e). Among seven buildings in Chaco Canyon, connections with the extreme moons were found to a building’s center or back wall.
Religion

There was definitely religious worship taking place in Chaco Canyon and Pueblo Bonito, thus the presence of fifteen great kivas. These great kivas, or circular buildings constructed for religious ceremonies, could possibly hold over four hundred individuals at one time. In addition to these large scale kivas were hundreds of respectively smaller ones, whose occupation capacity could reach one hundred people. With the information achieved by the collaborative efforts of the Solstice Project (Sofaer 1999), many interesting scenarios could be suggested. One interesting thought is thousands of people gathering to Pueblo Bonito, perhaps on the date of a solstice, entering these kivas and having elaborate and large scale ceremonies. Maybe the interconnecting roads leading back to Chaco Canyon provided a processional route for all pueblo sites in the area to come worship together. They all had a common interest in astronomy, including the sun and the moon. Religious worship may provide a possible explanation for Pueblo Bonito not being primarily used for residential purposes.
In reference to the roads previously described, the north road is thought to be symbolic of religious activity. This north road does not link any other towns with Pueblo Bonito, but extends for miles in a straight path, and does not appear to have been used often. At the end of this road is a staircase, with fragments of shattered pottery strewn on the ground. Shattering pottery is an Anasazi way of making an offering to the gods; the pottery is no longer usable in this life and is given to the afterlife. The Anasazi were thought to believe that they originated from the north, and perhaps traveled this road on special occasions to make offerings and have ceremonies.

Religion also may have offered a uniting force for the pueblo people, making the complex social and political life at Chaco Canyon easier to deal with. Refined organizational skills and communication methods must have been achieved in order to create such a monumental and grand-scale community like what existed at Chaco Canyon.

**Pueblo Arroyo Hondo**

**Location and Climate**

Pueblo Arroyo Hondo is located on five miles southeast of Santa Fe, New Mexico, a semiarid region of the Southwest (Wetterstrom 1986:6, Lang and Harris 1984:xvii, Creamer 1993:1) (refer to figure 2.f).
Figure 2.f Location of Arroyo Hondo Pueblo in the Northern Rio Grande region. (Adapted from Habicht-Mauche 1993: xi)

It rests on a seven thousand ninety foot high plateau on a westward inclination, with the narrow Arroyo Hondo canyon cutting through alluvium on northern edge of the site (Wetterstrom 1986:6) (refer to figure 2.g).
Figure 2.g Upper Arroyo Hondo Canyon and the Western Foothills of the Sangre de Cristo Mountains. (Adapted from Dickinson 1979:55)

This area provides one of the only reliable sources of water and fertile land in the region, supplied by a water source that runs through the base of the canyon. This water source can be considered a stream at best, which is supplied from runoff and perennial springs. The springs are the result of faulting occurring in the Precambrian rocks that lie below the surface, which produce a swampy canyon bottom below the site, and sinks into a streambed one half mile downstream (Creamer 1993:1). Periods of drought would definitely affect the presence of this water; it is often non-existent in drier periods. The annual precipitation for the Arroyo Hondo area is approximately fourteen inches, enough to support the sparse pinyon and one-seed juniper woodland ecosystem that exists there today (Wetterstrom 1986:6, Lang and Harris 1984:xvii).
The local animals that live there today are reflected as being very similar to what existed in the prehistoric past, according to faunal studies. The temperature is moderately cool, with freezing periods occurring in the critical crop development periods of late May and early September (Wetterstrom 1986:6). The Rio Grande lies twenty-one miles to the west; the gradual slope from the piedmont eventually reaches this location at a lower one thousand foot elevation. Only nine miles from Arroyo Hondo in the northeast direction are some of the highest surrounding altitudes in the area. The foothills of the Sangre de Cristo mountain range quickly rise up to peak elevations over ten thousand feet high (Lang and Harris 1984:10).

Excavations

There were a few individuals traveling in the northern Rio Grande district that took note of certain pueblo ruins; some of these travelers were in the military and others were early settlers in the area. Simpson (1850) was one of the first of such travelers. However, the first attempts at documentation with scientific intentions were Adolph Bendelier in 1881, who may never have actually visited Arroyo Hondo Pueblo, Edgar Lee Hewett, and most noteworthy Nels Nelson (Creamer 1993:6; Dickson 1979:6; Bendelier 1881:90-91). Nels Nelson was funded by the American Museum of Natural History in 1915, and performed many test excavations in the area. Nelson employed pioneering techniques in the Santa Fe region; he practiced stratigraphic analysis, which in turn laid a foundation for the establishment of future chronological sequences in the northern Rio Grande region (Dickson 1979:6, Nelson 1914:1-24). The next scientific visit to Arroyo Hondo was in 1933 when the Museum of New Mexico sent W.S. Stallings to obtain a single tree-ring sample (Creamer 1993:6; Robinson, Harrill, and Warren 1973:57).
Almost forty years later Swartz (1971) performed some more test excavations. One year later the School of American Research put on an intensive archaeological project, with multidisciplinary excavations taking place from 1971 to 1974 (Dickson 1979:xi; Creamer 1993:6).

**Chronology of Occupation**

Arroyo Hondo Pueblo exhibits two phases of occupation referred to as Component I and Component II. The short span of these occupations, in addition to no later pueblos being constructed on top of the originals, makes Arroyo Hondo Pueblo a rarity in providing the ability to observe undisturbed temporal change at the site (Habicht-Mauche 1993:xiii; Creamer 1993:4). Cranial studies have provided evidence that these pueblo people were ancestors of the Tewa-Tano groups of Eastern Pueblos (Mackey 1980: 179-180; Lang and Harris 1984:3). The Tewa Native Americans are still living today in six villages located in New Mexico and Arizona. Before the pueblo occupations, the more distant Tewa-Tano ancestors occupied the area of Arroyo Hondo for about three thousand years (Lang and Harris 1984:3). The first pueblo occupation, or Component I, began around A.D. 1300. There were only a few families at this point, who occupied a couple of small roomblocks (Dickson 1979:xi). The fifty years proceeding this initial occupation was characterized by small farmstead settlements with populations ranging from twenty to a few hundred individuals (Land and Harris 1984:3) (refer to figure 2.h).
Component I marked a period of exception in relation to the small villages that existed in the past. Pueblo Arroyo Hondo’s huge population increase in A.D. 1330 may be partly due to the ending of a long drought, indicated by a marked increase in the amount of precipitation received (Habicht-Mauche 1993:xiii; Lang and Harris 1984:xvii). During the 1330’s Arroyo Hondo Pueblo reached its peak occupation, with a population of over one thousand people. This was a unique change for the region, with the only size-comparable town existing at this time being Pecos Pueblo seventeen miles in the southeast direction (Lang and Harris 1984:3). The occupants of Arroyo Hondo constructed twenty-four blocks of one and two-story adobe buildings, containing one
thousand rooms, and surrounding ten plazas, in order to accommodate the growing population (Lang and Harris 1984:xvii, Habicht-Mauche 1993:xiii). These masonry rooms were skillfully built along the steep edge of the one hundred twenty foot deep Arroyo Hondo gorge (Habicht-Mauche 1993:xiii). Tree ring dates have suggested that the construction of these buildings had begun at least by A.D. 1315, and ended shortly after A.D. 1330 (Creamer 1993:4).

The first abandonment, marking an end to Component I, began to occur after A.D. 1335. The moisture in the area began to evaporate as the precipitation slowed, and another drought began. The adobe apartments were converted into refuse storage and dust collectors, walls began to collapse, the plazas were deserted, and by A.D. 1345 Pueblo Arroyo Hondo was abandoned (Lang and Harris 1984:xvii; Habicht-Mauche 1993:xiii). Drought is a leading theory of why abandonment occurred, but may not be mutually exclusive from possible problems like environment depletion, lack of firewood, and the extinction of hunted game (Habicht-Mauche 1993:xiv).

Around A.D. 1370 a new population began to settle at Arroyo Hondo, coinciding with another period of increased precipitation (Habicht-Mauche 1993:xiv). What followed was the construction of nine roomblocks around three plazas; this occupation is referred to as Component II (Dickson 1979:xi) (refer to figure 2.1).
The roomblocks consisted of approximately two hundred single story rooms, which were built on top of the ruins from Component I (Creamer 1993:4; Habicht-Mauche 1993:xiv). Most construction is believed to have occurred in the 1370s and 80s, however, one roomblock was build in A.D. 1410 (Creamer 1993:4). It was a time once again for a large and fully established village at Arroyo Hondo, but its time span would prove to be short. Within forty years, one of the most devastating droughts recorded in the dendroclimatological record would begin at the pueblo site (Habicht-Mauche 1993:xiv). In addition to the dry climate, another misfortune hit the village; a fire broke out around A.D. 1410 and destroyed a major section of the village (Lang and Harris 1984:xvii). This marked the end of what is now referred to as Component II at Arroyo Hondo Pueblo.
Construction

Arroyo Hondo, at its peak population, had grown to cover six acres of land. The pueblo consisted of twenty-four terraced roomblocks that reached one and two stories high. These roomblocks, laid out along north-south and east-west axes, enclosed or mostly enclosed about thirteen plaza areas of rectangle shape. Each room block could contain from four to seventy rooms each (Creamer 1993:1-2). Over twelve hundred rooms had been constructed between both Component I and Component II occupations. Within the plazas, depressed into the ground, were kivas. Along with the kivas, the plazas contained turkey pens and mealing bins. The rooftops of the kivas or other buildings were often used for many domestic purposes, including food preparation.

The architecture was mainly constructed adobe style; however, some structures were built with masonry techniques in the early phase of occupation (Creamer 1993: 1-2). Less than two percent of all structures were built with local adesite chunks for masonry (Creamer 1993:14). The remainder adobe style buildings were made of a clay mixture. This clay mixture was made by combining water with the clay, which created a stiff material that was able to support its own weight (Creamer 1993:15). The mason workers of Arroyo Hondo Pueblo would mold this stiff clay mixture with their hands into what is known as courses, which are the component sections of a wall. Each course would be laid and molded when the previous one had dried (Creamer 1993:15). Handprints and indications of the course outlines can still be viewed on the ruin walls. (refer to figure 2.j)
Figure 2.j Adobe and masonry wall abutment in room 11-5. The first few rooms built at Arroyo Hondo were masonry, but the bulk of the pueblo was built of adobe. This room illustrates the shift from masonry to adobe construction in a single wall. (Adapted from Creamer 1993:18)

Agriculture/Plant Foods

Although there is limited information on the subsistence economies of the prehistoric pueblo people of Arroyo Hondo, a few things are known. Agriculture appears to have played an important role to the region as a reliable food source (Lang and Harris 1984:5). The lower areas of the canyon were used for floodwater farming or as a source of irrigation, while the higher areas of the piedmont were dry farmed during years of sufficient moisture (Habicht-Mauche 1993:xiii). There were three cultivated crops including corn, beans, and squash (Wetterstrom 1986:11). Corn was the dominant cultivar, appearing in eighty-four percent of all proveniences excavated, and was therefore one of the most important staples for the pueblo diet (refer to figure 2.k).
Low percentages were recovered of beans and squash; however, both of these foods have low preservation abilities. In addition to the cultivated crops was the presence of many wild plants, with sixteen that could be identified (Wetterstrom 1986:11). Many wild plants were probably gathered when the season provided them, such as seeds, nuts, and wild greens (Habicht-Mauche 1993:xiv; Wetterstrom 1986:6).

Animal Food/Exploitation/Husbandry

A minimum of ninety-one species of animals are represented in the Arroyo Hondo Pueblo faunal sample, which is comprised of twenty four thousand five hundred eighty nine animal bones (Lang and Harris 1984:5). Although agriculture did play a major role in prehistoric pueblo subsistence, Lang and Harris (1984) claim that the role of animal foods is often underestimated; they reveal three reasons for this underestimation. First, Pueblo Indians are simply conceptualized by many as being agriculturalists. Secondly,
today the presence of game animals has been vastly diminished in the Southwest, causing the current Pueblo economies to rely almost predominantly on agriculture. Lastly, there is often a bias in excavations to focus on the pueblo interiors, where the presence of animal bones is rarer (Lang and Harris 1984:8).

The faunal collection consisted of seventy seven percent mammals, twenty two percent birds and one percent of all remaining animal classes (Lang and Harris 1984:45). The mammals by far contributed the majority of food to the economy, with artiodactyls being the leader of that contribution. It is shown that the artiodactyls were most important before A.D. 1315, because the supply of these hoofed animals was depleted after this date. The mule deer is the most common species of artiodactyl in the faunal record (Lang and Harris 1984:47). Although it may have slowed, the practice of hunting mule deer did persist into Component II times.

Lagomorphs are another class of animals that showed a high enough resiliency to hunting to maintain a successful population, which has persisted through prehistoric times into the present at Arroyo Hondo. Although rabbits and hares do not yield as much meat as a deer, their large numbers, ease of hunting, and the worth of their pelts made them a valuable prey. One technique for catching rabbits is the rabbit drive. This activity of surrounding the rabbits is still practiced by both sexes and all ages at contemporary Rio Grande Pueblos (Lang and Harris 1984:54). Another hunting strategy is the use of snares in the agricultural fields.

The use of animals went beyond their nutritional value. Animals contributed hides, antlers, bones, sinew, and feathers; all of these are items valued in the pueblo economy (Lang and Harris 1984:45). The wild birds caught ranged from the large Canada goose to a small meadowlark (Lang and Harris 1984:59).

During the Component I occupation, the hunting territory around Pueblo Arroyo Hondo probably covered approximately eighty square miles, which may have increased to ninety square miles by A.D. 1380. Hunters were discouraged from traveling too far
west toward the Santa Fe River only eleven miles away. Settled on the Santa Fe River in this area was **Pueblo Cieneguilla**, which is part of the composite Southwest Sample that was used in my study. The presence of certain ceramics has shown that Pueblo Cieneguilla was inhabited during all of Pueblo Arroyo Hondo’s occupation (Dickson 1979).

The presence of turkey pens at Pueblo Arroyo Hondo was mentioned previously. In the faunal sample, twenty-one large Indian domestic turkeys and three Tularosa turkeys were identified (Lang and Harris 1984:93). There is a lot of evidence showing that turkey raising was a common practice at Arroyo Hondo throughout its occupation (Lang and Harris 1984:109). This evidence included eggshell pieces in the pens and refuse, unhatched turkey poults, many young turkey skeletons, mended bone breaks of the wings and leg bones, turkey manure throughout the pens, and the identification of two domestic breeds of turkey (Lang and Harris 1984:101). These turkeys most likely provided many feathers to the Pueblo people, surpassing their contribution of meat (Wetterstrom 1986:32).

Another semi-domesticated animal present at Arroyo Hondo Pueblo was the Indian dog (Lang and Harris 1984:87). The use of dogs for any other purpose than food is left to speculation. Their presence in the faunal record is not very high, providing little evidence to strongly support any theory. However, the dogs did not have special burial treatment, they had no cut marks on the bones recovered, and their meat and hides could have been very useful (Lang and Harris 1984:89). If not used for food, the dogs would have probably been great hunting partners and/or companions.

A third semi-domesticated animal found at Arroyo Hondo is the scarlet macaw, which represents a similar religious connection with the sun as was shown in Chaco Canyon. The scarlet macaw was only bred at one Southwest pueblo called Chihuahua, between A.D. 1200 and 1300. Mexico is the main region where this bird was bred. People of Mexico and of the Southwest would pluck and sacrifice these birds at the
solstice, as they were strongly associated with the Sun Deity (Lang and Harris 1984:117). Red is the dominant color in the macaw’s feathers, and red is also the color representing directions south and southeast. Two macaw burials were found at Arroyo Hondo with associated turquoise fragments; turquoise is also associated with the sun by Pueblo belief (Lang and Harris 1984:117). These observations are important because they show that a form of sun worship similar to that displayed at other pueblos during this era took place during the solstice; as well as linking Pueblo Arroyo Hondo to a trade network that extended to the Mexico border. The only other non-indigenous animal found at Arroyo Hondo that also links them to a trade network is the painted turtle, which has been identified in five other settlements of the Southwest.

**Burials**

The first documented excavations by Nels C. Nelson revealed thirty skeletons, of which subadults and adults were equally represented (Nelson 1915:5). Of these thirty individuals, there is recorded data for only twelve (Palkovich 1980:2). The majority of Nelson’s excavations took place in rooms; he excavated a total of one hundred and one rooms dating to Component I. The twelve burials with recorded data were associated with these rooms, and are therefore from Component I as well (Palkovich 1980:2). They were found in rooms with other trash, two were in midden areas, and five were the victims of accidents. Of these twelve, only one individual was buried in a subfloor pit (Palkovich 1980:2).

Due to the fact that Nelson’s main objective was to establish a chronology for the Southwest region, there was very little attention given to the burials he excavated. There are minimal notes and descriptions of the interments. He mentions keeping some remains in his notes, but many of the thirty burials were reburied (Palkovich 1980:2).

During the 1970-1974 School of American Research excavations, all ninety nine burials uncovered were found in formal graves, except nine individuals who appeared to
be the victims of accidents (Palkovich 1980:1,7). Sixty seven individuals were subadults and the remaining fifty three were fully developed adults, indicating a high infant mortality rate (Palkovich 1980:2).

![Figure 21 Young child buried in subfloor pit. (Adapted from Palkovich 1980:12)](image)

Almost half of the burials were found in the plaza area; the others were found in refuse mounds or pits beneath room floors (Palkovich 1980:2) (refer to figure 2.1). These were single individual burials, commonly in oval shaped pits with flat bottoms and straight sides (Palkovich 1980:7). In almost all formal burial cases the skeletons were found in flexed or semi-flexed positions, with the pit large enough to accommodate the body size (Palkovich 1980:1-2,7). Thirty seven percent of the burials had the head pointing toward the east direction, although no single pattern can be considered typical for all cases (Palkovich 1980:2) (refer to figure 2.m).
Of the seventy individuals buried with grave goods, sixty three percent contained items such as hide blankets or yucca fiber mats (Palkovich 1980:2,17). Other accoutrements included decorated pottery sherds, plant remains, shell ornaments, stone beads and pendants (Palkovich 1980:17). There was one male skeleton found in association with Component I, who was given a more elaborate burial than the rest. The sixteen grave goods found in his burials included projectile points, wood bow remnants, stone balls and mica sheets, a bone awl tip, an eagle claw, raven skin, raven wings. These items suggest that this man held a high status or ceremonial position in the Arroyo Hondo community (refer to figure 2.n).
Before discussing the results of excavations that took place at Pecos, it is almost necessary that Alfred V. Kidder be discussed (Lister and Lister 1968:19). A. V. Kidder was associated with the Peabody Museum of Harvard University, and possessed an inherent intuition when it came to archaeology. He was a forward thinker, and after his first visit to the Southwest in 1907, his excitement only propelled his talent (Lister and Lister 1968:19). Located in the basement of Harvard University today is a brass head nail, which marks the spot where Kidder and Samuel J. Guernsey shook hands and declared, “Let’s do the Southwest!” (Lister and Lister 1968:19). (refer to figure 2.o)
While Guernsey was discovering that the Basketmakers were conclusively older than the Cliffdwellers, Kidder took on the archaeological endeavor of the entire Pecos Pueblo site (Kidder and Kidder 1917; Lister and Lister 1968:21). The Philips Academy of Andover, Massachusetts funded the excavation, and was responsible for putting Kidder in charge. The excavations began in 1915, and persisted for ten summer field seasons over a fifteen year period (Lister and Lister 1983:155; Noble 1991:192). The Pecos Pueblo archaeological site is located approximately fifteen miles southeast of Santa Fe in north-central New Mexico, only one mile from the Pecos River (Kidder 1958; Ruff 1991:33). The theoretical frameworks and methodologies initiated at Pecos would influence all of Southwest archaeology, as well as make the name Kidder and Pecos synonymous in the archaeological world (Lister and Lister 1968:21). In total, only twelve to fifteen percent of the site was ever excavated (Ruff 1991:35).
Building on the work of Nels Nelson, A.V. Kidder saw more potential for the Pecos Pueblo site than just the documentation of events that occurred there (Dickson 1979:6). He decided to focus his efforts on producing a chronology for the entire Rio Grande region derived from sequencing pottery types at the Pecos site (Lister and Lister 1983:155). In August of 1927, the first Pecos Conference was held (Dickson 1979:6). At this conference, Kidder and his crew proposed a total of eight prehistoric periods, which would serve as a foundation for Southwest archaeology. These periods were based on the stratigraphic record and millions of pottery shards (Ruff 1991:33; Kidder 1958; Kidder and Kidder 1917; Kidder 1931; Kidder and Shephard 1936). From earliest to latest, the eight pottery types are Black-on-white, Glaze I, Glaze II, Glaze III, Glaze IV, Glaze V, Glaze VI, and Modern (Kidder and Kidder 1917); the eight prehistoric periods were Basket Maker I through III and Pueblo I through V (Lister and Lister 1983:155). These Anasazi cultural stages therefore encompassed the beginning of the Basketmakers to a full developed Pueblo culture (Kidder 1927).

Environment/Natural Resources

The Pecos Pueblo site sits in the middle of a wide fertile valley on top of a flat rocky knoll or “Mesilla” with high mesas on the south side and the Glorieta Pass farther west (Ruff 1991:34). The Pecos River flows from these western mountains. The valley descends eastward from Pecos Pueblo, and expands into the Great Plains (Noble 1991:192).

This fertile area supplied the inhabitants of Pecos Pueblo with farmable land, a reliable water supply from springs, and plenty of wood for fuel. The higher elevations provided many plant resources exploited for food and other purposes, as well as timber for construction. This area was also occupied by game animals, which were frequently hunted (Noble 1991:192). The local resources were used in many aspects of life; the
Pueblo people made tools, weapons, pottery, and basketry with them (Noble 1991:192). Such items would often be traded with other pueblo communities. Pecos Pueblo was situated in an ideal trade location, in between the agriculturalists of the northern Rio Grande region and the nomadic hunters of the Great Plains (Noble 1991:192). As noted in previous sections, the occupants of the northern Rio Grande region were not limited to agriculture for their food supply, but were frequent hunters and animal domesticators as well.

**Chronology of Occupation/Site Construction**

The first inhabitants of the Pecos Valley region settled there after A.D. 800, and occupied dispersed pithouse hamlets (Hooton 1930: 332; Ruff 1991: 33-34; Noble 1991:193). The population slowly increased during this occupation, but never became a fully established community. However, a significant population expansion occurred around A.D. 1200. During this time, there seems to have been a great influx of people migrating into the area. This increase in population size led to the founding of Pecos Pueblo. There have been a few proposed dates for the founding; they include approximately A.D. 1200 (Kidder 1931), A.D. 1250 (Kidder 1932), and finally A.D. 1300 (Kidder and Shepard 1936). These dates were proposed with the application of continually improved dedrochronological methodologies (Ruff 1991:34). It is interesting to mention that the Pecos Pueblo inhabitants were Tewa-speaking Native Americans (Noble 1991:193), which provides an ancestral link to the Tewa-Tano groups of Eastern Pueblos. As mentioned previously, the Arroyo Hondo Pueblo people were also ancestors of the Tewa-Tano groups.

Pecos Pueblo was designed to have high outside walls surrounding the community, creating a protective shield and overlook to potential outside invaders (Noble 1991:193). Warriors posted at the top of these walls would have an excellent view in
every direction around the site. This defensive wall surrounded roomblocks of various level houses, all circumventing one large plaza area (Noble 1991:193). It has been suggested that the site of Pecos, on top of the high Mesilla, may have been initially chosen for defensive purposes (Ruff 1991:34).

Occupying these roomblocks at the Pueblo’s peak occupation were approximately 1,000 to 2,000 individuals (Hooton 1930: 331-341; Howells 1960:167-168; Ruff 1991: 34; Noble 1991:193). Just like Chaco Canyon, population estimates can be based on many different evidences, and different estimates were encountered in the Pecos research as well. Kidder believed that the peak occupation, sometime between A.D. 1500 and A.D. 1600, only reached a maximum of one thousand individuals (Lister and Lister 1983:155). Kidder also estimated that there were a total of one thousand twenty rooms between the two roomblock sections (Lister and Lister 1983:155). There is the larger northern unit called the Quadrangle built to four-stories, and the smaller complex to the south; however, they did not indicate contemporary occupation (Ruff 1991:34; Lister and Lister 1983:155). Kidder discovered many indications of almost constant repair, rebuilding, and abandonment of particular areas at the site, which may explain his more modest population estimate.

**European Contact/Abandonment**

Pecos Pueblo is unique because it is one of the first pueblos to have encounters with Europeans. In 1541, conquistador Francisco Vasquez de Coronado visited Pecos (Kidder 1924: 4-15; Ruff 1991:33; Lister and Lister 1968:21). Coronado did not occupy the site, because he was pursuing a quest for Quivira’s gold supposedly located in the Great Plains (Lister and Lister 1968:21). It was not until 1598 that Europeans once again contacted Pecos, when the Spaniard Cantano de Sosa forcefully
occupied the site. Juan de Onate had claimed all of New Mexico for the King of Spain; Pecos was not the only site to be under forceful rule (Lister and Lister 1968:21). During his occupation, Sosa documented observations of Pecos Pueblo. He wrote about how the four-story roomblocks were reached by ladders, which would then be pulled up behind the individuals. Sosa also noticed the attire of men and women. The men wore simplistic cotton blankets and bison robes. The women were more decorated; they wore a blanket tied in a knot over the shoulder, a sash, and another colorful blanket or turkey feather robe over this (Noble 1991:194).

A Spanish administration was implemented in 1598, which represents the progressive colonization that was occurring (Ruff 1991:34). Then in 1618, a Christian mission was established at Pecos by Franciscan monks (Noble 1991:194; Ruff 1991: 34).

![Figure 2.p Kiva and mission, Pecos National Monument. David Muench. (Adapted from Lister and Lister 1983:64)](image)

An adobe church and convent were soon to follow. This church remained for few decades, until it was destroyed when the Pueblo revolted in 1680 killing four hundred
Spaniards (Ruff 1991:34). It was rebuilt, however, after the Spanish conquest of 1693-96 (Noble 1991:194) (refer to figure 2.p). Although the Spanish presence at Pecos was initially opposed, the eighteenth century brought many hardships that required Spanish assistance. Epidemics flooded Pecos, and people were dying from measles to smallpox (Kidder 1924: 14-15; Ruff 1991:34; Noble 1991:194). In addition to the failing health of the inhabitants, Apaches and Comanches were a persistent threat that occasionally attacked (Kidder 1958;43,308-309; Ruff 1991:34; Noble 1991:194). A significant army for the time of five hundred people dwindled to almost nothing, and the Spanish forces were the only assistance. Only seventeen individuals were left at Pecos Pueblo in 1838, and they soon abandoned the site to live at Jemez Pueblo eighty miles northwest (Kidder 1924: 4-15; Ruff 1991:33; Noble 1991:194; Lister and Lister 1968:22). Left at the Pecos Pueblo site today are the remnants of adobe walls, arched doorways, the eighteenth century church, and a reconstructed kiva (Noble 1991:194).

**Burials**

The process of obtaining skeletons during the excavations at Pecos Pueblo was not done very scientifically, as revealed in Kidder's 1924 report. Kidder expresses that he had great concern to obtain a large skeletal sample for analysis, and therefore resorted to rewarding Mexican laborers twenty five cents for each body and associated artifacts uncovered (Lister and Lister 1968:22). This would obviously cause a large effort on the laborers part to retrieve as many skeletons as possible; along with haste came a price of disorganization and sloppy excavations. Very often the excavators did not attempt to properly preserve the skeletons; they would record data such as age and sex, and then rebury the body (Hooton 1930:16; Ruff 1991:35). The bonus was lessened to ten cents.
and eventually discontinued due to the overwhelming amount of skeletons obtained and their state of condition (Lister and Lister 1968:22). Two hundred burials were obtained from the refuse mounds during the 1915 excavations, and another one hundred fifty were from the church burials (Lister and Lister 1968:22). This is a huge skeletal collection from one site compared to other Southwest pueblo sites. It provided a unique opportunity for many anthropomorphic studies to be performed; Dr. E.A. Hooton of Harvard University was in charge of these studies (Lister and Lister 1968:22). In 1991 there were nine hundred individuals stored at the Harvard Peabody Museum; today some of these have been relocated to the American Museum of Natural History in New York.

The burials located among refuse were not just in mounds, but within many trenches that stretched up to two hundred fifty feet long (Lister and Lister 1968:22). They were located beneath floors, under the plaza and within the pueblo as well (Ruff 1991:35). Kidder describes some of the localities and abundance of burials in his writings.

“That interments were made almost everywhere is clearly shown by the dots on Figure 20. The Great East Midden was crowded from bottom to top with the dead (Kidder 1924:P1. 11). On the Mesilla, graves were dug wherever there was sufficient earth; most, except the earliest, in accumulations of refuse. There, as was noted in discussing conditions on the west side of the Quadrangle, there was a strong tendency to bury just outside the outer walls of groups of inhabited living rooms...This often enabled us to determine the phase of occupancy of such groups (Kidder 1958:280).”

When the observations of burials and recorded data were analyzed, the Pecos Pueblo appeared to have been an egalitarian society. During the time period in question, this type of social structure is thought to be typical (Willey 1966:186). This was derived from the fact that no distinctions could be made in regard to class; there was no preferential
treatment of some individuals over others (Ruff 1991:36). Kidder stated, “Nothing more clearly illustrates the classlessness of the Pecos than the uniform simplicity of their graves. Not one of the nearly two thousand we opened was outstanding in construction or… in wealth of offerings” (Kidder 1958:289).

Aztec Ruins

Excavations

As early as 1903, people were writing about the amazing Aztec Ruins of New Mexico. T. Michell Prudden anticipated future excavations and the presence of Earl Morris at this site when he wrote, “…here one of the most promising of the great old pueblos lies waiting for the trained and authorized explorer” (Lister and Lister 1968:24). In 1916 Earl Morris was asked by Nels C. Nelson and Clark Wissler to lead excavations at Aztec Ruins, which would be funded by the American Museum of Natural History (Lister and Lister 1968:24). Morris accepted the opportunity gratefully, and continued to spend the rest of his professional life restoring and excavating the site (Noble 1991:127-128). It was fortunate that excavations began when they did, because by 1916 the site had already been severely looted. The well preserved pueblo site did manage to hide some of its secrets from the looters, however, as the ceilings of three-story high buildings had collapsed and provided a safe haven from looters and environmental damage (Noble 1991:128).

Occupations

During excavations, certain evidences indicated to Earl Morris that there were two separate occupations of the Aztec Ruins (Lister and Lister 1968:37). It became clear that
the site was occupied for centuries. There is a Great House that would have accommodated a growing population (Lister and Lister 1968:37). In addition to the Great House all construction appeared completed, with the exception of some rooms in the South Wing (Lister and Lister 1968:37). The presence of generations inhabiting this area was supported by the presence of three feet of silt, which had accumulated and raised the land level along the structure walls (Lister and Lister 1968:37). Abandonment of this first occupation was indicated by the collapsing of walls and roofs that were not repaired, as before there were many signs of repair to these buildings (Lister and Lister 1968:37). Another indication of abandonment was a layer of sterile fill containing no cultural artifacts or signs of human presence (Noble 1991:128,130).

Above the sterile fill were signs of a new occupation, marked by new floors, renovation and remodeling to existing structures, and extensions to the plaza area. The cause of abandonment this time seems to be due to an invasion, during which the pueblo was set on fire causing permanent and severe damage (Lister and Lister 1968:38).

Some researchers say that Earl Morris did recognize that two separate Anasazi groups were responsible for the two occupations, others say that he simply recognized that there had been two occupations at Aztec Ruins. The first occupation was by people of the Chacoan culture, as all of the artifacts found from the associated stratum were of Chaco origin and style (Noble 1991:128). Chaco Canyon is located approximately fifty miles to the south of Aztec Ruins, and you can still detect a prehistoric road that connects the two sites from an aerial view (Noble 1991:130)!

The more recent occupation was by people of Mesa Verdean culture. Earl Morris may have realized this upon receiving three-ring dates for the site; the Chacoan occupation
dated to the early 1100's A.D. and the Mesa Verdean occupation dated to between 1225 A.D. to 1300 A.D (Noble 1991:130). Another interesting fact learned from the tree-rings was that the timber cut for Pueblo Bonito had been cut forty to forty five years earlier than the wood used at Aztec Ruins (Lister and Lister 1968:40).

Today a visitor can go to the Aztec Ruins and see a reconstructed Great Kiva that Earl Morris reconstructed in 1934. The original weight of the timber and dirt on the roof would have weighed ninety tons, and the large interior supported by masonry and wood columns is extremely impressive to see. (refer to figures 2.q and 2.r)

Figure 2.q Northeast corner of Aztec Ruins, with reconstructed kiva in foreground. George A. Grant, National Park Service, 1946. (Adapted from Lister and Lister 1983:80).
Burials

Earl Morris had a unique appreciation for the condition and context of the prehistoric burials; he was able to see how informative burials could be in revealing aspects of the prehistoric society (Lister and Lister 1968:31). In addition to the scientific interest, the burial accoutrements were often excellent specimens of prehistoric pueblo artwork. It was not uncommon during this time period for the successive of an excavation to be judged on the quality of such native artifacts (Lister and Lister 1968:31).

Morris was not disappointed with the discovery of about one hundred eighty burials at the site. The ages of individuals were commonly of subadult or old adults (Lister and Lister 1968:31). The skeletons were located among refuse in abandoned rooms or in subpits under rooms still dwelled in. Although not always in a burial pit, the bodies still appeared to be in flexed position (Lister and Lister 1968:31). Four times the
amount of skeletons found in the eastern portion of the Great House were located in the West Wing (Lister and Lister 1968:31).

**Grand Gulch, Utah**

The Grand Gulch site is located in southeastern Utah, with the San Juan River to the south, the Colorado River running to the west and northwest, the Elk Ridge to the north, and the Comb Wash to the east. The long and narrow canyon of Grand Gulch has multiple alternating water supplies of rain, springs and snowmelt (Noble 1991:75). The cliffs of the gulch are bare, but the valley bottom is rich with vegetation. Although there has been a substantial accumulation of artifacts from past excavations, little information about the people who lived there is available due to lack of interpretive analysis (Noble 1991:76). Most of the recovered artifacts from Grand Gulch were obtained by Richard Wetherill, during his 1893-1894 and 1896-1897 excavations (Noble 1991:76). The majority of these cultural materials can be found at the Chicago Field Museum and the American Museum of Natural History.

Addressed earlier was the fact that the Basketmaker populations preceded the Cliffdwellers in time. This was the case at Grand Gulch. A population that combined hunting and gathering with simplistic forms of horticulture in the green canyon, the Basketmakers, lived at Grand Gulch as early as A.D. 200 to A.D. 400 (Noble 1991:76-77). Richard Wetherill is responsible for this discovery, and is the source of the label, “basket people” (Noble 1991:77). This advancing culture changed its way of life after A.D. 500, by inventing pottery and making agriculture a main form of sustenance. The Basketmakers lived in pithouses during their occupation. Some floodwater farming was practiced, but probably most successful was the dry farming on the mesa tops (Matson and Lipe 1975:126).

The next inhabitants of Grand Gulch, as early as A.D. 700 to A.D. 1000, are referred to as the ‘Cliff-dwellers’. The cliff-dwelling pueblo community of Grand Gulch
is responsible for building the cliff houses tucked into the cliff walls that still remain today. They also decorated the canyon walls with many pictographs and petroglyphs (Noble 1991:75) (refer to figures 2.s and 2.t).

Figure 2.s Round House, Grand Gulch Primitive Area. (Adapted from Noble 1991:76)

Figure 2.t Pictographs in Grand Gulch. (Adapted from Noble 1991:78)
Chapter 3: Materials and Methods

The skeletal collections that were utilized for this study are held at the American Museum of Natural History in New York. The largest sample was taken from the Morphology Collection, which is a modern day skeletal collection of both males and females from diverse geographical evolutionary backgrounds. The Morphology Collection has documentation of known sex of the individuals, which will provide a standard for my abilities of sexing unknown samples. This collection will also allow me to compare a prehistoric group with possibly enhanced sexual dimorphism due to diet and/or lifestyle to a modern day group displaying hypothesized lower levels of sexual dimorphism. There are 29 female os coxae bones analyzed and 217 male os coxae bones, making a total of 249 os coxae from the Morphology Collection.

I also analyzed a total of 79 prehistoric Native American os coxae bones from fifteen prehistoric pueblo sites that were found in the four-corner region of the Southwest United States. The specific sites comprising the Southwest sample include Pueblo, New Mexico; Chaco Canyon, New Mexico; East Pacos, New Mexico; Pueblo Cienequilla; Pueblo Che, New Mexico; Mitten Rock, New Mexico; Bennett’s Peak, New Mexico; Pueblo Bonito, New Mexico; Aztec, New Mexico; Picos New Mexico; Pueblo Arroyo Hondo, New Mexico; Pecos, New Mexico; Aztec Ruin, New Mexico; La Plata, Colorado; and Grand Gulch, Utah. (see Table 3-1)

In an organized fashion, I laid out approximately 10 os coxae bones onto foam sheets. Accompanying the os coxae would be an index card provided by myself. The
index card would display all of the identifying information on the museum's catalog card, that the os coxae are stored with. This information would most commonly be the cabinet number, the tray number, where the specimen was found, the catalog number, the sex and age of the individual (only from morphology collection), as well as the ‘race’ (also just the morphology collection). I would write all of this information onto a data sheet that I had made and photocopied previously. When this was completed, I would begin taking the measurements. In between the two times I performed a single measurement, I would set the calipers or measuring board back to zero and start from scratch. I did not calculate the means of each measurement until I was done with all of my work at the museum. In addition, I did write some observations on the back of my data sheets. Observations that I made included the presence or absence of a preauricular sulcus, and sometimes the degree of presence. I also mentioned the areas of the os coxae that had been broken off, or damaged in any way. I tried to note how present the ischial spine was, because this feature is very fragile and was often not in complete form. Taphonomic observations were also made, including locations of trabecular exposure due to weathering, etc. I only used one os coxae per individual, and used the right side. In case of risking a small sample side, I did use the left side if that was all that was able to be analyzed.

I took my measurements using a digital coordinate caliper, a digital sliding caliper and a standard measuring board. I also utilized an overhead light bulb to help pinpoint some hard to discern points of reference. The measurements I took are derived from Karen Rosenberg, Wu et al., and Davivongs articles. There were a total of six measurements taken from Karen Rosenberg’s study. These include ischium length I, sciatic notch breadth, sciatic notch depth, OB measurement of sciatic notch, acetabular
vertical height and the maximum length of the os coxae. There were twelve measurements taken based on Davivongs article. These include Maximum length of os coxae, iliac breadth, length of pubic symphysis, vertical diameter of acetabulum, horizontal diameter of acetabulum, pubic length, ischial length, greatest width of the greater sciatic notch, greatest depth of the greater sciatic notch, OB measurement of sciatic notch, chilotic line of illium (pelvic), and the chilotic line of the illium (sacral). There are some repeat measurements between the two sets, so a total of 15 distinct measurements were taken. I took each measurement two times, and then calculated the mean as my final score. This aided in detecting human errors, as well as producing a more accurate score.

I also took digital photographs of many os coxae samples used, these included at least of few from each representative skeletal sample. This will help aid in providing a visual reference for describing the condition of the samples used. The condition of the samples used had to be fairly good in order to take the measurements that I needed. However, I did included specimens that had aspects broken off, but key features preserved. In such cases I omitted the measurements that I could not take. I did not use any os coxae specimens that had obvious pathology, which may have altered the shape and/or size of the specimen. Only adult individuals were used; if any primary or secondary points of fusion were still visible on the os coxae I did not use the specimen. The most common pathology noted was the fusion of the pelvis and sacrum.

In addition to observing and measuring the os coxae bones, I also utilized the vast archive records held at the American Museum of Natural History. Each skeleton that I dealt with had a corresponding catalog number. The catalog number provided a way for
me to locate any relevant supplemental material in the archives, having to do in some way with the skeletal specimen. I was my objective to obtain as many primary sources as I could from the excavations that resulted in the removal of the skeletons I observed. I wanted to verify the locality of the finds, perhaps learn about the condition of remains when they were uncovered, and become familiar with the pioneers of archaeology that ventured to these areas. In the early 1900’s, when most of the excavations took place, there was no established routine way of performing and documenting an excavation. The participants of the site excavations studied here provide personal documents of the first people to employ universally practiced methodologies used today. In addition, I did not want to take for granted the age of the individuals.

I have also performed extensive research on the lifestyle of the individuals, from what is know from oral histories, the archaeological record, and living pueblo Native Americans today. Perhaps the particular morphological variation pattern exhibited among these people is associated to daily activities in life, or diet. A key portion of this study is to document the pelvic variation of the pueblo Native Americans, as well as to compare these results with previous studies done other groups from different geographical regions.

The indices calculated for comparison purposes include; Coxal Index = (iliac breadth/ Maximum length) X 100; Ischium-pubis Index = (pubic length/ischial length) X 100 (Schultz, ’30); Index I of GSN = (greatest depth/ ischial length) X 100 (Olivier, ’60); Index II of GSN = (length OB/greatest width) X 100; Chilotic Index = (sacral chilotic line/pelvic chilotic line) X 100 (Derry, ’23); OB index = (length OB/greatest width) X 100.
Description of Os coxae Measurements (Davivongs 1963):

Twelve measurements taken in this study are derived from Davivongs’ 1963 article which analyzes the pelvis of Australian Aborigines. These twelve measurements are discussed below.

1. Maximum length of os coxae (Davivongs 1963) (fig. 3.g, AB)
   - This measurement was taken on an osteometric board. I had to maneuver the os coxae bone several times to ensure the maximum length was taken. Bass (1987) provides a more descriptive technique: “Place the ischial tuberosity (or ischium) against the fixed vertical of the board and affix the movable upright to the iliac crest. Raise the bone slightly and move it up and sown as well as from sided to side until the maximum length is obtained.” (Hrdlička 1952: 172; Bass 1987: 191)

2. Iliac breadth (Davivongs 1963) (fig. 3.g, CD)
   - This measurement was taken with an osteometric board, although it is possible to take this measurement with a sliding caliper. I had to maneuver the os coxae bone several times to ensure the maximum breadth was taken, which is the “distance between the anterior-superior iliac spine to the posterior-superior iliac spine.” (Hrdlička 1952: 172; Bass 1987: 191)

3. Length of pubic symphysis (Davivongs 1963) (fig. 3.h, PQ)
   - I used a digital sliding caliper for this measurement. It measures the complete length of the pubic symphysis, which faces the midline of the body. It is this surface where the two os coxae come closest to meeting; a fibrocartilaginous disk separates the symphyseal surfaces during life. (Bass 1991: 218-219)

4. Vertical diameter of acetabulum (Davivongs 1963) (fig. 3.g, EF)
This measurement was taken with a digital sliding caliper. I would hold the bone in anatomical position, to ensure that the diameter I was measuring was indeed vertical. The margin of the lunate surface of the acetabulum was always present at both points of measurement.

5. Horizontal diameter of acetabulum (Davivongs 1963) (fig. 3.g, GH)

This measurement was taken with a digital sliding caliper. I would once again hold the os coxae bone in anatomical position, to ensure that the diameter I was measuring was horizontal. This measurement is very close, if not exact, to being perpendicular to the vertical diameter of acetabulum measurement. Marginal points of the lunate articular surface were also the points of reference in this measurement. With variable acetabulum shapes, it may be tempting to measure what you see as the longest diameter. It is important to be consistent and use the same points of reference for each os coxae.

Before proceeding to the remaining measurements, it is essential to be able to locate the center of the acetabulum1. (Davivongs 1963: 445) (fig. 3.g, O) The central point of the acetabulum can be very tricky to discern, especially when the os coxae is completely fused together. The central point of the acetabulum has been defined by Davivongs as where the three main pelvic bones (illium, ischium, pubis) fuse together (Refer to fig. 3.k). Some guiding points to locate this region on a fused os coxae would include: creating an imaginary line that descends from the anterior, inferior, iliac spine until you reach the lunate articular surface, try and discern a thin area of bone in the acetabulum (holding the os coxae up to a light source may help). Schultz (30’) locates

__________________________
1 It should be noted that different researchers define the center of the acetabulum differently, such as the definition by Wu et al. (1982) discussed in next section.

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the center in a similar fashion. He believes that in all primates you can find the center at the intersection of the inner edge of the articular surface of the acetabulum with a straight line prolonging the lower part of the acetabular border of the ilium downward. Washburn ('48) has identified three identifying characteristics to locate the center of the acetabulum. He notices an 'irregularity' on the surface of the acetabulum as well as inside the pelvis itself, a change in thickness of the bone is detectable, and finally a 'notch' is said to appear frequently along the edge of the articular surface (Washburn 1948: 200).

No one way will work every time; the center of the acetabulum is a highly variable area. I often noted the presence of more than one 'notch' or 'irregularity'. In order to be consistent, the prolonging line from the inferior iliac spine in combination with all other strategies is the best approach. In addition, I highly recommend becoming familiar with the three main pelvic bones and how they appear before and during fusion. This can help in understanding where logically the center may lie (Refer to figures 3.a-3.f). Being familiar with descriptive pictures and words provides a better chance at correctly identifying the center point.
Table 3-1 Description of Collections Used.

<table>
<thead>
<tr>
<th>Collections</th>
<th>Female</th>
<th>Male</th>
<th>Unknown</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology Collection</td>
<td>29</td>
<td>217</td>
<td>3</td>
<td>249</td>
</tr>
<tr>
<td>Chaco Canyon New Mexico</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>East Pacos New Mexico</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pueblo Cienequilla</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Pueblo Che New Mexico</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mitten Rock New Mexico</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bennett's Peak New Mexico</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Pueblo Bonito New Mexico</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Aztec New Mexico</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Picos New Mexico</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pueblo Arroyo Hondo New Mexico</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pecos New Mexico</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>La Plata Colorado</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Aztec Ruin New Mexico</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Grand Gulch Utah</td>
<td>12</td>
<td>8</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>328</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 3.a Individual 99:7374 is from the Grand Gulch, Utah collection held at the American Museum of Natural History in New York. From the points of fusion, it can be estimated that the individual is approximately between 10-15 years of age. (Bass 1987: 188) Photograph taken by Dawn Corso, Courtesy of the American Museum of Natural History.
Figure 3.b Individual 99:7374 seen from a medial view. Notice the incomplete fusion of the ischium and pubis. Photograph taken by Dawn Corso, Courtesy of the American Museum of Natural History.
Figure 3.c Right side, individual 99:7374 from the Grand Gulch, Utah collection. Shows ilium epiphysis before fusion with other 2 primary portions of pelvis. This type of bumpy ridging is characteristic of ossification centers. Familiarity with this pattern is useful to help identify the additional 5 secondary areas of ossification that may be harder to notice. Photograph taken by Dawn Corso, courtesy of the American Museum of Natural History.
Figure 3.d Right and left sides, ilium of individual 99: 7374 from the Grand Gulch Utah collection. A closer look at ossification centers. Photograph taken by Dawn Corso, Courtesy of the American Museum of Natural History.
Figure 3.e Right and left sides, partly fused pubis and ischium of individual 99:7374 from the Grand Gulch, Utah collection. The concave depressions are the beginnings of a complete acetabulum. It is visible where the ilium will fuse; notice the irregular bumpy edges. Photograph taken by Dawn Corso, Courtesy of the American Museum of Natural History.
Figure 3.f Right side, partly fused pubis and ischium of individual 99:7374 from the Grand Gulch, Utah collection. Photograph taken by Dawn Corso, Courtesy of the American Museum of Natural History.
6. Pubic length (Davivongs 1963) (fig.3.g, OM)
   - I used a digital sliding caliper for this measurement. First locate the center of the acetabulum. Holding one end of the sliding caliper at the center point, guide the other end to the superior edge of the pubic symphysis. Do not change the point of reference between specimens, always measure to the edge closest to the iliopubic ramus.

7. Ischial length (Davivongs 1963) (fig.3.g, ON)
   - I used a digital sliding caliper for this measurement. Once again locate the center of the acetabulum. Using the same technique, hold one end in place at the center, and guide the other end to the ischial tuberosity. Try and locate the peak of the tuberosity curve, approximately in the middle.

The next three measurements (8, 9, 10) of the greater sciatic notch were measured simultaneously with a coordinate caliper. (Refer to fig. 3.j)

8. Greatest width of the greater sciatic notch (Davivongs 1963) (fig. 3.i, AB)
   - The greatest width, according to Davivongs, uses the pyramidal projection as one reference point. He describes the location of the pyramidal projection as “at the termination of the posterior border of the greater sciatic notch” (Davivongs 1963: 445). Figure 3.i locates this projection at point B. It should be noted that many problems were encountered during the present study when trying to locate the pyramidal projection on the majority of specimens. This location, almost bordering the edge of the auricular surface, is a highly variable area. In almost no cases does the actual specimen resemble the diagram in figure 3.i. There is almost no predictable appearance of this morphological region, and a more consistent location should be the point of reference for standardized studies.
9. Greatest depth of the greater sciatic notch (Davivongs 1963) (fig. 3.i, OC)

- While measuring the greatest width, the greatest depth can be taken simultaneously with the coordinate caliper. Locate the deepest point of the greater sciatic notch, using the greatest width line as a reference. Measure from the base of the deepest point perpendicular to the greatest width line, where the two intersect (Davivongs 1963: 445).

10. OB measurement of sciatic notch (Davivongs 1963) (fig. 3.i, OB)

- Keeping note of where the greatest width and the greatest depth intersect (fig. 3.i, O), measure the distance point O to point B (or the pyramidal projection). This is the OB measurement.

11. Chilotic line of ilium: pelvic (Davivongs 1963) (fig. 3.h, XY; fig. 3.l)

- I used a sliding caliper for this measurement. Before taking this measurement it is necessary to be able to locate the pubo-iliac point and the auricular point, as described by Derry (1923). The pubo-iliac point (fig. 3.h, X; fig. 3.l) is defined as being, “situated on the ilio-pectineal line at the site of the origin of the os pubis and ilium” (Derry 1923: 72, Davivongs 1963: 445-446). Figure 3.a and figure 3.b, photographs of individual 99:7374 from the Grand Gulch, Utah collection, provide an excellent reference to become familiar with the pubo-iliac point. The pubis and ilium are not yet fused in these two photographs, and where the junction will occur is very visible. This point is often hard to discern, and understanding the areas of fusion will provide the best possibility of detecting its presence. Davivongs (1963) suggests using the ilio-pectineal eminence as a landmark if you cannot locate the pubo-iliac point. The second point of reference is the auricular point. This is described as being on “the anterior margin of the auricular articular surface where this approaches nearest to the pubo-iliac point” (Derry 1923: 72, Davivongs 1963:
This more easily defined point can be seen in figure 3.1 and figure 8, point Y. The chilotic line is a line beginning at the pubo-iliac point and extending through the auricular point until it reaches the iliac crest (fig. 3.h, XZ; fig. 3.l). The pelvic chilotic line, what is being measured here, is the distance from the pubo-iliac point to the auricular point (fig. 3.h, XY; fig. 3.l).

12. Chilotic line of the ilium: sacral (Davivongs 1963) (fig. 3.h, YZ; fig. 3.l)

- I used a sliding caliper for this measurement. The sacral part of the above described chilotic line is the distance from the auricular point to the iliac crest.

**Description of Os coxae Measurements (Wu et. al. 1982; Rosenberg 2003):**

The lack of standardization regarding pelvic measurements is shown here in the different interpretations of where the center of the acetabulum is located. Davivongs used a method derived from Washburn (1948) and Schultz (1930). Wu et al. (1982) define the center of the acetabulum as the joint point of two curves of the interval margin of articular surface of acetabulum; this is not the transparent or semitransparent area of the acetabulum (see fig. 3.m). This difference in the identified center of the acetabulum will make the ischium length measurements taken in Davivongs (1963) differ slightly from Wu et al. (1982).

1. Ischium Length I (Wu et. al. 1982, Rosenberg 2003) (fig. 3.m)

- This measurement was taken with a sliding caliper. Wu et al. (1982) define this measurement as the maximum distance between the central point of acetabulum and the ischial tuberosity (see fig. 3.m) (Wu et al. 1982:1).

2. Sciatic notch breadth (Wu et. al. 1982, Rosenberg 2003) (fig. 3.n, AB)
- Wu et. al. (1982) do not use the pyramidal projection as a landmark for measuring the breadth of the greater sciatic notch, as was shown for Davivongs (1963) (fig. 3.i, B). Instead, they define their point of reference as the inferior corner of the auricular surface (Rosenberg 2002) (see fig. 3.n, B). I found this point of reference much easier to locate than the pyramidal projection. The tip of the ischial spine is shown as point A in figure 3.n, and is the other point of reference for measuring the greatest breadth (fig. 3.n, AB).

3. Sciatic notch depth (Wu et. al. 1982, Rosenberg 2002) (fig. 3.n, O to base of G.S.N.)

- This technique is the same as Davivongs (1963); however the result will differ due to the different methods of measuring the breadth. (fig. 3.n, O to base of G.S.N)

4. OB measurement of sciatic notch (Wu et al. 1982, Rosenberg 2002) (fig. 3.n, OB)

The OB measurement used here is used in the study by Karen Rosenberg, and was initially introduced by Wu, et al.'s 1982 article. This measurement differs from Davivongs previously discussed method; in this instance the OB measurement does not use the pyramidal projection as a landmark. Instead point B is described as “the inferior corner of the auricular surface” (Wu et. al. 1982; Rosenberg 2002).

5. Acetabular vertical height

- This measurement is the same in comparison to Davivongs (1963). It should be noted that Wu et al. (1982) refer to the maximum acetabular vertical height as the diameter of the acetabulum. Karen Rosenberg does not say that she acquired the method for measuring the acetabular vertical height from Wu et al. (1982), however, the techniques appear to be consistent.

6. Maximum length of the os coxae.

- The same technique was used as in the description of Davivongs (1963) method.
Figure 3.g Measurements of os coxae bone. AB, Maximum length; CD, Iliac breadth; EF, Vertical diameter of acetabulum; GH, Horizontal diameter of acetabulum; OM, Pubic length; ON, Ischial length.
(Adapted from Davivongs 1963: 444)
Figure 3.h Measurements of os coxae bone. PQ, Length of pubic symphysis; XZ, Chilotic line of ilium; XY, Pelvic part of chilotic line; YZ, Sacral part of chilotic line. (Adapted from Davivongs 1963: 445)
Figure 3.1 Measurements of greater sciatic notch. AB, Greatest width; OC, Greatest depth. (Adapted from Davivongs 1963: 445)
Figure 3. Instrument for measuring greater sciatic notch. (Adapted from Davivongs 1963: 445) This instrument is commonly referred to as a coordinate caliper. The one I used in my study was digital.
Figure 3.k Ossification centers of the os coxae. (Adapted from Bass 1987: 187)
Figure 3.1 An illustration of where to locate the Pubo-iliac point and the Auricular point. Both of these points are located on the Chilotic line, and divide it into two parts. The two parts are the Pelvic Chilotic Line and the Sacral Chilotic Line. (Adapted from Derry 1923: 72)
Figure 3.m This picture of an os coxae bone shows the central point of the acetabulum as defined by Wu et al. (1982). It also shows two measurements; the length of the pubic bone and the ischial length. (Adapted from Wu et al. 1982:119)
Figure 3. This illustration shows the method by Wu et al. (1982) for measuring the greatest width of the greater sciatic notch (AB); the greatest depth of the greater sciatic notch, and the OB measurement. The ilium is shown looking laterally at the interior surface, with anterior to the right. (Adapted from Wu et al. 1982:119)
Chapter 4 : Results

T-Test Results

The independent samples t-test was conducted to determine if a significant difference exists between the mean values of females and males within a population. This test is appropriate because I have two independent groups of people, males and females, and I am interested in comparing their scores in respect to seven different index values. These index values are derived from pelvic measurements of the Morphology and Southwest population samples. The seven indices include the OB Index (following Wu et al. 1982); OB Index following Davivongs (1963); Ischium-Pubis Index; Coxal Index; Chilotic Index; Greater Sciatic Notch Index I; Greater Sciatic Notch Index II. Tables 4.1 and 4.2 (shown below) display the mean, standard deviation, degrees of freedom, t-value, significance and Eta-squared values for each of the seven indices of the Morphology and Southwest samples. The male and female mean values of all seven indices were found to be significantly different within the Morphology sample. The Southwest sample displays significant differences in the mean values of all indices except the coxal index, which has a significance of 0.433. Eta squared is calculated by:

\[ \text{Eta Squared} = \frac{t^2}{t^2 + (N1 + N2 - 2)} \]

According to Cohen (1988), the strength of association (or effect size) can be categorized as small (0.01), medium (0.06) or large (0.14). The effect explains how much of the variance of each index is explained by sex. Although Cohen views 0.14 as a ‘large’ effect, this is not necessarily a very impressive value when determining the sex of an individual.
Table 4-1 Independent samples t-test results for the Morphology Sample

<table>
<thead>
<tr>
<th>Index</th>
<th>Morphology Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male Mean</td>
</tr>
<tr>
<td>OB (1982)</td>
<td>29.03</td>
</tr>
<tr>
<td>OB (1963)</td>
<td>16.35</td>
</tr>
<tr>
<td>Ischium -Pubis</td>
<td>81.60</td>
</tr>
<tr>
<td>Coxal</td>
<td>73.48</td>
</tr>
<tr>
<td>Chilotic</td>
<td>141.41</td>
</tr>
</tbody>
</table>

Table 4-2 Independent Samples t-test results for Southwest Sample.

<table>
<thead>
<tr>
<th>Index</th>
<th>SW Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male Mean</td>
</tr>
<tr>
<td>OB (1982)</td>
<td>19.75</td>
</tr>
<tr>
<td>OB (1963)</td>
<td>7.29</td>
</tr>
<tr>
<td>Ischium -Pubis</td>
<td>85.07</td>
</tr>
<tr>
<td>Coxal</td>
<td>72.42</td>
</tr>
<tr>
<td>Chilotic</td>
<td>132.55</td>
</tr>
<tr>
<td>G.S.N. I (1963)</td>
<td>132.55</td>
</tr>
<tr>
<td>G.S.N. II (1963)</td>
<td>7.29</td>
</tr>
</tbody>
</table>
One-Way ANOVA, Eta Value & Post Hoc Results

One-Way ANOVA will allow me to detect whether there are significant differences in the mean scores of the seven index values calculated between both sex and population. The Post Hoc test will be used to locate where the significant differences are found, if any. The Eta Squared will calculate the magnitude of the effect population and sex have in creating significant differences. Eta squared will only be calculated for an index that shows a significant difference.

1. OB Index (following Wu et. al. 1982)

Table 4-3 (shown below) provides basic descriptive statistics used during statistical analysis of the OB Index (following Wu et. al. 1982). Here the categories are divided into four groups: Morphology females, Morphology males, Southwest females, and Southwest males. For each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the OB Index for each category are shown.

Table 4-3 OB Index (following Wu et. al. 1982) descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th>OB Index Descriptives (following Wu et. al. 1982)</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
</tr>
<tr>
<td>Morph. Females</td>
<td>32</td>
<td>37.94</td>
<td>8.26</td>
<td>34.97</td>
<td>40.92</td>
<td>20.67</td>
</tr>
<tr>
<td>Morph. Males</td>
<td>214</td>
<td>29.03</td>
<td>8.45</td>
<td>27.90</td>
<td>30.17</td>
<td>4.96</td>
</tr>
<tr>
<td>SW Females</td>
<td>45</td>
<td>31.77</td>
<td>8.16</td>
<td>29.32</td>
<td>34.22</td>
<td>13.00</td>
</tr>
<tr>
<td>SW Males</td>
<td>30</td>
<td>19.75</td>
<td>9.17</td>
<td>16.33</td>
<td>23.17</td>
<td>3.91</td>
</tr>
<tr>
<td>Total</td>
<td>321</td>
<td>29.44</td>
<td>9.37</td>
<td>28.41</td>
<td>30.47</td>
<td>3.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>53.99</td>
</tr>
</tbody>
</table>
The One-Way ANOVA test results for the OB Index (following Wu et. al. 1982) are shown below in Table 4-4. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the OB Index (following Wu et. al. 1982) for the four categories. However, this test does not reveal which group(s) is significantly different from one another.

Table 4-4 OB Index (following Wu et. al. 1982) One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>OB Index: One-Way ANOVA</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>5410.36</td>
<td>3</td>
<td>1803.45</td>
<td>25.21</td>
<td>0.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>22677.54</td>
<td>317</td>
<td>71.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>28087.90</td>
<td>320</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In order to determine where the significant differences lie among the mean values of the OB Index (following Wu et. al. 1982), a post hoc test was performed. The results of this test are shown in Table 4-5. All of the mean differences were found to be significant, with only one exception. The mean values of the Southwest females and the Morphology males were not found to be significantly different.
Table 4-5 OB Index (following Wu et. al. 1982) Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>CATEGORY</th>
<th>Mean Difference (I-J)</th>
<th>Significance</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morph</td>
<td>females</td>
<td>8.91*</td>
<td>0.000</td>
<td>4.77 13.05</td>
</tr>
<tr>
<td>sw females</td>
<td>6.18*</td>
<td>0.009</td>
<td>1.13 11.23</td>
<td></td>
</tr>
<tr>
<td>sw males</td>
<td>18.19*</td>
<td>0.000</td>
<td>12.64 23.75</td>
<td></td>
</tr>
<tr>
<td>Morph</td>
<td>males</td>
<td>-8.91*</td>
<td>0.000</td>
<td>-13.05 -4.77</td>
</tr>
<tr>
<td>sw females</td>
<td>-2.73</td>
<td>0.202</td>
<td>-6.31 0.85</td>
<td></td>
</tr>
<tr>
<td>sw males</td>
<td>9.29*</td>
<td>0.000</td>
<td>5.03 13.54</td>
<td></td>
</tr>
<tr>
<td>SW</td>
<td>females</td>
<td>-6.18*</td>
<td>0.009</td>
<td>-11.23 -1.13</td>
</tr>
<tr>
<td>morph males</td>
<td>2.73</td>
<td>0.202</td>
<td>-0.85 6.31</td>
<td></td>
</tr>
<tr>
<td>sw males</td>
<td>12.02*</td>
<td>0.000</td>
<td>6.87 17.17</td>
<td></td>
</tr>
<tr>
<td>SW</td>
<td>males</td>
<td>-18.19*</td>
<td>0.000</td>
<td>-23.75 -12.64</td>
</tr>
<tr>
<td>morph males</td>
<td>-9.29*</td>
<td>0.000</td>
<td>-13.54 -5.03</td>
<td></td>
</tr>
<tr>
<td>sw females</td>
<td>-12.02*</td>
<td>0.000</td>
<td>-17.17 -6.87</td>
<td></td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

The effect size is calculated by using Eta squared:

\[
\text{Eta Squared} = \frac{\text{Sum of Squares Between Groups}}{\text{Total Sum of Squares}}
\]

According to Cohen (1988), the effect size can be categorized as small (0.01), medium (0.06) or large (0.14). The Eta squared value for the OB Index (following Wu et. al. 1982) is 0.19 (shown in Table 4-6), which would imply that sex and population had a very large effect on creating the significant differences.

Table 4-6 OB Index (following Wu et. al. 1982) Eta Squared results for groups with significant differences.

<table>
<thead>
<tr>
<th>Effect Size (Cohen 1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eta Squared</td>
</tr>
<tr>
<td>0.19</td>
</tr>
</tbody>
</table>
A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.a. The mean of the OB Index (following Wu et. al. 1982) is lower for males than females within each population. The close similarity of the Morphology males and Southwest females is very apparent; the mean value of the Morphology males is still lower than the mean value for the Morphology females.

Figure 4.a OB Index (following Wu et al. 1982) mean values comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

![Graph showing mean OB Index values with error bars for different groups.]

2. OB Index (following Davivongs 1963)

Table 4-7 (shown below) provides basic descriptive statistics used during statistical analysis of the OB Index (following Davivongs 1963). Here the categories are
divided into four groups: Morphology females, Morphology males, Southwest Females, and Southwest males. For each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the OB Index for each category are shown.

Table 4-7 OB Index (following Davivongs 1963) descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th>OB Index Descriptives (following Davivongs 1963)</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
</tr>
<tr>
<td>Morph Females</td>
<td>32</td>
<td>26.52</td>
<td>8.26</td>
<td>23.55</td>
<td>29.50</td>
<td>10.34</td>
</tr>
<tr>
<td>Morph Males</td>
<td>214</td>
<td>16.35</td>
<td>6.67</td>
<td>15.45</td>
<td>17.25</td>
<td>.40</td>
</tr>
<tr>
<td>SW Females</td>
<td>41</td>
<td>21.77</td>
<td>6.69</td>
<td>19.65</td>
<td>23.88</td>
<td>4.72</td>
</tr>
<tr>
<td>SW Males</td>
<td>29</td>
<td>7.29</td>
<td>6.16</td>
<td>4.94</td>
<td>9.63</td>
<td>-3.13</td>
</tr>
<tr>
<td>Total</td>
<td>316</td>
<td>17.25</td>
<td>8.18</td>
<td>16.35</td>
<td>18.16</td>
<td>-3.13</td>
</tr>
</tbody>
</table>

The One-Way ANOVA test results for the OB Index (following Davivongs 1963) are shown in Table 4-8. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the OB Index (following Davivongs 1963) for the four categories. However, this test does not reveal which group(s) is significantly different from one another.
Table 4-8 OB Index (following Davivongs 1963) One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>OB Index: One-Way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Sum of Squares</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

In order to determine where the significant differences lie among the mean values of the OB Index (following Davivongs 1963), a post hoc test was performed. The results of this test are shown in Table 4-9. All of the mean differences were found to be significant.

Table 4-9 OB Index (following Davivongs 1963) Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>OB Index (following Davivongs 1963) Post Hoc Test (Tukey HSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) CATEGORY</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Morph Females</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Morph Males</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SW Females</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SW Males</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*The mean difference is significant at the 0.05 level.
The Eta squared value for the OB Index (following Davivongs 1963) is 0.32 (shown in Table 4-10), which would imply that sex and population had a very large effect on creating the significant differences.

Table 4-10 OB Index (following Davivongs 1963) Eta Squared results for groups with significant differences.

<table>
<thead>
<tr>
<th>Effect Size (Cohen 1988)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eta Squared</td>
<td>0.32</td>
</tr>
</tbody>
</table>

A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.b. The males display a lower mean within and between each population.
Figure 4.b OB Index (following Davivongs 1963) mean values comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

3. Ischium-Pubis Index

Table 4-11 (shown below) provides basic descriptive statistics used during statistical analysis of the Ischium-Pubis Index. Here the categories are divided into four groups: Morphology females, Morphology males, Southwest Females, and Southwest males. For each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the Ischium-Pubis Index for each category are shown.
Table 4-11 Ischium-Pubis Index descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th>Ischium-Pubis Index Descriptives</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Morph Female</td>
</tr>
<tr>
<td>Morph Male</td>
</tr>
<tr>
<td>SW Female</td>
</tr>
<tr>
<td>SW Male</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

The One-Way ANOVA test results for the Ischium-Pubis Index are shown in Table 4-12. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the Ischium-Pubis Index for the four categories. However, this test does not reveal which group(s) is significantly different from one another.

Table 4-12 Ischium-Pubis Index One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>Ischium-Pubis Index: One-Way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
In order to determine where the significant differences lie among the mean values of the Ischium-Pubis Index, a post hoc test was performed. The results of this test are shown in Table 4-13. All of the mean differences were found to be significant.

Table 4-13 Ischium-Pubis Index Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>(J) CATEGORY</th>
<th>Mean Difference (I-J)</th>
<th>Significance</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morph Female</td>
<td>morph male</td>
<td>10.73*</td>
<td>0.000</td>
<td>7.82 13.64</td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>-8.36*</td>
<td>0.000</td>
<td>-12.18 -4.54</td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>5.67*</td>
<td>0.002</td>
<td>1.60 9.74</td>
</tr>
<tr>
<td>Morph Male</td>
<td>morph female</td>
<td>-10.73*</td>
<td>0.000</td>
<td>-13.64 -7.82</td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>-19.09*</td>
<td>0.000</td>
<td>-21.96 -16.22</td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>-5.06*</td>
<td>0.000</td>
<td>-8.26 -1.86</td>
</tr>
<tr>
<td>SW Female</td>
<td>morph female</td>
<td>8.36*</td>
<td>0.000</td>
<td>4.54 12.18</td>
</tr>
<tr>
<td></td>
<td>morph male</td>
<td>19.09*</td>
<td>0.000</td>
<td>16.22 21.96</td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>14.03*</td>
<td>0.000</td>
<td>9.98 18.07</td>
</tr>
<tr>
<td>SW Male</td>
<td>morph female</td>
<td>-5.67*</td>
<td>0.002</td>
<td>-9.74 -1.60</td>
</tr>
<tr>
<td></td>
<td>morph male</td>
<td>5.06*</td>
<td>0.000</td>
<td>1.86 8.26</td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>-14.03*</td>
<td>0.000</td>
<td>-18.07 -9.98</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

The Eta squared value for the Ischium Pubis Index is 0.54 (shown in Table 4-14), which would imply that sex and population had a very large effect on creating the significant differences.

Table 4-14 Ischium-Pubis Index Eta Squared results for groups with significant differences.

<table>
<thead>
<tr>
<th>Effect Size (Cohen 1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eta Squared</td>
</tr>
<tr>
<td>0.54</td>
</tr>
</tbody>
</table>
A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.c. The males display a lower mean within and between each population.

**Figure 4.c** Ischium-Pubis Index (following Davivongs 1963) mean values comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

4. Coxal Index

Table 4-15 (shown below) provides basic descriptive statistics used during statistical analysis of the Coxal Index. Here the categories are divided into four groups: Morphology females, Morphology males, Southwest Females, and Southwest males. For
each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the Coxal Index for each category are shown.

Table 4-15 Coxal Index descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morph Female</td>
<td>32</td>
<td>76.39</td>
<td>2.54</td>
<td>75.47</td>
<td>71.64</td>
<td>80.39</td>
</tr>
<tr>
<td>Morph Male</td>
<td>214</td>
<td>73.48</td>
<td>3.19</td>
<td>73.05</td>
<td>63.55</td>
<td>80.47</td>
</tr>
<tr>
<td>SW Female</td>
<td>40</td>
<td>73.06</td>
<td>3.10</td>
<td>72.07</td>
<td>65.33</td>
<td>79.01</td>
</tr>
<tr>
<td>SW Male</td>
<td>30</td>
<td>72.42</td>
<td>3.63</td>
<td>71.07</td>
<td>62.78</td>
<td>79.23</td>
</tr>
<tr>
<td>Total</td>
<td>316</td>
<td>73.62</td>
<td>3.30</td>
<td>73.25</td>
<td>62.78</td>
<td>80.47</td>
</tr>
</tbody>
</table>

The One-Way ANOVA test results for the Coxal Index are shown below in Table 4-16. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the Coxal Index for the four categories. However, this test does not reveal which group(s) is significantly different from one another.

Table 4-16 Coxal Index One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>304.511</td>
<td>3</td>
<td>101.504</td>
<td>10.144</td>
<td>0.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>3121.886</td>
<td>312</td>
<td>10.006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3426.397</td>
<td>315</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In order to determine where the significant differences lie among the mean values of the Coxal Index, a post hoc test was performed. The results of this test are shown in Table 4-17. The mean values of the Morphology females were found to be significantly different from all other groups. The remaining three groups had no significant difference to one another.

**Table 4-17** Coxal Index Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>CATEGORY (I)</th>
<th>CATEGORY (J)</th>
<th>Mean Difference (I-J)</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morph Female</td>
<td>morph male</td>
<td>2.91*</td>
<td>0.000</td>
<td>1.36</td>
<td>4.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>3.33*</td>
<td>0.000</td>
<td>1.39</td>
<td>5.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>3.96*</td>
<td>0.000</td>
<td>1.89</td>
<td>6.04</td>
<td></td>
</tr>
<tr>
<td>Morph Male</td>
<td>morph female</td>
<td>-2.90*</td>
<td>0.000</td>
<td>-4.46</td>
<td>-1.36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>0.42</td>
<td>0.868</td>
<td>-0.99</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>1.06</td>
<td>0.320</td>
<td>-0.54</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>SW Female</td>
<td>morph female</td>
<td>-3.33*</td>
<td>0.000</td>
<td>-5.26</td>
<td>-1.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>morph male</td>
<td>-0.42</td>
<td>0.868</td>
<td>-1.83</td>
<td>0.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>0.64</td>
<td>0.839</td>
<td>-1.34</td>
<td>2.61</td>
<td></td>
</tr>
<tr>
<td>SW Male</td>
<td>morph female</td>
<td>-3.96*</td>
<td>0.000</td>
<td>-6.04</td>
<td>-1.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>morph male</td>
<td>-1.06</td>
<td>0.320</td>
<td>-2.65</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>-0.64</td>
<td>0.839</td>
<td>-2.61</td>
<td>1.34</td>
<td></td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.

The Eta squared value for the Coxal Index is 0.09 (shown in Table 4-18), which would imply that sex and population had a medium to large effect on creating the significant differences.

**Table 4-18** Coxal Index Eta Squared results for groups with significant differences.

<table>
<thead>
<tr>
<th>Effect Size (Cohen 1988)</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.09</td>
</tr>
</tbody>
</table>
A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.d. The males display a lower mean within and between each population. Males display a lower mean value of the Coxal Index within populations; however, the males show a different pattern of having a higher mean value between populations.

Figure 4.d Coxal Index mean values comparing four groups:
Morphology females; Morphology males; Southwest females; Southwest males.

5. Chilotic Index

Table 4-19 (shown below) provides basic descriptive statistics used during statistical analysis of the Chilotic Index. Here the categories are divided into four groups:
Morphology females, Morphology males, Southwest females, and Southwest males. For each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the Chilotic Index for each category are shown.

Table 4-19 Chilotic Index descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
</tr>
<tr>
<td>Morph Female</td>
<td>32</td>
<td>114.51</td>
<td>18.78</td>
<td>107.74</td>
<td>121.28</td>
<td>76.16</td>
</tr>
<tr>
<td>Morph Male</td>
<td>214</td>
<td>141.41</td>
<td>18.96</td>
<td>138.86</td>
<td>143.97</td>
<td>96.11</td>
</tr>
<tr>
<td>SW Female</td>
<td>42</td>
<td>117.09</td>
<td>21.96</td>
<td>110.25</td>
<td>123.93</td>
<td>69.22</td>
</tr>
<tr>
<td>SW Male</td>
<td>29</td>
<td>132.55</td>
<td>18.08</td>
<td>125.68</td>
<td>139.43</td>
<td>102.53</td>
</tr>
<tr>
<td>Total</td>
<td>317</td>
<td>134.66</td>
<td>21.95</td>
<td>132.24</td>
<td>137.09</td>
<td>69.22</td>
</tr>
</tbody>
</table>

The One-Way ANOVA test results for the Chilotic Index are shown in Table 4-20. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the Chilotic Index for the four categories. However, this test does not reveal which group(s) is significantly different from one another.
Table 4-20 Chilotic Index One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>35845.72</td>
<td>3</td>
<td>11948.572</td>
<td>32.130</td>
<td>0.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>116397.44</td>
<td>313</td>
<td>371.877</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>152243.16</td>
<td>316</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In order to determine where the significant differences lie among the mean values of the Chilotic Index, a post hoc test was performed. The results of this test are shown in Table 4-21. Significant differences here are successful in distinguishing males from females; however, males are not significantly different between populations, and females are not significantly different between populations. In other words, the Morphology females show a significant difference to Morphology males and Southwest males; the Morphology males show a significant difference to Morphology females and Southwest females; Southwest females show a significant difference to Morphology males and Southwest males; and Southwest males show a significant difference to Morphology females and Southwest females.
Table 4-21 Chilotic Index Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>(I) CATEGORY</th>
<th>Mean Difference (I-J)</th>
<th>Significance</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morph Female</td>
<td>morph male</td>
<td>-26.91*</td>
<td>0.000</td>
<td>-36.35 -17.46</td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>-2.58</td>
<td>0.941</td>
<td>-14.27 9.10</td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>-18.05*</td>
<td>0.002</td>
<td>-30.82 -5.28</td>
</tr>
<tr>
<td>Morph Male</td>
<td>morph female</td>
<td>26.91*</td>
<td>0.000</td>
<td>17.46 36.35</td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>24.32*</td>
<td>0.000</td>
<td>15.91 32.73</td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>8.86</td>
<td>0.095</td>
<td>-0.10 18.72</td>
</tr>
<tr>
<td>SW Female</td>
<td>morph female</td>
<td>2.58</td>
<td>0.941</td>
<td>-9.10 14.27</td>
</tr>
<tr>
<td></td>
<td>morph male</td>
<td>-24.32*</td>
<td>0.000</td>
<td>-32.73 -15.91</td>
</tr>
<tr>
<td></td>
<td>sw male</td>
<td>-15.46*</td>
<td>0.006</td>
<td>-27.49 -3.44</td>
</tr>
<tr>
<td>SW Male</td>
<td>morph female</td>
<td>18.05*</td>
<td>0.002</td>
<td>5.28 30.82</td>
</tr>
<tr>
<td></td>
<td>morph male</td>
<td>-8.86</td>
<td>0.095</td>
<td>-18.72 0.10</td>
</tr>
<tr>
<td></td>
<td>sw female</td>
<td>15.46*</td>
<td>0.006</td>
<td>3.44 27.49</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

The Eta squared value for the Chilotic Index is 0.24 (shown in Table 4-22), which would imply that sex and population had a very large effect on creating the significant differences.

Table 4-22 Chilotic Index Eta Squared results for groups with significant differences.

<table>
<thead>
<tr>
<th>Effect Size (Cohen 1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eta Squared</td>
</tr>
<tr>
<td>0.24</td>
</tr>
</tbody>
</table>
A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.e. The females display a lower mean within and between each population.

**Figure 4.e** Chilotic Index mean values comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.
6. Greater Sciatic Notch Index I

Table 4-23 (shown below) provides basic descriptive statistics used during statistical analysis of the Greater Sciatic Notch Index I. Here the categories are divided into four groups: Morphology females, Morphology males, Southwest females, and Southwest males. For each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the Greater Sciatic Notch Index I for each category are shown.

Table 4-23 Greater Sciatic Notch Index I descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morph Female</td>
<td>32</td>
<td>47.31</td>
<td>5.88</td>
<td>45.19</td>
<td>38.19</td>
<td>63.92</td>
</tr>
<tr>
<td>Morph Male</td>
<td>214</td>
<td>53.43</td>
<td>9.21</td>
<td>52.19</td>
<td>35.11</td>
<td>103.35</td>
</tr>
<tr>
<td>SW Female</td>
<td>41</td>
<td>44.40</td>
<td>7.01</td>
<td>42.19</td>
<td>31.60</td>
<td>64.26</td>
</tr>
<tr>
<td>SW Male</td>
<td>29</td>
<td>45.22</td>
<td>7.65</td>
<td>42.31</td>
<td>31.50</td>
<td>72.19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>316</td>
<td>50.89</td>
<td>9.29</td>
<td>49.86</td>
<td>31.50</td>
<td>103.35</td>
</tr>
</tbody>
</table>

The One-Way ANOVA test results for the Greater Sciatic Notch Index I are shown in Table 4-24. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the Greater Sciatic Notch Index I for the four categories. However, this test does not reveal which group(s) is significantly different from one another.
Table 4-24 Greater Sciatic Notch Index I One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>Greater Sciatic Notch Index I : One-Way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

In order to determine where the significant differences lie among the mean values of the Greater Sciatic Notch Index I, a post hoc test was performed. The results of this test are shown in Table 4-25. The Morphology males were shown to be significantly different to all other three groups, with the remaining three groups showing no significant difference to one another.

Table 4-25 Greater Sciatic Notch Index I Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>Greater Sciatic Notch Index I : Post Hoc Test (Tukey HSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) CATEGORY</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Morph Female</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Morph Male</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SW Female</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SW Male</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.
The Eta squared value for the Greater Sciatic Notch Index I is 0.16 (shown in Table 4-26), which would imply that sex and population had a large effect on creating the significant differences.

Table 4-26 Greater Sciatic Notch Index I Eta Squared results for groups with significant differences.

<table>
<thead>
<tr>
<th>Effect Size (Cohen 1988)</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.16</td>
</tr>
</tbody>
</table>

A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.f. The females display a lower mean within and between each population.

Figure 4.f Greater Sciatic Notch I mean values comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.
7. Greater Sciatic Notch Index II

Table 4-27 (shown below) provides basic descriptive statistics used during statistical analysis of the Greater Sciatic Notch Index II. Here the categories are divided into four groups: Morphology females, Morphology males, Southwest females, and Southwest males. For each category the sample number (N), mean, standard deviation, lower and upper bound values of a 95% confidence interval, minimum value, and maximum value of the Greater Sciatic Notch Index II for each category are shown.

Table 4-27 Greater Sciatic Notch Index II descriptive statistics for males and females of both Morphology and Southwest samples.

<table>
<thead>
<tr>
<th>Greater Sciatic Notch index II Descriptives</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Morph Female</td>
</tr>
<tr>
<td>Morph Male</td>
</tr>
<tr>
<td>SW Female</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

The One-Way ANOVA test results for the Greater Sciatic Notch Index II are shown below in Table 4-28. The significance value is 0.000, which is less than or equal to 0.05, therefore a significant difference does exist somewhere among the mean scores of the Greater Sciatic Notch Index II for the four categories. However, this test does not reveal which group(s) is significantly different from one another.
Table 4-28 Greater Sciatic Notch II One-Way ANOVA results comparing 4 groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>Greater Sciatic Notch Index II: One-Way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>Within Groups</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

In order to determine where the significant differences lie among the mean values of the Greater Sciatic Notch Index II, a post hoc test was performed. The results of this test are shown in Table 4-29. All of the mean differences were found to be significantly different to one another.

Table 4-29 Greater Sciatic Notch Index II Post Hoc Test results comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.

<table>
<thead>
<tr>
<th>Greater Sciatic Notch Index II: Post Hoc Test (Tukey HSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) CATEGORY</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Morph Female</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Morph Male</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SW Female</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SW Male</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.
The Eta squared value for the Greater Sciatic Notch Index II is 0.32 (shown in Table 4-30), which would imply that sex and population had a very large effect on creating the significant differences.

Table 4-30 Greater Sciatic Notch Index II Eta Squared results for groups with significant differences.

| Effect Size (Cohen 1988) |  
|-------------------------|---
| Eta Squared             | 0.32 |

A visual comparison of the mean values for the four categories studied in the One-Way ANOVA is shown below in Figure 4.g. The males display a lower mean within and between each population.

Figure 4.g Greater Sciatic Notch Index II mean values comparing four groups: Morphology females; Morphology males; Southwest females; Southwest males.
8. Pelvic Comparisons with Different Geographic Regions

All statistical data presented thus far has been in relation to the Southwest and Morphology samples. In this section I would like to present some mean comparisons of the Ischium-Pubis Index of diverse geographic populations. These populations include: Han (Wu et. al. 1982); Czech (Novotný 1986); Eskimo (Hanna and Washburn 1953); American White (Washburn 1948); American Negro (Washburn 1948); Bantu (Washburn 1949); Southwest (Corso 2005); Morphology (Corso 2005); Australian Aborigine (Davivongs 1963). With limited statistical data on these groups, the comparison is limited to the distribution of means for the Ischium-Pubis Index solely. The data will be presented in a couple of different ways, which will supplement points to be addressed later in the discussion chapter.

The first mean distribution is shown in figure 4.h. The x-axis is a list of each geographic population, with alternating females and males. The y-axis shows the mean values of the Ischium-pubis Index. The line on top, connecting the higher distribution points, represents the female samples. The line on bottom, connecting the lower distribution points, represents the male samples.
The same Ischium-Pubis Index mean is represented in figure 4.i, however, this time in a boxplot. From this graph you can see the minimum and maximum values, the mean, as well as the 95% quartile range. This graph is useful to view potential overlap between the different samples. I did not have the range for the Han and Czech samples, which is why the means are only shown.
Next is a boxplot that combines both males and females. This will aid in viewing interpopulational variation without discriminating by sex. The graph is shown in figure 4.j, and is once again comparing the mean and range of the Ischium-Pubis Index.
Figure 4.j Boxplot of Ischium-Pubis Index by combined sex for each geographic sample.
Chapter 5 : Discussion

T-test results; Morphology

The t-test results, comparing the means of males and females within the Morphology sample, display significant differences for all seven index values. This is evidence that statistically, there is a detectable degree of sexual dimorphism present among a modern day population of mixed ancestral affiliation. In order to determine which indices were best differentiated by sex, I used the eta squared equation (Cohen 1988). The ischium-pubis index was most effective at distinguishing sex with an eta value of 1.31. The three other indices with a strong sexual separation are the OB index (following Davivongs 1963), the chilotic index, and the greater sciatic notch index II. Those with a moderate eta value explaining variance by sex include all remaining indices; these include the OB index (following Wu et al. 1982), the coxal index, and the greater sciatic notch index I.

T-test results; Southwest

The t-test results for the Southwest sample showed some stronger results of variance explainable by sex. Six index values, except the coxal index, had significant differences in means, as well as a large part of the variance explained by sex according to Cohen (1988). The coxal index had a significance of 0.433, making it the only index with no significant difference between the mean of sexes in the Southwest sample.
T-test result discussion

Sexual dimorphism is detected by the t-test in both the modern Morphology, and prehistoric Southwest samples. Some differences and interpretations can be detected from these results, and will be discussed below.

First, my original hypothesis was that less sexual dimorphism would be detectable in regards to all seven index values of the Morphology sample than in the Southwest. In addition, I also hypothesized that a significant difference would be detected in all seven index values. The coxal index forces me to reject this null hypothesis in at least one aspect. No significance was found in the Southwest sample, and a moderate one was detected for the Morphology. The coxal index does display the lowest eta-squared value calculated for the Morphology sample. Therefore, I find that the coxal index is thus far the least reliable at distinguishing sex within a population.

Secondly, I must reject the null hypothesis of less sexual dimorphism present in the Morphology sample. Two indices of the Morphology sample displayed a larger explanation of variance by sex; these are the OB index (following Davivongs 1963), and the ischium-pubis index. My null hypothesis; however, was represented accurately on four accounts. The OB index (following Wu et. al. 1982), the chilotic index, and the greater sciatic indices I and II all had significant differences with a larger amount of the variance explained by sex in the Southwest sample in comparison to the Morphology sample. Therefore, if I disregard the coxal index, four of six index values indicate a higher degree of sexual dimorphism in the Southwest sample than in the Morphology sample.
All of this data must be taken with a grain of salt, mostly in respect to sample size. With a sample size of over 200 Morphology males, and less than 150 individuals representing a combination of Morphology females, Southwest males and Southwest females, I have to consider the effect this has on the statistics. It is possible that more of a normal distribution curve was achieved for the Morphology sample, which may have more accurately achieved means for the sample population.

In addition, the patterns observed from the t-test results indicate that certain index values may be more accurate at determining sex within one population and less accurate at determining sex in another. This must be considered when an individual is trying to sex a specimen from a particular geographic ancestry. A researcher must consider data that will indicate what the best sexual indicators will be, population-dependent. For the present study, I can make some initial decisions based on the t-test results for which indices would make the best sex determination for the two populations being discussed. The best, thus far, for the Morphology sample would be the OB index (following Davivongs 1963), the ischium-pubis index, the chilotic index, and the greater sciatic notch index II. The best sex determiners for the Southwest sample, thus far, would be all index values minus the coxal index. I base these decisions on index values that show a significant difference in means, as well as displaying an explanation of variance by sex that is ‘large’ (Cohen 1988).

It is also very apparent that there is a need for the standardization of measurements. This is shown in both tables 4-1 and 4-2; observe the mean values obtained for the OB indices following Wu et al. (1982) and Davivongs (1963). Although these indices are representing virtually the same aspect of the pelvis, both relating to the
greater sciatic notch, their mean values are very different. A decision of creating one
standard measurement would alleviate future researchers for having to take multiple
measurements on this area for comparability purposes. Decisions should be made in
respect to the most accurately repeatable measurement, as well as the most consistent in
showing significant differences between the sexes. In the cases of the Morphology and
Southwest samples, both versions of the OB index display significant differences in sex
means. However, less variance was attributable to sex following Wu et al. (1982) in both
samples. Further discussion of measurement standardization will be discussed later.

**OB Index results (following Wu et al. 1982)**

The OB index descriptive statistics are provided in table 4-3 and the one-way
ANOVA results are presented in table 4-4 in the results chapter. From this information a
significant difference was detected somewhere in the mean values of the four groups
being compared; these include Morphology females, Morphology males, Southwest
females, and Southwest males. Table 4-5 provides results of the post-hoc test, which
identifies where the significant differences are. All groups were found to be significantly
different from one another when comparing the OB Index, except the Southwest females
and Morphology males. The close OB index mean values of the Southwest females and
Morphology males are shown in figure 4.a. Even though the OB Index does prove
effective at distinguishing sex within a population, there is a problem when groups of
different geographic ancestry are combined. This index provides inefficiency in the
present study at between group sexual determinations. If this was the only index
employed by a researcher on a blind study of the discussed groups, he or she might
mistake a male from a modern population with a female from the prehistoric Southwest.
It is also interesting to note that the females of both populations show approximately a 10 mm higher in mean value than the males of their respective sample.

**OB Index results (following Davivongs 1963)**

The OB index descriptive statistics are provided in table 4-7 and the one-way ANOVA results are presented in table 4-8 in the results chapter. These analyses revealed that a significant difference does exist somewhere among the four discussed groups. The post hoc test showed that each group was significantly different from one another with respect to this OB Index, with the results shown in table 4-9. The males show a lower mean of the OB index for both populations. The OB index shows to be very effective at distinguishing between and within population sexes. Although significantly different, the Morphology males and Southwest females are once again the closest when it comes to mean distribution, as shown in figure 4.b. In addition to the close mean value, the Southwest females exhibit a higher OB Index mean than the morphology males. This may be misleading, just like the discussed results for the OB Index measured according to Wu et al. (1982).

**Ischium-pubic Index results**

The OB index descriptive statistics are provided in table 4-11 and the one-way ANOVA results are presented in table 4-12 in the results chapter. This data indicates that there is a significant difference somewhere between the four groups, which is confirmed by the post hoc test showing significant differences between all four groups. Once again the females display higher mean values compared to the males within each sample population. The mean difference is 8.36 between the two female groups. The
smallest mean difference is between the males of each population, at 5.03. Even with this qualifying as a significant difference, researchers should be aware of this close mean difference. The mean distribution can be seen in figure 4.c.

Another problem may arise when trying to distinguish Morphology females with Southwest males. The mean difference between these two groups is only 5.67. The Southwest males have a mean that lies almost equidistant to the means of the Morphology females and Morphology males. Therefore the ischium-pubis index may not be exceptionally effective at between group sexual determinations. However, with the noticeably higher mean of Southwest females, the ischium-pubis index may be useful in distinguishing them from all other three groups. On the other hand, within group sexual determination appears to be very effective at discerning males from females. Both population samples have a sex mean difference of over 10 mm.

Coxal Index results

The Coxal index descriptive statistics are provided in table 4-15 and the one-way ANOVA results are presented in table 4-16 in the results chapter. A significant difference was detected from these results to be present somewhere between the four compared groups. It is discovered in the post hoc results found in table 4-17, that the mean of the coxal index for Morphology females is significantly different than all other three groups. Also shown in table 4-17 is that none of the other groups display a significant difference in the coxal index between one another.

This mean distribution is displayed in figure 4.d. The Morphology females may appear at first glance to be an extreme outlier, however, the y-axis only ranges a total of 5 mm. The morphology females may be detected by this index better than distinguishing
all other three groups; however, due to the small range of difference it should not be trusted as one of the more reliable methods. In the view of this paper, the coxal index appears to be the least reliable at determining sex both within and between populations.

**Chilotic Index results**

The chilotic index descriptive statistics are provided in table 4-19 and the one-way ANOVA results are presented in table 4-20 in the results chapter. Significant differences were indicated by the one way ANOVA, and located specifically by the post hoc test. As discussed in the results chapter, the males and females are distinguished nicely both within and between populations. This sexual dimorphism is displayed in figure 4.e. The y-axis of figure 4.e encompasses a range of 40mm. The mean difference between Morphology females and Morphology males is 26.91, which is a very nice and observable separation. The Morphology females have a mean difference of 18.05 with the Southwest males, which is still impressive and large enough to detect. Southwest females have a large mean difference with Morphology males at 24.32, and a still impressive difference of 15.46 with Southwest males. The least convincing difference, as previously mentioned, is the mean difference of 2.58 between Southwest and Morphology females. The male difference is also not significant at 8.86.

According to the results of this study, the Chilotic Index is a good indicator of sex determination within and between populations. The males exhibit a significantly higher mean chilotic index then do the women. However, the chilotic index is not effective at distinguishing the same sex between populations. In other words, you can tell females from males, but you can not distinguish males from different population samples or females from different population samples.
Greater Sciatic Notch Index I results

The chilotic index descriptive statistics are provided in table 4-23 and the one-way ANOVA results are presented in table 4-24 in the results chapter. A significant difference was only located between the Morphology males and all other three groups. Refer to figure 4.f to view the mean distributions of the greater sciatic notch index I. The Southwest females and males are almost indistinguishable with a 0.81 mean difference. There appears to be more sexual dimorphism according the greater sciatic notch index I within the morphology sample, with the mean difference of males and females at 6.12. This is once again against my null hypothesis of less sexual dimorphism present in the Morphology sample. Also notice how close the female groups are, with a mean difference of only 2.91. Therefore the greater sciatic notch index I only shows the modern male sample of mixed ancestry to be distinguishable from all other studied groups.

Greater Sciatic Notch Index II results

The chilotic index descriptive statistics are provided in table 4-27 and the one-way ANOVA results are presented in table 4-28 in the results chapter. Significant differences were detected by the one way ANOVA, and the post hoc test showed each group to be significantly different from one another.

Within each population sample, the mean of the greater sciatic notch index II is not only significantly different between men and women, but observably different and convincing. The distribution of the greater sciatic notch II index means can be found in figure 4.g. The mean difference of Morphology males and females is 10.17. The females and males of the Southwest sample have a mean difference of 14.48. The most striking
difference, however, is between the Morphology females and Southwest males. They have a mean difference of 19.24.

The greater sciatic notch index II may not be that helpful at distinguishing females of one sample from females in another sample. The difference between the Morphology and Southwest females is the lowest of the mean differences at 4.76. In addition, between groups determination of males and females appears to be tricky. The Morphology males fall very close to Southwest females with the low significant difference of 5.42.

**Ischium-pubis Index of diverse geographic regions**

The present study was concerning a modern morphological collection of individuals from mixed geographic ancestry, as well as a prehistoric sample of Southwest Native American groups. The ischium-pubis index is one of the most well-documented indices concerning pelvic measurements. There are many advantages to using the pubic bone length, a component of the ischium-pubis index, for measurements. Washburn (1948) reveals these advantages as: giving an estimate of the primary variable, measurement is easy to take, only one os coxae is needed, avoids hassle of articulating a pelvic girdle, avoids cartilage estimates at pubic symphysis, facilitates working with fragmentary remains, and is part of a highly sexually dimorphic skeletal feature. Figure 4.h is a graph displaying the mean distribution of the ischium-pubis index for nine sampled populations, or groups of people from distinct geographic ancestry. A few things can be learned from this graph.

First, it is easy to notice that each population has a higher ischium-pubis index mean among females than males. The ischium-pubis index therefore shows consistent
accuracy at being able to distinguish females from males within a given population. By at least the time of puberty, the pubic length of females is usually longer than the pubic length in males (Davivongs 1963:449). Washburn (1948) attributes the common obtuse subpubic angle and triangle-like form of the obturator foramen to the longer pubic length in females. In contrast to the longer pubic bone in females, the ischial length in female is usually shorter (Davivongs 1963:450). This is why the ischium-pubis index means for all the populations discussed are is greater in females than males. Washburn (1949) finds that the ischium-pubis index is extremely accurate, because it utilizes the documented relationship of the ischium and pubis. Davivongs (1963) observes a small amount of overlap between males and females for his Australian Aborigine sample, and regards its ability for sex determination as having high value. Similar patterns were observed for the Southwest and Morphology samples; histograms displaying this common pattern are shown below in figures 5.a, 5.b, and 5.c. Karen Rosenberg states, “Although the direction of the differences between males and females is generally the same, the magnitude of the male and female values differs regionally (Rosenberg 2002).”

**Figure 5.a** Australian Aborigine Ischium-Pubis Index histogram
Secondly, the range of mean difference within each population is almost identical, with the smallest mean difference observed in the Morphology sample. This shows that modern populations of mixed geographic origin do in this circumstance exhibit the least...
sexual dimorphism specific to the ischium-pubis index, as I hypothesized to be true. The consistent pattern of almost an equidistant separation between males and females throughout each population further supports the first observation of accurate male and female determination.

Third, with mean values alone I was not able to determine the statistical significance of mean difference in regards to the ischium-pubis index. However, by looking at the distribution of means in figure 4.h, you can get a good sense of female mean distributions and male mean distributions. In most cases, the females fall within a 5 mm unit range. The biggest difference can be seen between the Czech (Novotný 1986) females and the Morphology or Australian Aborigine (Davivongs 1963) females. The same variation is true for the males of each group. Most male groups have at most 5mm between them, with the Czech males (Novotný 1986) and Australian Aborigine (Davivongs 1963) males exhibiting the greatest mean difference. Enough variation is observed between populations that chance can not possibly be the only explanation. There have to be other biological and environmental factors that contribute to observed variation.

The boxplot shown in figure 4.i once again displays the mean distributions of the nine sample populations, with the mean value appearing as the dark vertical line in each box. I did not have the raw data in order to portray a true interquartile range, shown by the box surrounding the mean value line. The whiskers of the plot do show the true maximum and minimum values for the ischium-pubis index, which were not obtained for the Han and Czech samples. I chose to display this graph to acknowledge a trend in data that is not always discussed in a sexual dimorphism study; the trend in question is overlap.
The mean values of males and females were shown nicely separated in figure 4.h, but this chart was only displaying mean values. When the full range of variation is considered, each population shows overlap between the females and males specific to their sample. In addition, the males of each population sample show overlap with the males of every other sample, and the same thing occurs for females. When the population samples are combined to show both males and females together, as displayed in figure 4.j, the degree of population overlap in regards to the ischium-pubis index becomes very obvious. This presents some difficulty in assessing the accuracy of sexing skeletons from different geographic regions. The overlapping of male and female features of the pelvis is discussed by Hrdlička (Stewart 1952). It is pointed out that variation for male specimens and female specimens will range from hypo- to hyper-masculine and hypo- to hyper-feminine respectively, and overlap occurs in the hypo-masculine and hypo-feminine categories (Davivongs 1963:443). The range of where this ‘hypo’ stage exists is shown here to vary from population to population. Indeed variation does exist, but is best exemplified by mean values. A researcher should not, however, disregard the overlapping variation shown here. Although the ischium-pubis index is one of the best sex indicators of the pelvis, and should be used as evidence in cases where the pelvis is the only bone recovered, every other available sex indicator from the crania or post-crania should be used in addition whenever possible.

**Population differences**

Population differences in pelvic variation, with significant differences in mean values, have been found in almost every area of the pelvis when studied (MacLaughlin and Bruce 1986; Rosenberg 2002, Walker 2005). In order to accurately sex a skeleton
for a given population, the available literature addressing the variation of that population needs to be considered. This precaution will attempt to eliminate errors in further interpretation of a population based on sexual categories of observation. Philip Walker (2005) addresses this issue relative to greater sciatic notch variation when he states, “If unaccounted for, such large population differences in sexing errors could greatly distort mortality profiles and create the appearance of sex-specific population differences in mortality rates where none exist.”

Similar concerns recently reported by Van Arsdale et al. (abstract 2005) state, “Human populations in different areas of the world vary significantly in the degree to which they display sexual dimorphism and in the craniometric traits which dimorphism is expressed. Population and regional level variation in the expression of sexual dimorphism is not necessarily surprising, but it has important consequences both for how we understand sexual dimorphism in extant species, and how we deal with sexual dimorphism in the fossil record (Van Arsdale et al. 2005:221).”

One point that has been neglected in sexual dimorphism studies is discussed by Karen Rosenberg (2002). She points out that there have been no “systematic efforts to quantify this variation” (Rosenberg 2002). There are many studies that have focused on discussing sexual dimorphism in diverse geographical regions (Akpan, et al. (1998), Davivongs (1963), Derry (1923), Genoves (1954), Hager (1989), Hanna and Washburn (1953), Hauser and Jahn (1984), Howells and Hotelling (1936), Iscan (1981), Jovanovic and Zivanovic (1965), MacLaughlin and Bruce (1986), Novotny (1986), Orban (1980), Orban-Segebarth (1984), Richman et al. (1979), Rosenberg (1988), Rosenberg (2002),

In order to illustrate the different ranges and overlap of particular pelvic features between populations I created histograms of the Southwest, Morphology, and Australian Aborigine data (recreated from Davivongs 1963). The histograms show the distributions of females and males for four pelvic attributes considered by Davivongs (1963) to be the most effective at sexing a skeleton from the pelvis, in addition to the ischium-pubis index. These include the vertical diameter of the acetabulum, the length OB of the greater sciatic notch (following Davivongs 1963), the index II of the greater sciatic notch, and the chilotic index; they are shown in figures 5.d-5.o.

**Figure 5.d** Vertical diameter of acetabulum sex distribution; Morphology
Figure 5.e Vertical diameter of acetabulum sex distribution; Southwest

Figure 5.f Vertical diameter of acetabulum sex distribution; Australian Aborigine
Figure 5.g Length OB of GSN; Morphology

Distribution of Length OB of Greater Sciatic Notch: Morphology Collection

Figure 5.h Length OB of GSN; Southwest

Distribution of Length of Greater Sciatic Notch: Southwest Collection
Figure 5.1 Length OB of GSN; Australian Aborigine

![Distribution of Length OB of Greater Sciatic Notch: Australian Aborigine (Davivongs 1963)](image)

Figure 5.j Index II of Greater Sciatic Notch; Morphology

![Distribution of Index II of Greater Sciatic Notch: Morphology Collection](image)
Figure 5.k Index II of Greater Sciatic Notch; Southwest

Figure 5.l Index II of Greater Sciatic Notch; Australian Aborigine
Figure 5.m Chilotic Index distribution; Morphology

Distribution of Chilotic Index: Morphology Collection

Figure 5.n Chilotic Index distribution; Southwest

Distribution of Chilotic Index: Southwest Sample
Nongenetic explanations of variation

During the data collection of the Southwest sample, the majority of my time and attention was spent measuring the os coxae. Unfortunately, this restricts the ability to detect certain disease or malnutrition markers that may have affected the growth and development of these prehistoric individuals. The research done by Ann Palkovich (1980) was on the skeletal remains of Pueblo Arroyo Hondo. At this time she did a full assessment of the skeletal material, and observed a lot of bone porosity in the forms of porotic hyperostosis, endocranial lesions, and cribra orbitalia (Palkovich 1980: 43). A lot of this pathology was attributed to malnutrition, which has been documented in other populations with high rates of such pathologies in juveniles (Wills and Waterloo 1958; Gordon, Wyon, and Ascoli 1967; Puffer and Serrano 1973), and which has been linked to
malnutrition in many other instances (Garn 1966; Goldstein 1969; Hengen 1971; Kunitz and Euler 1972; Stini 1973; Lallo, Armelagos, and Mensforth 1977; Mensforth et al. 1978). Therefore, it is very likely that prehistoric or historic societies undergoing regular periods of famine or nutritional stress will be reflected in the skeleton. Of concern here is how it will effect the pelvis.

On April 9, 2005, I was able to discuss the 14th century ancestral pueblo site and the Arroyo Hondo skeletal remains with Ann Palkovich; she is currently doing a reassessment of the entire collection. Thirty years after her initial assessment, Palkovich has discovered some very interesting signs of vitamin D deficiency and scurvy that she previously did not notice, or had no explanation for (personal communication, April 2005). She has now documented many instances of these diseases in approximately 120 of 170 studied individuals. Palkovich states that, “though not often identified in prehistoric populations, these skeletal changes form a distinct pathological signature” (Palkovich 2005:163). Both adults and juveniles showed signs of rickets. A total of 89 individuals had limb deformities. In Component I, Palkovich observed 9/49 adults with deformities; these included bowing and bending of the diaphysis, cortical thinning, and sparse coarse trabeculae. In Component II there was one adult case out of seven with similar deformities. There were 8 juveniles from Component I, and 3 juveniles from Component II with rickets.

At first Palkovich thought that rickets, (and she thinks scurvy is present as well), was an impossibility with the sun of the Southwest. However, after further analysis, she could not avoid the observations that she was making. Of CI, the long east side she thinks was an aristocracy of some sort, closer to the arroyo. They displayed much less
rickets. The west side, however, was full of it. Ann Palkovich is still wondering how vitamin D deficiency is a possibility for so many individuals residing under the hot Southwest sun. One hypothesis was that some other disease, not detectable in the skeleton, had caused some individuals to remain indoors, and little sunlight was received on a daily basis.

It has been suggested by Walker (2005) that even if an os coxae does not display signs of severe rickets, rickets in childhood still has the capacity to distort the human pelvis, and in turn modifying particular morphological features used to assess sex. Later onset of adult osteomalacia is also suggested to have an effect on the adult pelvis morphology (Bible et al. 1983; Kaufman 1993), which can only be omitted from a sample if this distortion and rachitic condition is visually detected. The manipulating affects of rickets on skeletal development and deformation is well documented (Hess 1929; Ortner and Putschar 1985; Rauschmann et al. 2003; Rüttimann and Böni 2000). These changes can be made just by walking or taking on a daily routine (Hess 1929; Ortner and Putschar 1985). The lifestyle of the prehistoric Southwest was a hard one, and required many activities needed for survival (as discussed in background chapter). Such a disorder would be debilitating in many ways, and the effects on the pelvis should be evaluated more thoroughly.
Chapter 6 : Conclusion

This project can be summarized in a few concluding statements, elucidating what has been learned and observed from the Morphology and Southwest collections, as well as all supporting comparative studies.

There is a need for the standardization of pelvic measurements in sexual dimorphism studies. By employing repeatable measurements and obtaining hard data, more accurate studies are done with the potential for comparative analysis. There are presently too many different methodologies for measuring the same areas of pelvic sexual assessment, this makes data collection difficult and more time consuming.

The effects of diet, lifestyle, disease and pathology on the morphology of the os coxae, especially in areas used for sexual assessment, need to be explored for diverse geographic populations. Diseases such as rickets and osteomalacia have been found to effect pelvic morphology, even when visually undetectable from an isolated os coxae.

There is a similar distribution of females and males for the populations analyzed in this study; however, a significant amount of variation is present. This variation needs to be understood on both genetic and environmental levels. In addition, temporal changes of os coxae morphology have been observed, and must be considered when sexing an individual.

The pueblo people of the prehistoric Southwest endured many hardships, especially dealing with times of drought. Drought has been the main cause in the majority of hypotheses explaining the abandonment of pueblo sites. Despite difficulties with a harsh climate, many great accomplishments in site construction, road construction, astrological observations, and trade were made.
T-tests reveal significant differences in all seven indices calculated for the Morphology collection between males and females. The Southwest sample had similar results, with the exception of the coxal index. This indicates that overall the pelvis is a good indicator of sexual dimorphism, with some indices displaying more accuracy than others. The most effective indices at distinguishing sex for the Morphology sample were the ischium-pubis index, the OB index (following Davivongs 1963), the chilotic index, and the greater sciatic notch index II. The most effective indices at distinguishing sex for the Southwest sample were the ischium-pubis index, the OB index (following Davivongs 1963), the greater sciatic notch II index, and the greater sciatic notch II index. The coxal index is the least effective at distinguishing sex of the seven index values calculated.
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