3-1984

Metric Variation on the Arikara Pelvis

Cheryl Lee Puskarich
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by Cheryl Lee Puskarich entitled "Metric Variation on the Arikara Pelvis." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

William M. Bass, Major Professor

We have read this dissertation and recommend its acceptance:

Richard Jantz, Walter E. Klippel, Eugene B. Linton

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

METRIC VARIATION IN THE ARIKARA PELVIS

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Cheryl Lee Puskarich

March 1984

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ABSTRACT

Metric variation in the innominates, sacra and articulated pelves of the South Dakota Plains Indian group, the Arikara, are analyzed in an attempt to delineate biological relationships. The specimens examined represent 10 archaeological sites ranging in date from A.D. 1600 to 1832. The following sample sizes for innominate, sacrum and articulated pelvis data sets are employed: 292, 305, and 151, respectively. The data are analyzed utilizing univariate as well as multivariate statistical procedures.

The results indicate that consistent within-group patterning exists. Common elements of pelvic structure can therefore be identified. Group analysis results indicate that temporal patterning can be identified on the innominate and articulated pelvis. In general, these results are consistent with those of several Arikara craniometric studies.

Several explanations, namely obstetrical significance, demographic age structure differences, and gene flow, for the observed patterning are explored. Neither alone, however, appears to completely explain the patterning noted.

An analysis of the patterns of sexual dimorphism expressed in the Arikara groups examined indicates that nutritional factors alone are not responsible for the noted patterning. The results tend to more strongly support a greater genetic component to ranging patterns of Arikara sexual dimorphism and are also consistent with the resent results obtained for the Arikara postcranial skeleton.

Future studies employing data from other Plains Indians groups are designed to delineate the environmental and genetic components of variation of the boney pelvis as necessary in order to disprove or substantiate the present results.

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CHAPTER I

INTRODUCTION

Literature Review

Within the past several decades, skeletal biology has experienced major theoretical reorientation. Prior to the early 1960's, relationships among groups represented solely by skeletal remains were assessed on the basis of physical appearance. Those groups which "looked" similar were viewed as having similar biological origins. Little or no attention was given to morphological variability, either intra- or intergroup, and its meaning. This theoretical orientation has been appropriately referred to as the "typological" approach and exemplified by the work of Neumann (1952).

During the 1960's and 1970's emphasis shifted to population variation coupled with the use of multivariate, rather than univariate statistical procedures. Researchers such as Bass (1964), Howells (1973), Jantz (1972, 1973, 1974, 1977), Jantz and colleagues (Jantz and Owsley 1982; Jantz et al. 1978; Key and Jantz 1981), and Key (1979, 1982) have successfully illustrated the utility of such an approach.

Traditionally, the cranium, for various complex reasons, has been the skeletal element employed in such studies. Successful attempts have been made to delineate "universal" patterns of cranial variation (Howells 1973; Key 1979), identify microevolutionary trends (Jantz 1972, 1973, 1974, 1977; Key and Jantz 1981), and aid in the solving of culture-historical problems (Jantz et al. 1978; Key 1982;

Owsley and Jantz 1978). The postcranial skeleton, however, has been given very little attention as a source of data from which intra- and intergroup variation can be examined.

Recently, however, Zobeck (1983), employing an approach very similar to that of Howells (1973) and Key (1982), examined the nature of within- and among-group variation in the Arikara long bones, clavicle, and scapula. The results obtained did not correspond with those previously acquired employing cranial data. Can we, therefore, conclude that the postcranial skeleton is not a satisfactory indicator of group relationships? Hopefully, this manuscript, which concentrates upon another element of the Arikara postcranium, the pelvis, will shed additional light on this problem.

A review of the literature quickly reveals the human pelvis has been the subject of numerous studies. Primary emphasis, however, has been placed on its utility as a sex discriminator (Abbie 1957; Bass 1971; Burr, Van Gerven and Gustav 1977; Caldwell and Moloy 1933, 1934; Caldwell et al. 1934, 1935; Davivongs 1963; Day and Pritcher-Wilmott 1975; Derry 1909, 1923; Didio 1963; Emmons 1913; Fawcett 1938; Flander 1978; Greulich and Thoms 1938, 1939; Hanna and Washburn 1953; Heyns 1947; Hoyme 1957; Jovanovic and Zivanovic 1965; Jovanovic et al. 1968; Krogman 1962; Kurkicrek 1951; Morton and Hayden 1941; Nicholson 1945; Orford 1934; Pons 1955; Shultz 1930; Singh and Potturi 1978; Stewart 1979; Straus 1927; Thieme 1957; Thieme and Schull 1957; Trotter 1926; Washburn 1948, 1949; Wilder 1920, Young and Ince 1940). It is well known that the pelvis serves two primary functions. In males and females alike, the pelvis functions as a weight distributing mechanism whereby the weight of the body is transmitted to the lower extremities. However, in females, the pelvis is modified to accommodate the process of childbearing. The morphological differences noted between the sexes are, therefore, attributed to those adaptations in the female pelvis associated with childbirth.

The importance of the pelvis as an indicator of racial differences has been recognized by physical anthropologists, anatomists, and obstetricians. Stander (1945), in a widely read obstetrics textbook, historically reviews the obstetricians' perspective on racial variation in the pelvis. For example, based upon a calculated general size index (height versus width), Topinard in 1875 concluded that a relationship could be established between the degree of "civilization" of a race and its associated index value (Stander 1945). The more civilized the race, the lower and broader the pelvis. Riggs (1904), in a study comparing the articulated pelves of Black and White Baltimore women, was able to demonstrate that a higher frequency of contracted pelves occurred among the former. In general the Black pelvis is considered to exhibit smaller pelvic dimensions when compared to other "racial stocks" (Stander 1945).

Classifications of the pelvic inlet (superior strait) have been historically employed by obstetricians to describe not only sexual variation, but ethnic variation as well. Turner (1886), for example, employing the relationship between the transverse and anteroposterior diameters of the pelvic inlet, described three such classifications. These were: dolichopellic (anteroposterior diameter greater than the transverse diameter), mesatipellic (anteroposterior transverse diameter), mesatipellic (anteroposterior and transverse diameters of equal size), and platypellic (transverse diameter greater than anteroposterior diameter).

Most referenced of all such pelvic inlet classificatory systems is that proposed by Caldwell and colleagues (Caldwell and Moloy 1934; Caldwell et al. 1934, 1935). Not only were the variations of the female superior strait described in great detail, but the classifications were also employed to clinically evaluate a female's potential for a "normal" birth. If, based upon the category chosen as the best representation of the female's inlet morphology, it was deemed the individual would experience problems during birth, an operative delivery was conducted prior to an assessment of labor potentials (Linton, personal communication). The four general classifications suggested by Caldwell and co-workers are: gynecoid ("normal" female pelvis), android (male-type pelvis), anthropoid (pelvic form of great apes), and platypelloid (simple flat form). Unfortunately, much to the dismay of Caldwell and colleagues, further studies revealed the "normal" or gynecoid female pelvis was not as common in living females as expected (Stander 1945). The variations noted in the female pelvis in the above mentioned studies were not seen as resulting from pathological processes. Rather, as Stander (1945) points out, they were attributed to racial, sexual, and/or other inherited factors.

Racial differences in pelvic morphology have also been examined by physical anthropologists as well as anatomists (Adair 1921; Derry 1923; Douglass 1979; Flander 1978; Howells and Hotelling 1936; Letterman 1941; Reynolds 1930; Straus 1927; Thoms 1946; Todd 1929; Todd and Lindala 1928; Torpin 1951; Wilder 1920). The human anatomist, Gordon S. Letterman, examined variability in several dimensions of the greater sciatic notch in the Terry collection's American Whites and Negroes. The height of the sciatic notch in the latter was described as being smaller than in the White sample. It is interesting to note that Letterman (1941) also observed that in most sciatic notch dimensions examined, the variability expressed was greatest in the Negro sample. Adair (1921), in a study employing French and American females as subjects, noted not only overall smaller pelves, but also a greater degree of pelvic variability in the French sample when compared to the American females. Todd and Lindata (1928) as well as Strauss (1927), based upon observations of American White and Black medical school specimens, concurred that, in general, the dimensions of the Negro pelvis are characteristically smaller than those of Whites. This is also in agreement with the previously discussed findings of Stander (1945).

Howells and Hotelling (1936) compared the true pelvis of several Pueblo-living Indians from the southwestern United States to those of Europeans and Negroes. In comparison to European Whites and the Black sample employed, Indian pelves were described as exhibiting lower normal conjugate diameters, higher sagittal diameters, and a shorter symphyseal face. Negroes were characterized as expressing the narrowest sacra. In the same study, the authors also examined the correlation between various elements of the pelvis. Surprisingly, their results indicated that two widely employed dimensions in sex determination, the breadth of the sciatic notch and the subpubic angle, expressed relatively low intra-individual correlations.

In all of the studies discussed thus far, although pelvic variation is adequately described and differences in variability noted between samples, no attempts were made to explain why such variations exist. Recently, however, Douglass (1979) conducted an analysis in which the innominates from several Arikara sites were compared to those of American Whites and Negroes from the Terry collection in Washington, D.C. On the basis of 23 measurements, she was able to successfully discriminate the groups with 93.3% and 87.1% accuracy in females and males, respectively. Unlike the researchers previously discussed, Douglass concluded that nutritional differences could have potentially contributed to the differences noted. She did not, however, relate this to her specific results and describe in what dimensions nutritional status might affect pelvic morphology.

Employing the same set of innominate variables, Douglass (1978) also examined intergroup variation in pelvic material from four Arikara sites. An increase in pubis length through time was noted in her samples. Douglass concluded that an increase in the length of the pubis would appear to also reflect an increase in the overall size of the pelvic inlet. She further suggested that the observed increase through time in adult head length among the Arikara noted by Jantz (1972) was the force responsible for the observed changes in the pelvis.

In a re-analysis of Douglass' original data, employing a principal components approach, Puskarich (1980) derived essentially similar results. However, the conclusions drawn by Douglass were questioned for the following reasons: (1) insufficient information available relating to the degree to which the flexibility and size of the neonate skull and overall size of the newborn can act as limiting factors during birth, (2) the lack of information available concerning, specifically, the dimensions of the Arikara newborn cranium, (3) the lack of information available concerning the relationship between adult and infant cranial morphology, and (4) our lack of knowledge of the structural and functional interrelationships and significance of the various elements of the pelvis.

Primarily as a result of the above analysis, as well as the inability of the previously discussed researchers to approach variability in the pelvis from a population perspective, it became evident that a study concentrating on intra- and intergroup variation in the pelvis was needed.

Statement of Purpose

As previously pointed out, the usefulness of craniometric data to separate human groups has been amply demonstrated. In addition, it has been observed by Howells that ". . . population differences in cranial shape are based upon traits which have a common ground of individual genetic variation within all populations" (1973:146). Can this statement be applied to the postcranial skeleton as well? Recently, Zobeck (1983) attempted to answer this question employing metric variables of the Arikara long bones, clavicle, and scapula. His results were inconclusive. It is the general goal of the present analysis to further extend the examination of Howells' statement to an element of the postcranial skeleton not examined by Zobeck, the pelvis. More specifically, I intend to (1) examine the nature of intrapopulation (within-group) patterns of pelvic variability, and (2) determine what relationships, if any, can be identified between patterns of intragroup and intergroup (among-group) pelvic variation.

An approach very similar to that of Key (1982) and Zobeck (1983) will be employed to accomplish these stated goals. As such, the analytical procedures utilized are multivariate in nature. Several researchers, namely Corruccini (1975, 1978), Andrews and Williams (1973), and Zegura (1978) have discussed both the advantages and disadvantages of such an approach. In general, all agree that, if misused, multivariate statistical procedures can be viewed as no more useful than univariate analyses. One of the most important advantages of a multivariate approach to assessing biological relationships between groups, is the ability to simultaneously consider variables which are expressing similar information. In other words, a great amount of the redundancy present in the data can be eliminated. However, as pointed out by Corruccini (1975), several guidelines must be followed before the usefulness of morphometric analysis can be appropriately evaluated. Among these are: (1) justifying the use of a morphometric approach, (2) employing a well-defined measurement set, (3) conducting as complete an analysis as possible, and (4) explicitly delineating the functional significance of the results obtained. Being in agreement with the suggestions made by Corruccini (1975), the guidelines outlined above were followed in the present analysis.

Primarily due to the lack of pelvic data from other skeletal populations comparable to those of the present study, an assessment of the hypothesis of "universal" pelvic structure cannot be conducted. However, employing the methodology similar to that of Howells (1973), it is possible to examine microevolutionary trends and culture-historical problems on a regional scale. This has been adequately demonstrated for the crania by Key (1982). Conducting such an analysis necessitates the employment of several spacially and temporally restricted populations which can be considered closely related. One such group is the Arikara. According to Jantz:

> This material is particularly amenable to microevolutionary analysis for several reasons. First, it is circumscribed in time and space, ranging from about A.D. 1600 to 1830, and from Pierre to Mobridge, South Dakota, respectively.

> Second, the material is either historically documented as Arikara, or belongs archaeologically to the Coalescent tradition, thought by many to be ancestral to the Arikara (Wedel 1961:190-200; Hoffman 1967:75; Hurt 1970:207-13). Finally, environmental changes occasioned by European contact presented a situation conducive to biological change (1972:20).

In craniometric studies which have examined intra- and interpopulation variation, the underlying assumption is that the metric traits employed are highly heritable in nature. Put another way, groups which express similar cranial morphology are viewed as being genetically similar. Several researchers, namely Osborne and DeGeorge (1959) and Nakata et al. (1974), have provided evidence in support of this contention. This assumption will also be extended to the pelvis; however, it should be pointed out, to the best of my knowledge, the genetic and environmental components of pelvic traits have yet to be accurately delineated, only inferred.

Finally, in addition to the stated purposes of this study, several specific questions will also be addressed, namely:

1. How well, if at all, do the pelvic results obtained correspond to the culture-historical relationships delineated through cranial and postcranial analyses?
2. Can age-related changes in pelvic morphology be identified?
3. What effect, if any, did the environmental changes experienced by the Arikara have upon patterns of pelvic sexual dimorphism?

4. If intergroup differences in pelvic morphology can be identified, do they reflect obstetrical importance?

CHAPTER II

ARIKARA ARCHAEOLOGICAL FRAMEWORK

The skeletal remains of prehistoric and historic Arikara, a South Dakota Plains Villager group, are the subjects of investigation in this study. The archeology of this group has been adequately discussed in other manuscripts (Deetz 1965; Jantz 1972, 1973; Key 1982; Lehmer 1971; Lehmer and Jones 1968). As a result, Arikara archaeology will be only, comparatively, briefly discussed in this chapter.

The Arikara are linguistically affiliated with the Caddoan speakers of the Southern Plains region. Culturally, they are considered part of the Plains Village Pattern which marks the first appearance of agriculture in the Southern Plains around A.D. 1000. Three cultural traditions make up the Plains Village Pattern. These are: Central Plains, Middle Missouri, and Coalescent (Lehmer 1971). The Arikara represent the temporally later Coalescent Tradition which is considered to be a unique cultural entity formed by the fusion of Central Plains and Middle Missouri characteristics (Lehmer 1971). Evidence, in the form of cranial data, has recently been presented by Jantz (1977) to lend support to the contention that the Coalescent Tradition at least partially originated from the Central Plains Tradition. Jantz documented a striking morphological similarity between Arikara crania and those representing St. Helena Phase (Central Plains Tradition) peoples.

The Coalescent Tradition is usually separated into four temporal variants: Initial Coalescent (A.D. 1300-1550), Extended Coalescent (A.D. 1550-1675), Post Contact Coalescent (A.D. 1675-1780), and Disorganized Coalescent (A.D. 1780-1862) (Lehmer 1971). These variants together span approximately 462 years. The pelvic remains analyzed in the present study, however, are from sites associated with only the three later variants. Unfortunately, skeletal remains from the Initial Coalescent were not available for examination.

The exact origin of the Arikara as a distinct cultural/ biological entity is at present unknown. According to Deetz, it is agreeable by most to consider the Arikara as being either "formerly allied or actually a part of the Skidi Pawnee, their closest linguistic relatives" (1965:5). Following "separation," the Arikara left their native homeland of Nebraska and began their northward expansion from the Loup River up the Missouri River Drainage Basin. According to Lehmer (1970), during this migration the Arikara were exposed to a series of climatic changes which ultimately affected the Arikara way of life. The following will be a brief discussion of the four temporal variants of the Coalescent Tradition.

The Initial Coalescent is marked by the Arikara's initial northward migration. It has been suggested (Deetz 1965; Lehmer 1970) that droughts occurring during the Pacific I climatic episode in the Central Plains were the primary stimulus for this migration. During this period, the Arikara penetrated as far north as the Bad-Cheyenne River region and apparently replaced the Initial Middle

Missouri groups while also displacing the Extended Middle Missouri peoples in the area (Key 1982). Large villages with extensive fortifications characterize the Initial Coalescent. The presence of such fortifications appears to indicate the movements of this group were accompanied by some degree of friction. Houses were from medium to large in size and randomly scattered throughout the village stockade. The overall settlement pattern of the Arikara during this time is described by Deetz as being a "Central Plains type village within a modified Middle Missouri type fortification" (1965:4).

In contrast to the Initial Coalescent, the Extended Coalescent (A.D. 1550-1675) is characterized by less intergroup friction as can be inferred from the decrease in the frequency of fortified villages noted. In general, villages were small, unfortified and located on the first or second terraces of the Missouri River (Deetz 1965). Houses were circular and larger than those built in the preceding time period. As in the Initial Coalescent, the Extended Coalescent is characterized by rapid expansion. By late in this period, Arikara groups occupied the entire Missouri River trench in South Dakota.

Climatic changes, associated with the Neo-Boreal Climatic episode, appear to have, at least potentially, affected Arikara life style during this period. The Neo-Boreal began around the middle of the sixteenth century and is characterized as a period of reduced summertime temperatures (Lehmer 1970). These climatic changes affected the entire Midwestern United States, particularly the Middle

Missouri area, where it is suggested that cooler summers would have severely reduced crop yields (Lehmer 1970). Lehmer (1970) suggests that the cultural response to these climatic changes included not only a reduction in the length of time a village was occupied, but also a reduction in village size. This resulted in not only a decrease in the number of occupied villages, but also the abandonment of large sections of the area. In essence, "the available evidence suggests that the great majority of the Extended Coalescent people lived a hand-to-mouth existence in typically small communities that had a high degree of geographic mobility" (Lehmer 1970:70).

The Post Contact Coalescent (A.D. 1675-1780) is characterized by the first appearance of European trade materials in the Arikara assemblages. The Arikara as a distinct cultural entity is generally recognized during this period (Deetz 1965). A return to heavily fortified villages is noted. However, villages were described as relatively small, more closely approaching those of the Extended Coalescent in size. Although the Arikara of this period did not face the climatic limitations imposed by the Neo-Boreal episode, two events, the acquisition of the horse and European contact, brought about drastic changes in the Arikara way of life. The acquisition of the horse from Spanish settlements in the Southwest gave rise to powerful equestrian tribes who exerted considerable pressure on the Plains Villagers. Although the horse undoubtedly increased the Arikara catchment area, it may have also increased intertribal conflict, as is evidenced at Larson (Owsley et al. 1977).

Increasing contact with Europeans associated with the fur trade brought prosperity to the Arikara. However, this not only endangered the Arikara as a cultural entity, but also introduced new diseases, like smallpox for example, for which these groups had no immunological response. Eventually, these two events, the acquisition of the horse and European contact, undoubtedly exerted a considerable amount of "stress" on the Arikara.

The Disorganized Coalescent (A.D. 1780-1862), the final phase of the Coalescent Tradition, represents the Historic Arikara. In contrast to the three previous periods, the Arikara lived in conglomerate villages or wandered aimlessly about the Plains (Deetz 1965). The 1780's marked the beginning of a series of smallpox epidemics which drastically reduced the Arikara population. At the beginning of this period, only three Arikara villages remained (Bass et al. 1971; Lehmer 1971). The end of the Plains Village pattern, as well as the Coalescent Tradition, as a distinct cultural entity is generally associated with the reservation period which began in 1862.

The Arikara, and Plains Villagers in general, subsisted mainly on crops harvested from their garden plots and hunting big game animals such as the bison and antelope (Lehmer and Wood 1977). Garden plots were usually located on the Missouri River flood plain. Corn was the single most important plant resource of the Arikara; however, beans, squash, sunflowers, gourds, and tobacco were also cultivated (Lehmer and Wood 1977). The Arikara also exploited the natural environment for food resources. The Missouri River not only provided a means of transportation, but also provided a source of fish and occasionally big game animals which crossed the Missouri on their migratory routes. The grasslands provided wild food plants, especially the prairie turnip. Unlike most native Amerindian groups, the Arikara placed equally heavy dependence on both horticulture and big game hunting.

CHAPTER III

DATA BASE

Sample

Ten Arikara sites were employed in the present analysis. All ten sites have been associated with the Arikara or their direct ancestors (Bass 1964; Bass et al. 1971; Hurt 1957; Hurt et al. 1962; Jantz 1972; Lehmer and Jones 1968; Sigstad and Sigstad 1973). A large percentage of these sites were excavated by Dr. William M. Bass and University of Kansas field crews.

Most of the Arikara sites employed in this analysis represent single occupational components. However, the sites of Mobridge (39WW1) and Sully (39SL4) are thought to be multi-component. Two components from the former, Mobridge Feature 1 and Feature 2 and three Sully components, Sully A, D, and E, were employed in the present analysis. Each of these components is considered as a distinct sample. Together with the eight single component sites examined, thirteen groups were employed.

Skeletal material from the above sites is housed at the Smithsonian Institution (Anthropology Department) in Washington D.C. and The University of Tennessee, Knoxville.

The preservation of specimens in most sites can be considered good to excellent. This factor, combined with the very high skeletal recoverability obtained by Dr. Bass and his crews, has made the Arikara a very attractive population for use in the investigation of specific problems, including the ones to be examined in the present analysis.

Variables

Ninety-five pelvic variables were examined in the present analysis. Included is a group of innominate measurements which have been traditionally employed. These would include measurements such as maximum innominate width and height, pubic and ischial length, maximum length of the auricular surface, and upper and direct iliac height, to name a few. In addition to these variables, a series of measurements, unique to the present analysis, was designed to allow the collection of shape as well as size information from articulated specimens as well as single innominates. Of greatest importance to the acquisition of shape information were the angles employed.

Forty-five measurements were collected on innominate specimens. From these, eight angles were computed. The angles employed are illustrated in Figures 1 and 2. The variable, code name, and instrument employed are presented in Appendix A, Table A-1. Measurement definitions and their source can be found in Appendix A, Table A-2. The designation as adult was made on the presence or absence of the iliac crest epiphysis. Only those individuals exhibiting complete or nearly complete epiphyseal fusion were measured. Right innominates were employed when available.

All measurements were taken by the author and recorded to the nearest millimeter. A FORTRAN-10 program, ANGLE, written by Dr.

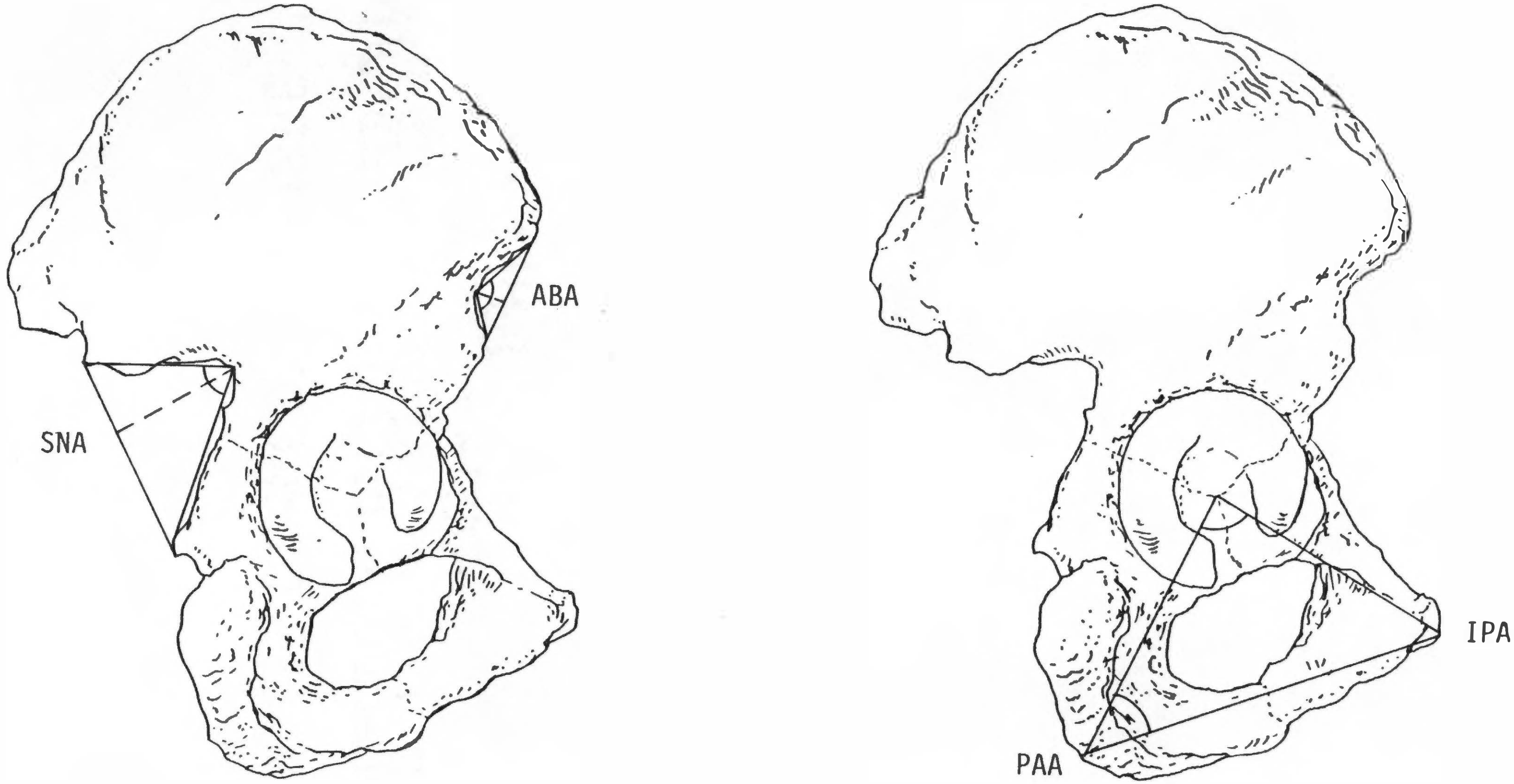

Figure 1. Innominate Angles: Medial View

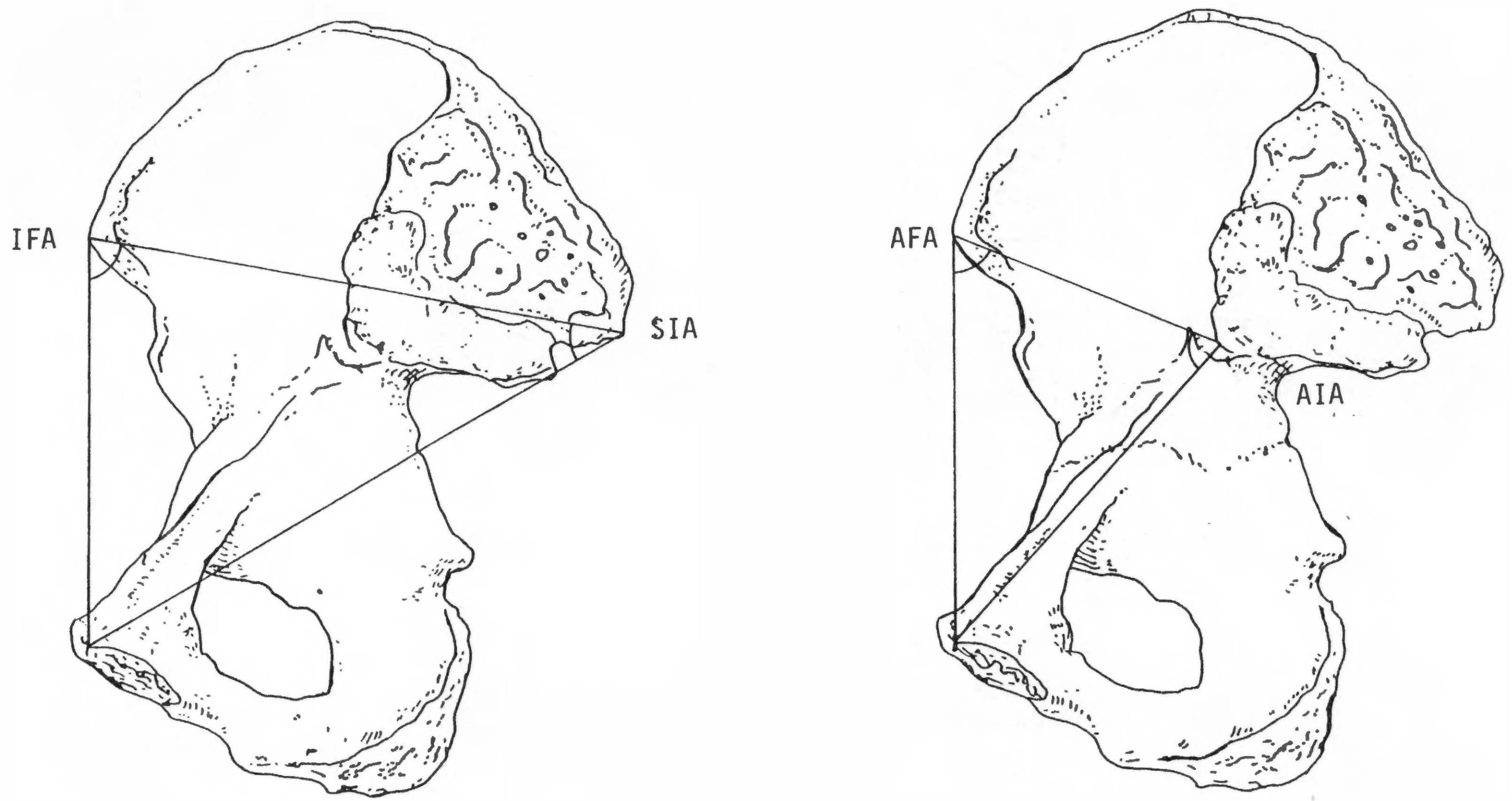

Figure 2. Innominate Angles: Lateral View

Patrick J. Key was employed to compute the necessary angles. The program utilizes several trigometric principles, identical to those outlined by Howells (1973:187-89), in its computations. All angles were calculated to the nearest degree.

Initially 555 specimens were measured. However, only 292 were "complete" enough to allow the collection of all 52 variables. Twelve individuals were excluded from the analysis due to incomplete site information, while an additional 261 specimens were not included as a result of their extremely fragmentary nature.

In addition to the 52 variables recorded for complete innominates, 23 measurements were collected on those individuals in which all three elements of the pelvic girdle, both innominates and sacrum, were present. A total of 151 complete pelves was available for data collection. From the original 23 variables, 11 angles were computed employing the FORTRAN-10 program, ANGLE, mentioned above. Angle illustrations are presented in Figures 3 through 6. The variable, code name, and instrument employed are given in Appendix A, Table A-1. Definitions and their sources are shown in Appendix A, Table A-3. Prior to the actual measurement procedure, the three elements of the pelvic girdle were articulated. The following is a description of the procedure employed.

The two innominates and sacrum are articulated employing dental wax. After heating in a water bath at 37° C, a small amount of wax is placed on the auricular surface of each innominate as well as the corresponding surfaces of the sacrum. The dental wax need

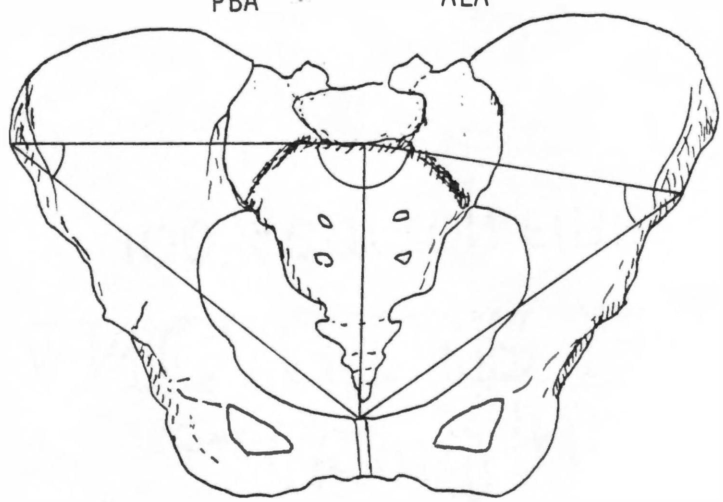

Figure 3. Articulated Pelvis Angles: Inferior View

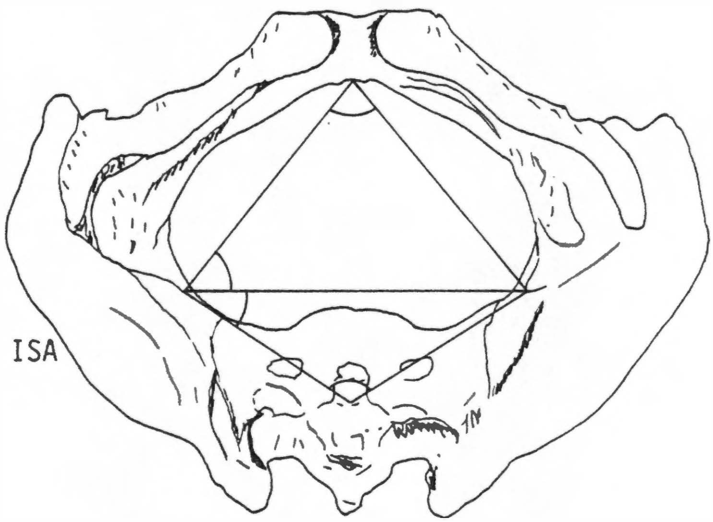

Figure 4. Articulated Pelvis Angles: Superior View

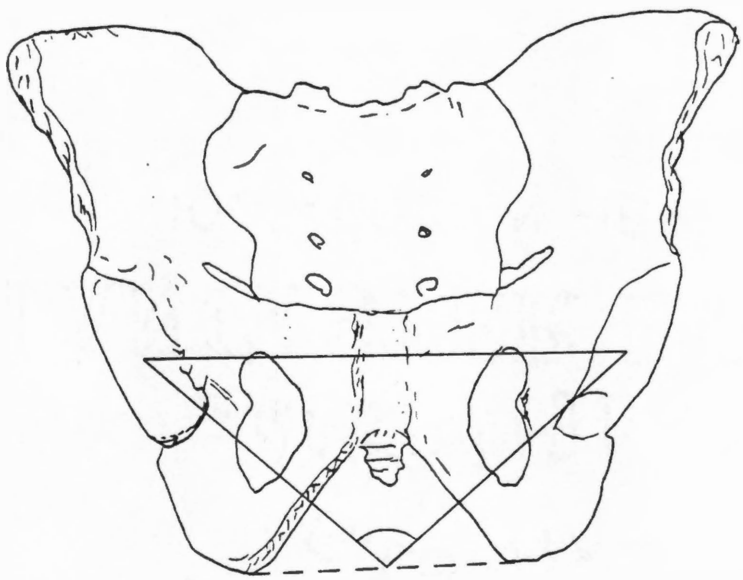

Figure 5. Articulated Pelvis Angles: Pelvic Outlet Angle

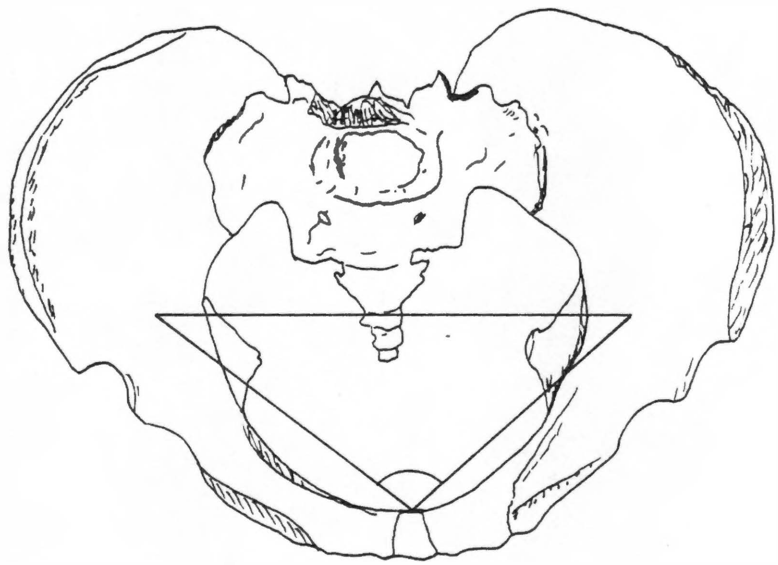

Figure 6. Articulated Pelvis Angles: Pelvic Inlet Angle

only be applied to the superior one-third of each surface.

Following wax application, the three elements are ready for actual articulation. This is accomplished by first taking one of the innominates and the sacrum and lightly pressing them together along the surfaces where the wax has been applied. Formation of a continuous plane between the sacral ala and the corresponding surface of the innominate must be established. In addition, each innominate must articulate with the sacrum at the inferior margin of the auricular surface. The remaining element is articulated in the same fashion.

Finally, the anterior pelvis is to be positioned such that the pubic portions of each innominate unite at their posterior positions. This is accomplished by carefully rotating the auricular surfaces until the desired position of the posterior symphysis is achieved, without disrupting the appropriate articulation of the sacrum and the innominates. Each pelvis must, therefore, articulate at the following five points before the specimen is properly positioned for measurement: the superior one-third of the auricular surface of each innominate and the corresponding surfaces of the sacrum, the most inferior margin of the articular surface of the sacrum on each side and the posterior portion of the pubic symphysis. A properly articulated male pelvis is shown in Figures 7 and 8.

Prior to a discussion of the sacral measurements, a few brief comments will be made concerning the use of the radiometer to collect

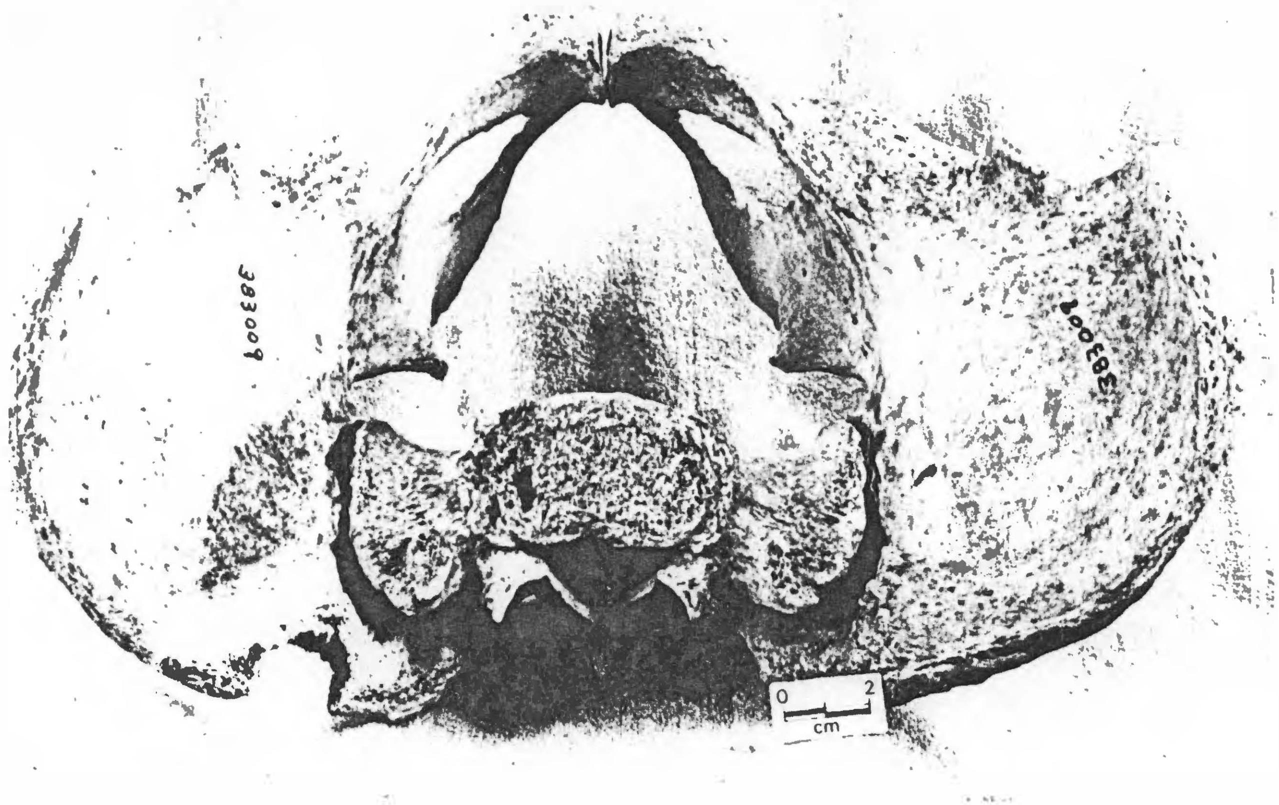

Figure 7. Properly Articulated Male Pelvis: Superior View

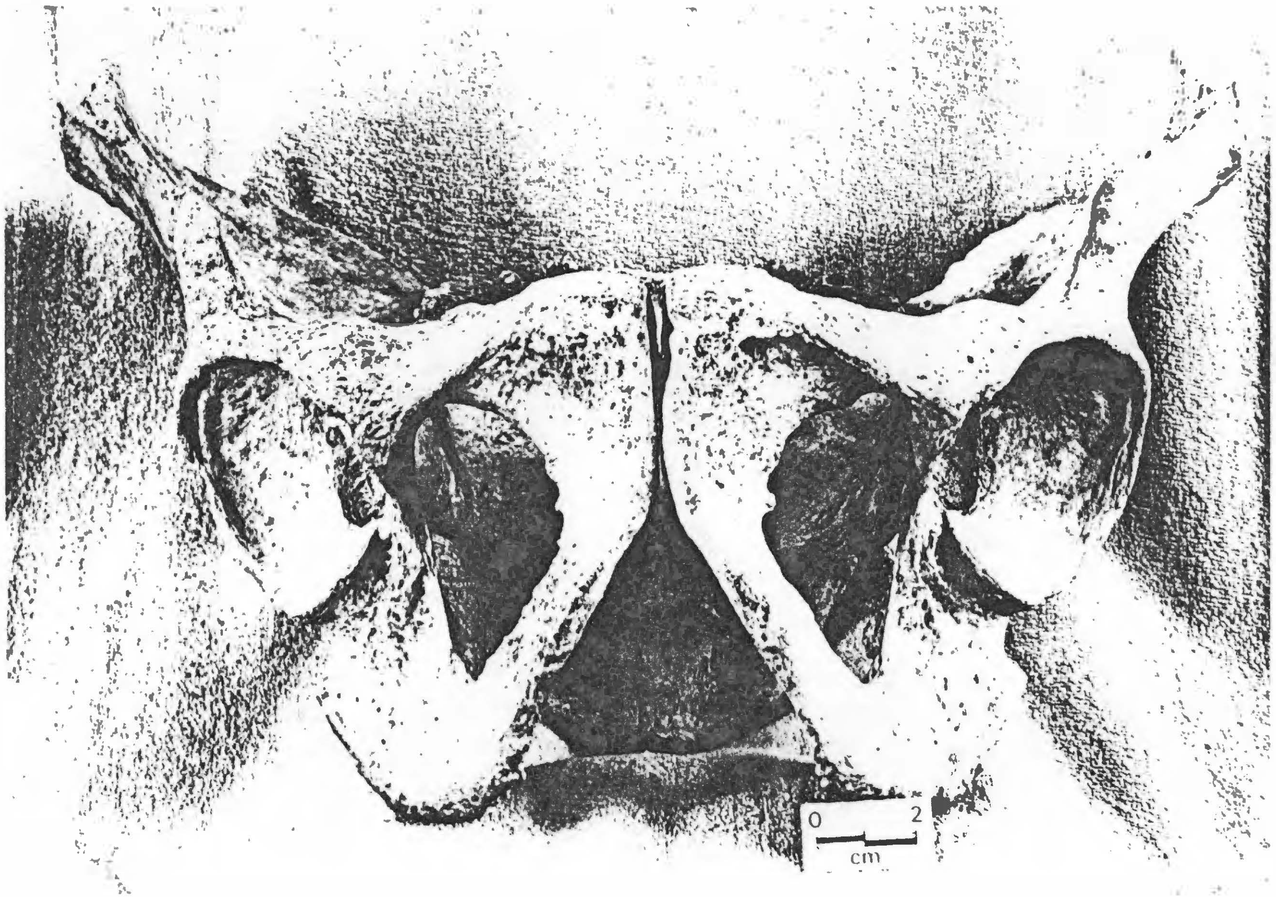

Figure 8. Properly Articulated Male Pelvis: Anterior View

measurements required in angle calculation. This instrument has recently been employed in craniometric studies (Howells 1973; Key 1982). However, extending its use to collecting pelvic information has not been attempted prior to the present analysis. The use of the radiometer as a potentially valuable means to acquire important pelvic shape information was suggested by Dr. Richard L. Jantz.

Several articulated pelvic measurements, namely biacetabular breadth (or acetabular chord), pubic subtense, pubic fraction, ischial tuberosity subtense, ischial tuberosity fraction, ischial spine subtense, and ischial spine fraction, were collected employing this instrument. The "bullets" normally inserted in the external auditory meatus in collecting craniometric information are placed in the acetabulae at that point where the three elements of the innominate unite. The instrument must be kept in this position until all succeeding measurements have been taken. Following the initial positioning of the radiometer, the remaining measurements can be collected. This is accomplished by rotating the radiometer around the pelvic girdle, being sure the projections of the instrument are still properly positioned in the acetabulae, until the point of measurement (i.e., ischial spine) has been reached. At this point, the perpendicular arm of the radiometer is lowered and a reading measuring the depth from the transverse axis is taken. This measurement is referred to as the subtense. That point on the main or transverse axis where the depth measurement is recorded is the fraction. Unfortunately, due to the limitations imposed by the structural design of the pelvic girdle, only those measurements listed above could be recorded. Lengthening the transverse arm of the radiometer would appear to allow the complete clockwise rotation around the pelvis. As a result, additional measurements similar to those employed in the present analysis could be collected. This would greatly increase the amount of shape information obtainable.

Seven sacral measurements were also collected. The variable, code name, and instrument employed are presented in Appendix A, Table A-1. Measurement definitions and their source are shown in Appendix A, Table A-4. Only 305 complete sacra were measured. In addition to the above variables, one angle, the angle of sacral curvature, was computed employing ANGLE, a FORTRAN-10 program. This angle is illustrated in Figure 9. As previously noted, all measurements were collected by the author and recorded to the nearest millimeter. The angle of sacral curvature was computed to the nearest degree.

Demographic Information

In almost all cases, the age and sex of the specimens examined had been previously determined. The demographic information utilized was obtained by Dr. Douglas Owsley of Louisiana State University. The determination of sex was made on the basis of several standard osteological criteria (Bass 1971; Krogman 1962; Phenice 1969; Stewart 1979). In only a few instances was there disagreement with the assigned sex of the individual. Re-evaluation was made on the

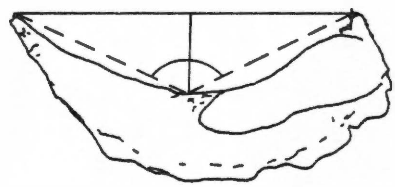

Figure 9. Angle of Sacral Curvature

basis of the above mentioned criteria as well as consultation with colleagues.

Estimating the age of specimens was also accomplished employing a variety of indicators. As in sex determination, a large proportion of the individuals measured were previously examined by Owsley. Age assessments were made employing the following techniques, in combination whenever possible: pubic symphyseal remodelling (Gilbert and McKern 1973; McKern and Stewart 1957; Suchey et al. 1979), age changes in the auricular surface (Lovejoy et al. n.d.), dental wear (Miles 1963), and epiphyseal fusion in the case of young adults (Bass 1971; Krogman 1962; McKern 1957; McKern and Stewart 1957; Stewart 1979). When the age of a specimen had not been assigned, assessments were made employing the above criteria. Reassessment was seldomly necessitated.

Missing Data Estimation

The employment of multivariate statistics necessitates complete data sets for each individual examined. However, as is well known, the percentage of complete skeletal specimens available for measurement in archaeological collections is rather small indeed. Therefore, in order to increase the number of "complete" specimens, missing data were estimated. In some cases, the amount of missing information was far too large to justify estimation of missing values. Only in those cases in which a small proportion of measurements were not obtainable were values for the missing variables estimated.

Howells (1973) suggests several methods for estimating missing data. These include: (1) substituting group means for those measurements which are not present, (2) making a guesstimation in the presence of the specimen, and (3) regression analysis. Due primarily to the degree of shape distortion which may result by substituting group means for the missing variables, this method was not employed. In order to reduce the potential amount of interobserver error, missing data were estimated utilizing the regression approach. The SAS (SAS Institute, Inc. 1979) procedure GLM was employed.

Sources of Error

In any metric analysis of a skeletal collection, several potential sources of error can be identified. Howells (1973) discusses a variety of these. However, only those deemed applicable to the present analysis will be commented upon.

As previously mentioned, all measurements taken were collected by the author. Therefore, error originating from interobserver sources does not enter in. However, it is the author's opinion that interobserver biases may greatly affect the amount of potential error if the present data are employed in comparative analyses. It is strongly felt that the degree of difficulty in the measurement set itself could potentially produce a considerable amount of such error. Although care has been taken to define the variables as precisely as possible, the caution of Howells (1973) that differences between observers in the manner in which the definitions are interpreted, the instruments are held, the specimens are positioned, and the experience of the observer in taking the various measurements can have an effect on the readings produced, is definitely applicable here. Therefore, it is suggested that any future attempts employing the present data for comparative purposes should be conducted with extreme caution.

Sources of error resulting from the instruments themselves were reduced as much as possible by employing the same instruments throughout the entire data collection phase. The instruments were periodically calibrated and cleaned.

Data were continuously collected between the months of June and October, 1982. Only short disruptions in data collection were experienced. Therefore, the amount of error which may be produced as a result of having long intermissions between data collection episodes were minimized.

Recently Utermohle and Zegura (1982) conducted a study examining the nature and degree of intra- and interobserver error in craniometry. Although their results specifically pertain to cranial measures, they would nevertheless appear to be applicable, in general, to all anthropometric studies. Of primary concern are their results relating to intraobserver error. Utermohle and Zegura concluded that the greatest amount of intraobserver error was noted in linear and angular measurements. Unfortunately, the exact degree to which such biases contributed to the results of the present study is unknown. However, the authors noted that the intraobserver biases observed were consistent and as such should not affect overall results.

Ideally, an intraobserver study should be conducted to control for such biases. This is usually accomplished by taking each measurement on a specimen more than once and then conducting an error analysis. Due to time limitations, however, such an analysis was not conducted in the present study. Therefore, the magnitude and patterning of intraobserver error is unknown.

Other potential sources of error include reading errors, recorder errors, and card punching errors. Eliminating all such errors would be a very difficult and time consuming task when dealing with a data set as large as the present one. However, an attempt was made to correct as many of these as possible. Initially, the original data sheets were compared with their corresponding computer cards. In addition, the MEANS procedure in SAS (SAS Institute, Inc. 1979) was employed to calculate the minimum and maximum values for all variables examined. These values were then compared to the expected range for the individual measurements. Values falling outside the expected range were then compared to the originally recorded value. Questionable cases were remeasured. Most reading, recorder, and card punching errors were eliminated in this manner. The percentage of such errors which remain, however, is unknown.

Site Data

Thirteen Arikara and/or proto-Arikara groups were employed in the present analysis. As previously mentioned, the archaeological tradition generally associated with the Arikara and their recent ancestors is the Coalescent. Although this tradition has been described as being composed of four temporal variants, only pelvic material from sites representing three of these variants, the Extended Coalescent (EC), Post Contact Coalescent (PCC), and Disorganized Coalescent (DC), was examined. The site name, temporal variant and phase, tribe affiliation, geographical coordinates, and site number are given in Table 1. The geographical location of each of these sites is presented in Figure 10. Table 1 and Figure 10 were modified from Key (1982).

Site dates employed were those recently utilized by Key (1982) in his craniometric analysis of Plains Indians. These data were derived through a variety of methods including archaeological inference, ethnohistoric reports, dendrochronometric studies, and radiocarbon analyses. Site date ranges and the dating method employed are shown in Table 2. A more detailed discussion of the dating techniques utilized can be found in Key (1982).

The male and female sample sizes varied with the specific measurement subset (i.e., sacrum, articulated pelvis, and innominate) examined. Sex specific sample sizes for each measurement set are shown in Tables 3 through 5.

Table 1. Site Data

	Site	Name	Tribe	Geo.	Coordin.	Variant	Phase
1	39ST235	Stony Point	Arikara	44.31	100.09	PCC	Bad River 2
2	39WW1	Mobridge F1	EC	45.56	100.45	EC	La Roche
3	39WW1	Mobridge F2	Arikara	45.56	100.45	PCC	Le Beau 3
4	39WW2	Larson	Arikara	45.52	100.41	PCC	Le Beau 3
5	39DW2	Four Bear	Arikara	45.19	100.30	PCC	Le Beau 2
6	39SL4	Sully A	EC	44.59	100.58	EC	La Roche
7	39SL4	Sully D	EC	44.59	100.58	EC	La Roche
8	39SL4	Sully E	Arikara	44.59	100.58	PCC	Le Beau 1
9	39ST215	Leavitt	Arikara	44.44	100.39	PCC	Bad River 2
10	39HU2	Oahe Village	Arikara	44.47	100.56	PCC	Le Beau 1
11	39WW7	Swan Creek	Arikara	45.31	100.29	PCC	Le Beau 2
12	39CA4	Rygh	EC	45.64	100.38	EC	La Roche
13	39CO9	Leavenworth	Arikara	45.67	100.36	DC	Hist. Arikara

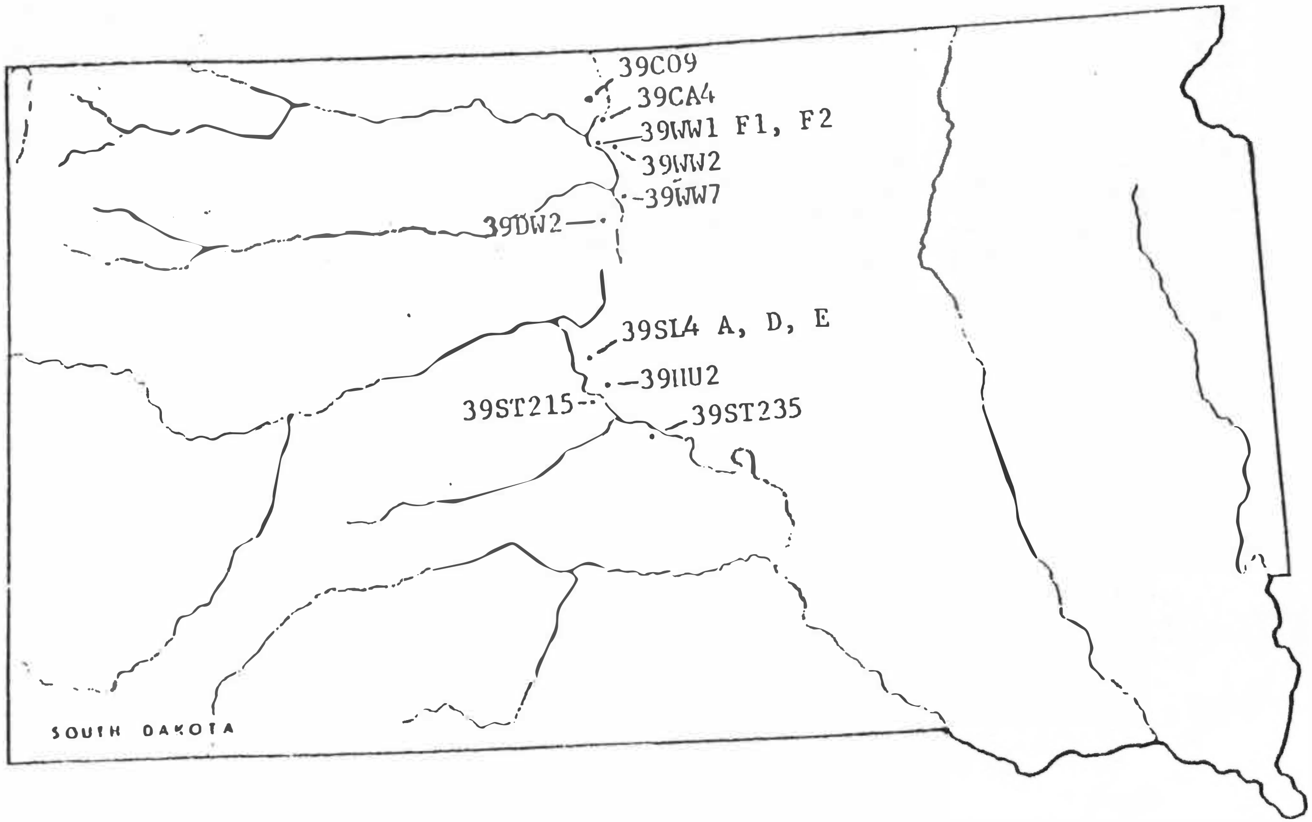

Figure 10. South Dakota Sites Yielding Skeletal Material

Table 2. Site Date Ranges and Dating Methods

Site Name	Date Range	Dating Method
Stony Point	1740-1795	Arch.
Mobridge F1	1600-1650	Arch.
Mobridge F2	1675-1700	Arch.
Larson	1679-1733	Arch.
Four Bear	1758-1774	Dend.
Sully A	1663-1694	Dend.
Sully D	1650-1675	Dend.
Sully E	1675-1700	Dend.
Leavitt	1740-1792	Arch.
Oahe Village	1675-1780	Arch.
Swan Creek	1675-1725	Arch.
Rygh	1600-1650	Arch.
Leavenworth	1802-1832	Hist.

Table 3. Innominate: Male and Female Sample Sizes by Site

Site	Male N	Female N	Total N
Stony Point	3	3	6
Mobridge F1	16	13	29
Mobridge F2	30	23	53
Larson	56	54	110
Four Bear	0	3	3
Sully A	5	7	12
Sully D	10	5	15
Sully E	6	1	7
Leavitt	2	1	3
Oahe Village	3	1	4
Swan Creek	1	2	3
Rygh	5	9	14
Leavenworth	21	12	33
TOTAL	159	134	292

Table 4. Articulated Pelvis: Male and Female Sample Sizes by Site

Site	Male N	Female N	Total N
Stony Point	1	0	1
Mobridge F1	10	7	17
Mobridge F2	16	11	27
Larson	29	32	61
Four Bear	0	2	2
Sully A	1	4	5
Sully D	4	2	6
Sully E	3	0	3
Leavitt	1	0	1
Oahe Village	2	0	2
Swan Creek	0	1	1
Rygh	2	4	6
Leavenworth	15	4	19
TOTAL	84	67	151

Table 5. Sacrum: Male and Female Sample Sizes by Site

Site	Male N	Female N	Total N
Stony Point	3	4	7
Mobridge F1	16	15	31
Mobridge F2	33	25	58
Larson	56	50	106
Four Bear	0	2	2
Sully A	3	6	9
Sully D	12	4	16
Sully E	8	3	11
Leavitt	1	1	2
Oahe Village	3	0	3
Swan Creek	0	2	2
Rygh	6	9	15
Leavenworth	28	15	43
TOTAL	169	136	305

Descriptive Statistics

The calculated means and standard deviations for all groups employed are presented in Tables B-1 through B-3, Appendix B. They are separated not only on the basis of site affiliation, but sex as well. The MEANS procedure in SAS (SAS Institute, Inc. 1979) was employed in the computations.

CHAPTER IV

ANALYTICAL METHODS

Principal Components Analysis with VARIMAX Rotation

A primary goal of the present analysis is to examine the nature of intragroup (within-group) variation in Arikara pelvic morphology. The usefulness of principal components analysis to examine such variation in various elements of the Arikara skeletal system has been recently demonstrated by Key (1979, 1982) and Key and Jantz (1981) for the cranium and Zobeck (1983) for the long bones, clavicle, and scapula. In all these studies, the principal components generated are viewed as defining patterns of intragroup variation in that they reflect "independent structural dimensions along which population differences can be assessed" (Key 1982:66). This does not necessarily mean to imply that the components reflect underlying genetic traits. Rather, as Key (1982) points out, they are at best mathematical approximations of them.

A detailed description of principal components analysis is beyond the scope of the present manuscript. However, for a more complete discussion of this technique the reader is referred to Harman (1976), Morrison (1967), and Mulaik (1972). In addition, an excellent discussion of the differences between factor analytic techniques and principal components analysis can be found in Zegura (1978).

Unlike "true" forms of factor analysis, in which the diagonal elements of the correlation matrix employed are estimated, principal components, in its most traditional sense, employs a total correlation matrix containing 1's in the diagonals. Primarily due to this as well as other differences (see Zegura 1978), there is considerable debate as to whether or not the correlated elements of the pattern matrix should be referred to as components or factors. Reviews of this controversy can be found in Zegura (1978) as well as Zobeck (1983). For the present analysis, the term "factor" will be employed to describe the structure of the rotated pattern matrices generated.

A great advantage of using principal components analysis is that the factors extracted effectively reduce a large battery of measurements to a smaller set of uncorrelated "variables" which, theoretically, can be interpreted in morphologically meaningful terms. According to Corruccini (1978), the interpretation of these new variables depends heavily upon the structure of the original data. As pointed out by Zobeck (1983), in the case of skeletal material, this would necessarily include functional as well as morphological considerations. Corruccini (1978), however, cautions that in order for principal components analysis, as well as other forms of multivariate analysis, to succeed in attaining its goal of reducing a large set of measurements to more meaningful components, the morphological and functional significance of the results must be clearly understood.

Extraction of factors from a pooled within-groups correlation matrix, rather than the more frequently utilized total correlation matrix, was employed in the present analysis. According to Key (1982) pooling Sum of Squares and Cross Product (SSCP) allows the contribution of each group to be assessed in terms of the sample sizes present. Zegura (1978) also discusses the advantages of using a "dispersion" matrix rather than the more traditional total correlation matrix. The use of a pooled within-groups correlation matrix was necessitated due to the inclusion of angles and linear measurements.

In order to extract the principal components from a pooled within-groups correlation matrix, the procedures outlined by Zobeck (1983) were employed. The steps outlined are:

> 1. For each group (with n > 5), by sex, a covariance matrix is calculated with the CORR procedure of SAS (SAS Institute, Inc. 1979). Sexes were calculated separately to reduce the effects of size. 2. The individual group covariance matrices are converted to Sums of Squares and Cross Product (SSCP) matrices and then summed to produce the pooled SSCP matrix with the MATRIX procedure of SAS (SAS Institute, Inc. 1979). 3. The within-groups standard deviations are extracted from the pooled SSCP matrix. The standard deviations are used in the calculation of individual component scores. 4. The pooled within-groups covariance matrix is converted into a pooled within-groups correlation matrix with the MATRIX procedure of SAS (SAS Institute, Inc. 1979) (1983:24-25).

The following degrees of freedom were employed for the three matrices extracted:

Sacrum	280
Articulated Pelvis	145
Innominate	284

Following the calculation of the pooled within-groups correlation matrix, the factors are extracted employing the FACTOR procedure (METHOD = PRIN) of SAS (SAS Institute, Inc., 1979). Harman (1976) outlines a variety of ways, all essentially subjective in nature, in which the number of factors extracted can be determined. In the present analysis, only those components with eigenvalues greater than 1.0 were retained. These factors were then rotated via the VARIMAX option in SAS (SAS Institute, Inc. 1979). The factors were then interpreted employing the technique suggested by Harman (1976).

As previously stated, the factors generated can be viewed as a new set of uncorrelated variables. As such, factor scores generated for each individual can be employed in further analyses. The factor scores employed in the present analysis were calculated with the SCORE procedure in SAS (SAS Institute, Inc. 1979). This procedure utilizes the previously calculated factor scoring coefficient matrix (a regression coefficient-type matrix) and the original data. The original data, however, are converted to z-scores with means of 0 and the previously calculated within-groups standard deviations. Factor scores are calculated by multiplying the z-scores by the factor score coefficient matrix. The resulting factor scores have a mean of 0 and standard deviation of 1. The scores generated were employed in all subsequent analyses. Sacral, articulated, and innominate data sets were analyzed separately.

Pooling the Sexes

Due to the extremely small sample sizes available for examination in some of the sites employed, the sexes were pooled to increase overall sample size. Prior to the pooling of the male and female samples, a comparison of the individual rotated factor pattern matrices was conducted to determine whether or not the factor structures obtained were comparable enough to allow the pooling of these two samples. To accomplish this, the following procedures were employed:

1. Initially, a rotated factor pattern matrix was generated for each sex for each data set employed, using the SAS (SAS Institute, Inc. 1979) subprogram FACTOR (METHOD = PRIN, MINEIGEN = 1.0 and VARIMAX rotation). Three and 13 factors were retained for both sexes in the sacral and disarticulated data sets, respectively. In the articulated data set, however, the number of male factors extracted was 10, while only seven were retained for the female sample.

2. A comparison of the resulting rotated factor matrices (designated as Matrix A and Matrix B) for males and females for each data set was conducted employing RELATE, a FORTRAN program (Veldman 1967). This program is designed to compare factor structures with orthogonal axes, as in principal components analyses, and requires that the number of variables in each matrix be the same as well as being arranged in the same order. The number of factors in each matrix, however, may vary. A matrix of cosines among the factor vectors of the two structures (A and B) is computed. In essence, they represent the maximum contiguity between the vectors.

> After printing, the cosine matrix is premultiplied by the original B matrix, which effectively rotates its factor

axes to the position that produces maximum contiguity between the two sets of corresponding vectors (Veldman 1967:240).

3. Interpretation of the matrix representing maximum contiguity, new Matrix B, follows. The salient loadings and corresponding variables are then compared to the structure of the original, unaltered A matrix. In the case of all three data sets, comparisons revealed that the structure similarity noted between the male and female matrices was great enough to warrant pooling. There were no a priori reasons to expect the factor structures to differ.

Multiple Regression Analysis

The second primary goal of this analysis is to identify any patterns of intergroup variation which may be present in the data. The factor scores are employed. Therefore, an attempt is made to delineate along which factors, if any, the groups examined differ. The exploration of intergroup variation is conducted at two levels. First, employing median site date, an attempt is made to identify temporal patterning. Second, the sites are grouped according to archaeological temporal variant to examine whether differences could be potentially attributed to the cultural and environmental changes associated with each variant.

Multiple regression analysis is the statistical tool chosen to explore the relationship between median site date and the factors. Multiple regression is a statistical procedure in which a single criterion variable is predicted from a set of predictor variables. The single criterion or dependent variable in the present analysis is median site date, while the factors represent the predictor or independent variables. Therefore, the general model employed for the sacral, articulated pelvis, and innominate data sets is:

Median Site Date = Factor Scores

The total sums of squares (SST) or variability in the dependent variable may be partitioned into two components. These are: (1) the sums of squares regression (SS_{reg}) which is the amount of variance accounted for by the regression line, and (2) the sums of squares residual (SS_{res}) or the amount of unexplained variance. The ratio of the SS_{reg} to the SS_{tot} is the multiple correlation coefficient or r^2 and represents "the proportion of the variance of the criterion variable that is 'explained' by the predictors, in the sense that it is predictable" (Veldman 1967:281).

Testing the predictability or the overall test of goodness of fit of the regression model is accomplished through an examination of the F value. The null hypothesis that the population multiple correlation is equal to zero is tested. In other words,

> the test indicates whether the (assumed random) sample of observations being analyzed has been drawn from a population in which the multiple correlation is equal to zero, and that any observed multiple correlation is due to sampling fluctuation or measurement error (Nie et al. 1975:335).

The F value is computed by dividing the mean square model by the mean square error (SAS Institute, Inc. 1979). An examination of the univariate F tests indicates those factors, if any, deemed as significant contributors to the amount of explained variance accounted for in the model.

The SAS (SAS Institute, Inc. 1979) procedure GLM was employed to perform the necessary computations. The general model mentioned above was utilized. For a more complete discussion of multiple regression analysis, the following sources are recommended: Neter and Wasserman (1974), Nie et al. (1975), Tatsuoka (1971), and Veldman (1967).

Multiple Analysis of Variance

In an attempt to further identify along which factors intergroup variation occurs, a multiple analysis of variance (MANOVA) was conducted. Unlike the previously discussed regression analysis, the grouping variable employed is temporal variant. In addition, to further reduce the effects of size differences in the male and female samples, the factor scores for each sex were standardized according to the mean score for each component by sex. The SCORE procedure in SAS (SAS Institute, Inc. 1979) with MEAN = 0 was employed.

A MANOVA calculates the amount of overall heterogeneity present for each treatment. The treatments employed are Group, Sex, and their Interaction. The Group treatment measures the amount of group heterogeneity present in the factors employed, while the Sex treatment measures the overall degree of sexual dimorphism expressed. The Interaction effect assesses the degree of sexual dimorphism expressed in each group and tests whether a difference in the magnitude of sexual dimorphism exists between the groups considered.

In addition to the overall tests mentioned above, MANOVA also indicates, by way of analysis of variance (ANOVA), along which factors the effect heterogeneity occurs. The following general model was employed in all two-way MANOVAs calculated:

Factor Scores = Group + Sex + Interaction

Due to the unequal sample sizes, the design in each of the analyses conducted is unbalanced. As such, Type IV sums of Squares were employed, due to their conservative nature, as tests of significance in the univariate ANOVAs.

For a more detailed, mathematical discussion of MANOVA, the reader is referred to Morrison (1967) and Tatsuoka (1971).

CHAPTER V

RESULTS

Principal Components Analysis

Sacral Factors

Three factors with eigenvalues greater than 1.0 were extracted from the sacral pooled within-groups correlation matrix. These factors account for 70% of the total variance present. The percentage of variance accounted for by each factor, both pre- and post-roational, is presented in Table 6. Following is a description of the rotated factor pattern matrix. The lowest salient loading, 0.5688, was obtained for basal width (BWD) on Factor I.

I. Sacral curvature. This factor accounted for 24.1% of the total variance present in the sample and appears to measure the size of the sacral angle. The highest loading obtained was on sacral curvature angle (SCA). A high negative loading on sacral subtense (SBT) does not contradict the above interpretation. This variable measures the depth from the transverse axis of the sacrum. The greater this depth, the smaller the angle of sacral curvature. Low factor scores on this factor would be indicative of sacra exhibiting more oblique angles of sacral curvature, and, therefore, less curved sacra. Salient loadings, presented in order of magnitude, are:

SCA	0.8371
SBT	-0.8036
BWD	0.5688

Table 6. Sacra: Pre- and Postrotational Percentages of Total Variance Accounted for by Each Factor

Eigenvalue Number	Prior to Rotation: λ Value	Prior to Rotation: % Total Variance	After Rotation: λ Value	After Rotation: % Total Variance
I	1.70	30.4	1.54	24.1
II	1.37	24.0	1.28	22.5
III	1.10	15.6	1.25	22.4

II. Anteroposterior and transverse dimensions of the first sacral vertebra. This was the second largest factor, accounting for 22.5% of the total sample variance. High correlations with this factor were obtained for three variables. Two of these variables, anterior straight breadth (ABS) and the transverse diameter of S1 (TRS), reflect the transverse dimensions of the first sacral vertebra. The third, anteroposterior diameter of S1 (APS), measures the anteroposterior dimensions of this element. High factor scores would, therefore, be indicative of sacra that exhibit overall larger first sacral vertebra. Salient loadings are:

ABS	0.7448
TRS	0.6847
APS	0.6779

III. Sacral length. This factor accounts for 22.4% of the total variance present in the sacral data. The two variables most highly correlated with this factor, mid-ventral straight length (MVS) and sacral fraction (SFC) both reflect the length of the sacrum. High factor scores would, therefore, be associated with longer sacra. Salient loadings are:

MVS	0.8787
SFC	0.7609

<u>Articulated Pelvis Factors</u>

Eight factors, accounting for 81.4% of the total variance present in the articulated data, were extracted which had eigen-values greater than one. Pre- and post-rotational percentages of variance accounted for by each factor are presented in Table 7. Following is a description of the rotated factor pattern matrix.

I. <u>Transverse and oblique dimensions of the pelvis above the midpelvis.</u> This factor accounted for 19.4% of the total variance present in the articulated pelvis sample.

Of the nine variables highly correlated with this factor, four measure the transverse dimensions of either the false pelvis or the pelvic inlet. Bicristal breadth (BCB) and interspinous diameter (ISD) reflect the transverse diameter of the false pelvis, while the greatest breadth of the inlet (GBI) and transverse diameter of the pelvic brim (TDB) reflect the horizontal dimensions of the pelvic inlet. Oblique dimensions of the false pelvis are reflected by: anterior superior spine to superior symphysis (ASS), anterior superior spine to midventral promontory (ASV), and anterior inferior spine to the midventral promontory (AIS). Oblique diameter of the

Table 7. Articulated Pelvis: Pre- and Postrotational Percentages of Total Variance Accounted for by Each Factor

Eigenvalue Number	Prior to Rotation		After Rotation	
	λ Value	% Total Variance	λ Value	% Total Variance
I	7.46	21.9	6.74	19.4
II	5.25	15.5	4.39	12.9
III	4.02	11.8	3.29	9.7
IV	3.75	11.0	3.58	10.8
V	2.50	7.4	3.00	8.7
VI	1.86	5.5	2.33	7.2
VII	1.61	4.7	2.22	7.1
VIII	1.20	3.5	2.13	6.3

pelvic brim measures the oblique dimension of the pelvic inlet. The exact relationship of pubic fraction (PFR) to the above mentioned variables is at present unknown. High scores on this factor would be indicative of pelves with greater transverse and oblique dimensions of the false pelvis and pelvic inlet. Highest loadings are:

BCB	0.8442
ISD	0.8341
GBI	0.8330
TDB	0.8193
ASS	0.7657
AIS	0.7530

ASV	0.7136
OBD	0.6851
PFR	0.6329

II. Transverse capacity of the midpelvis. This factor accounts for 12.9% of the total sample variance. Salient loadings were obtained for four variables. In combination, these variables appear to reflect the transverse capacity of the midpelvis as measured at the level of the ischial spines. The highest loading was obtained for midpelvis angle (MPA). This variable also appears to reflect subpubic angle. A high negative loading for angle of the inferior pubis at the level of the ischial spine (SPA) does not contradict the above interpretation. A lesser degree of inferior pubic angulation corresponds with a more oblique midpelvis angle and therefore a wider midpelvis and greater subpubic angle. The remaining two variables highly correlated with this factor are bispinous diameter (BSD) and intertuberal diameter (ITD). High factor scores indicate midpelves with greater transverse volume or capacity at the level of the ischial spines. Salient loadings include:

MPA	0.9106
SPA	-0.9060
BSD	0.9044
ITD	0.6432

III. Flare of the iliac blade. This was the third largest factor, accounting for 9.7% of the total variation present. Both variables highly correlated with this factor are angles and appear to reflect the flare of the iliac blade or the degree to which the ilium encroaches upon the false pelvis. The highest loading was obtained for the iliac angle at the level of the anterior superior spine (ISA). A slightly lower loading was obtained for the iliac angle at the level of the anterior inferior spine (IIA). High factor scores are indicative of pelves with greater iliac flare. Salient loadings are:

ISA	0.9207
IIA	0.8233

IV. Antero-posterior dimensions of the pelvic inlet. This factor accounted for 10.8% of the total variance present in the articulated pelvis sample. The variables most highly correlated with this factor, true conjugate diameter (TCD) and obstetric conjugate diameter (OCD), appear to clearly reflect the antero-posterior dimensions of the pelvic inlet. High factor scores would indicate greater antero-posterior diameters of the pelvic inlet. Salient loadings include:

TCD	0.9179
OCD	0.9040
AIV	0.5852

V. Anteroposterior capacity of the midpelvis. This factor accounts for 8.7% of the total variance present. Four variables exhibit high factor correlations. All appear to reflect the degree to which the sacrum encroaches upon the midpelvis. High loadings were obtained for the midpelvis sacral angle (MSA) and the ischial spine posterior angle (IPA). Ischial spine to mid-basal sacrum (JOB) and the anteroposterior diameter of the pelvic outlet (APO) expressed moderate correlations with this factor. High scores on this component would be indicative of pelves which express a lesser degree of sacral encroachment upon the midpelvis and therefore, greater anteroposterior capacity. Highest loadings are:

MSA	0.9644
IPA	-0.9646
JOB	0.7276
APO	0.6821

VI. Prominence of the ischial spines. This was the sixth largest factor, accounting for 7.2% of the total sample variance. Ischial spine subtense (ISB) and the pelvic outlet angle at the ischial spines (POS) expressed the highest factor loadings. A smaller factor correlation was obtained for the ischial tuberosity subtense (ITB). All variables appear to reflect the prominence of the ischial spine. The ischial spine subtense measures the distance between the most medial projection of the ischial spine and that point in the acetabulum where the three elements of the innominate unite. A higher, but negative, loading for OSA does not contradict this interpretation. The greater the acetabulum-spine distance, the smaller the pelvic outlet angle at the spines. High factor loadings would, therefore, be associated with pelves with greater ischial spine prominence. Salient loadings are:

ISF	0.9399
OSA	-0.9023
ITF	0.5038

VII. Shape of the pelvic outlet at the level of the ischial tuberosities. Although this factor contains a considerable amount of shape information, the size element has not been totally eliminated. This factor accounts for 7.1% of the total variance present and appears to reflect the shape of the pelvic outlet as well as biacetabular breadth. The angle of the pelvic outlet (POA) expressed the highest correlation with this factor. A slightly smaller loading was obtained for biacetabular breadth (ACC). High factor scores would be indicative, therefore, of pelves with not only wider pelvic outlets but with greater interacetabular distance as well. Salient loadings are:

POA	0.8273
ACC	0.8224
PIA	0.4622

VIII. Distance of the ischial spine from the transverse axis of the acetabular chord. This factor accounts for 6.3% of the total sample variance. A moderate factor loading was obtained for the ischial spine subtense (ISS). This variable measures the distance of the ischial spine from the transverse axis of the acetabular chord. A small, but salient, loading was obtained for the pubic symphysis subtense. High factors scores would, therefore, be obtained for specimens which exhibit a greater depth of the ischial spine as measured from the transverse axis of the acetabular chord. Salient loadings are:

ISS	0.7172
PSB	0.4756

Innominate Factors

Thirteen factors with eigenvalues greater than 1.0 were extracted from the innominate pooled within-groups correlation matrix. Together, these components account for 78.5% of the total variance present in the sample. The percentage of variance accounted for, before and after rotation, by each factor is presented in Table 8. Following is a description of the rotated factor pattern matrix.

I. Pubic curvature. This factor accounts for 14.3% of the total variance present in the innominate data set. Two angles, superior iliac angle (SIA) and auricular-iliac angle (AIA), are highly correlated with this factor. Both variables appear to reflect the shape of the pubis bone. In each case a more antero-medial extension of the pubis would result in more oblique angles and therefore greater capacity of the fore pelvis. A smaller, but salient, loading was obtained for symphysis to posterior superior

Table 8. Innominate: Pre- and Postrotational Percentages of Total Variance Accounted for by Each Factor

Eigenvalue Number	Prior to Rotation		After Rotation	
	λ Value	% Total Variance	λ Value	% Total Variance
I	13.72	26.9	6.91	14.3
II	4.09	8.0	3.83	7.6
III	3.48	6.8	4.06	8.0
IV	2.93	5.7	3.77	7.4
V	2.45	4.8	2.36	5.4
VI	2.05	4.0	2.01	4.0
VII	1.91	3.7	1.88	3.7
VIII	1.66	3.3	3.08	6.0
IX	1.58	3.1	2.36	4.6
X	1.36	2.7	1.64	3.2
XI	1.31	2.6	1.77	3.4
XII	1.28	2.5	1.61	3.1
XIII	1.13	2.2	3.65	7.1

spine (SPS). High scores on this factor would be indicative of innominates expressing greater antero-medial curvature of the pubis. Highest loadings are:

SIA	0.8675
AIA	0.8024
SPS	0.5833

II. Anterior border breadth. This was the second largest factor, accounting for 7.6% of the total sample variance. Three variables are highly correlated with this factor. These include: anterior border breadth (ABB), acetabulum to anterior superior spine (AAS), and symphysis to anterior superior spine (SAS). All variables appear to reflect the width of the anterior border. Therefore, high factor scores would be associated with wider anterior borders. Salient loadings are:

ABB	0.8779
AAS	0.7385
SAS	0.6292

III. Curvature of the iliac blade. This factor is comparable to Factor III of the articulated pelvis rotated factor pattern matrix and accounts for 8.0% of the total variance present. Salient loadings were obtained for iliac flare angle at the level of the anterior superior spine (IFA), iliac flare angle at the level of the anterior inferior spine (AIA), maximum width of the innominate (MXW), and superior iliac breadth (SBB). These variables appear to reflect the flare of the iliac blade and therefore the overall size of the false pelvis. High factor scores would be indicative of more curved or flared ilia. Salient loadings include:

IFA	0.8331
AFA	0.7466
MXW	0.6094
SBB	0.6093

IV. Lower iliac height. This factor accounts for 7.4% of the total variance present in the sample. The highest salient loading was obtained for lower iliac height (LOH). Slightly lower correlations with this factor were obtained for four other variables. Together with LOH, these measurements present a clear picture of lower iliac height. High factor scores would be indicative of the specimens with greater lower iliac height. Salient loadings include:

LOH	0.7611
RAB	0.7218
RAI	0.7175
RSN	0.6142
RAS	0.5729

V. Pubic shape. This was the fifth largest factor, accounting for 5.4% of the total sample variance. Salient loadings were obtained for two variables, PAA (pubic angle) and MNW (minimum ilial width). PAA reflects the shape of the pubic bone. The relationship between this variable and MNW is at present not completely understood. However, high factor scores would be indicative of innominates with smaller minimum ilial width and more extended pubic bones. Greater extension of the pubis would seemingly result in an increase in the capacity of the fore pelvis. Highest loadings are:

PAA 0.9207

MNW -0.6813

VI. Anterior border shape. This factor accounts for 4.0% of the total sample variance and appears to reflect the shape of the anterior border. Two variables, anterior border subtense (AST) and anterior border angle (ABA), were highly correlated with this factor. The former measures the maximum depth of the anterior border. A high, but negative, loading for anterior border angle indicates that as the depth of this structure increases, the angle becomes more acute. Therefore, high factor scores would be indicative of specimens with deep, narrow, anterior borders. Salient loadings include:

AST 0.9400

ABA -0.9274

VII. Pubis length. All variables highly correlated with this factor clearly reflect pubis length. This factor accounts for 3.7% of the total variance present in the sample. The highest salient loading was obtained for pubis length (PLG). Smaller, but salient, loadings were also obtained for symphysis to acetabular border (SAC), symphysis to midsciatic notch (SMS), maximum ischio-pubic diameter

(IPD), symphysis to anterior superior spine (SAS), symphysis to inferior ischial tuberosity (SIT), symphysis to auricular surface (SAR), maximum height of the innominate (MXH) and ischial length (ILG). This factor along with factors III and V appear to ultimately reflect the overall capacity of the fore pelvis. High factor scores are associated with longer pubes and fore pelves of greater capacity. Salient loadings are:

PLG	0.8224
SAC	0.7524
SMS	0.7477
IPD	0.7081
SAS	0.7007
SIT	0.6785
SAR	0.5801
MXH	0.5194
ILG	0.4650

VIII. Length of the auricular surface. A total of 6.0% of the total sample variance is accounted for by this factor. All variables with salient loadings reflect the length of the auricular surface. The highest loadings were obtained for auricular surface to posterior inferior spine (RPI) and maximum length of the auricular surface (MXA). High factor scores would, therefore, be indicative of innominates with "longer" auricular surfaces. Highest loadings are:

RPI	0.9021
MXA	0.7481
API	0.6770
RPS	0.6763
IFB	0.6737
APS	0.4011

IX. Upper iliac height. This was the ninth largest factor, accounting for 4.6% of the total variance present. Six variables were deemed as having salient factor loadings. The correlation of three of these variables, upper iliac height (UPH), acetabulum to anterior superior spine (AAI), and direct iliac height (DRH), with this factor are relatively high. These measurements appear to reflect the height of the upper portion of the iliac blade. High factor scores would be indicative of pelves with greater upper iliac height. The remaining three variables, however, do not appear to be related to this dimension. The factor loadings for these measurements are somewhat smaller in magnitude in comparison to the above mentioned variables. Salient loadings are:

UPH	0.6760
AAI	0.6263
DRH	0.5793
DAC	0.5545
ACD	0.4446
SYH	0.4108

X. Uninterpretable. High factor correlations were obtained for two variables, sciatic notch subtense (SCT) and anterior border fraction (AFC). The former measures the maximum depth of the sciatic notch, while AFC is that distance along the length of the anterior border that the maximum depth is recorded. The morphological relationship between these two variables is, unfortunately, at present unclear. This factor, however, accounts for 3.2% of the total variance present in the sample. Highest loadings are:

SCT 0.8347

AFC 0.6199

XI. Obturator foramen size. All three variables highly correlated with this factor clearly reflect the overall size, both width and height dimensions, of the obturator foramen. This factor accounts for 3.4% of the total sample variance. The middle width of the pubic ramus (WPR) expresses a moderately high negative factor loading. This does not, however, contradict the above interpretation. A larger value for this measurement would seemingly result in smaller values for obturator height. High factor scores would seem to reflect large obturator foramen dimensions coupled with smaller values for the middle width of the pubic ramus. Salient loadings include:

OBW 0.7078

OBH 0.6751

WPR -0.5465

XII. Ischio-pubic shape. This factor accounts for 3.1% of the total variance present in the sample. However, only one variable, ischio-pubic angle (IPA) was highly correlated with this factor. This is not surprising given the low communality estimate calculated for this variable. Based on the above results, the removal of this variable from subsequent analyses is recommended. Salient loading for the ischio-pubic angle is 0.9091.

XIII. Sciatic notch size and shape. This factor accounts for 7.1% of the total sample variance and clearly reflects not only the shape, but also the size of the sciatic notch. Two variables, sciatic notch breadth (SNB) and sciatic notch angle (SNA) were highly correlated with this factor. High factor scores would be indicative of wider sciatic notches with a more oblique sciatic notch angle. Highest loadings are:

SNB	0.8270
SNA	0.7799

In summary, three, eight, and thirteen factors with eigenvalues greater than 1.0 were extracted from pooled within-groups correlation matrices to describe the sacrum, articulated pelvis, and innominate, respectively. In all three data sets, a considerably large percentage of the factors derived appear to consist of interpretable, morphologically meaningful structures. Employing the component score coefficient matrix and the original data, factor scores for each specimen in the analysis were generated. These scores are utilized in all subsequent analyses.

In order to examine the relationship of intragroup patterns of variation to intergroup variability, the factor scores were analyzed at two levels. Employing site date as the dependent variable, a multiple regression analysis was conducted to determine whether or not any temporal patterning could be identified. To further examine along which factors the intergroup variation noted in the regression analysis occurred, a multivariate analysis of variance (MANOVA) employing the factor scores as dependent variables was conducted. Sites were grouped according to temporal variant (i.e. Extended Coalescent, Post-Contact Coalescent, and Disorganized Coalescent).

Multiple Regression Analysis

As in the principal components analysis, the sacral, articulated pelvis and innominate data sets were analyzed separately. The SAS (SAS Institute, Inc. 1979) subprogram GLM was employed to perform the necessary calculations. Midpoint values for the site data ranges were regressed on the factor scores. The site date ranges as well as the midpoint values employed are presented in Table 9. The following general model was utilized:

Median Site Date = Factor Scores

Sacra

A total of 305 sacra were employed in the analysis. The overall multiple regression results for the sacra examined are presented in Table 10. An examination of these results indicates that no significant difference in site variation could be delineated

Table 9. Site, Date Ranges, and Midpoint Values Employed in the Regression Analysis

Site	Date Range	Midpoint Value
Rygh	1600-1650	1625.0
Sully A	1663-1694	1662.5
Sully D	1650-1675	1662.5
Mobridge 1	1600-1650	1625.0
Leavitt	1740-1792	1766.0
Stony Point	1740-1795	1767.5
Oahe Village	1675-1780	1727.5
Four Bears	1758-1774	1766.0
Swan Creek	1675-1725	1700.0
Larson	1679-1733	1706.0
Sully E	1675-1700	1687.5
Mobridge 2	1675-1700	1687.5
Leavenworth	1802-1832	1817.0

Table 10. Sacral Overall Multivariate Regression Results

Model Sum of Squares	F Value	PR > F	R-Square
6033.91	0.64	0.5917	0.0064

employing median site date as the dependent variable. Therefore, it can be concluded that temporal patterning in sacral dimensions, as described by the factor scores, is not detectable. Only 0.64% of the variance present in median site date could be explained in terms of the three sacral factors employed. Univariate regression results are presented in Table 11. Due to the extremely small percentage of variance accounted for by the sacral factors, the sacrum was excluded from all subsequent analyses.

Articulated Pelves

A total of 151 articulated pelvic specimens was employed in the analysis. Overall multiple regression analysis results are presented in Table 12. An examination of these results reveals that, unlike the sacra, a significant relationship exists between site date and the factor scores employed. A total of 18.68% of the variation present in median site date can be explained in terms of the factors examined. Univariate regression results are shown in Table 13. Four factors (Factors II, V, VI, and VII) contributed to the temporal patterning noted. Mean factor scores for all significant factors are presented in Table 14. Mean factor scores

Table 11. Sacrum: Univariate Regression Results

Factor	Type IV SS	F Value	PR > F
I	118.88	0.04	0.84
II	5863.66	1.88	0.17
III	1.38	0.00	0.98

Table 12. Articulated Pelvis: Overall Multiple Regression Results

Model Sum of Squares	F Value	PR > F	R-Square
79690.99	4.08	0.0002	0.1868

plotted against site date midpoint values for each factor are illustrated in Figures 11 through 14. Following is a description of the temporal trends observed for each factor deemed as contributing to the patterned variation noted.

Factor II. This factor has been previously described as relating to the overall capacity or volume of the midpelvis as measured at the level of the ischial spines. An examination of the results presented in Table 14 for this factor and those illustrated in Figure 11 reveals that an overall decrease in mean factor score through time can be observed. Low factor scores were previously interpreted as being indicative of pelves with greater transverse midpelvis capacity. In other words, the pelves representing earlier

Table 13. Articulated Pelvis: Univariate Regression Results

Factor	Type IV SS	F Value	PR > F
I	6217.49	2.54	0.11
II	33161.24	13.57	0.00
III	408.04	0.17	0.68
IV	204.53	0.08	0.77
V	10381.31	4.25	0.04
VI	9966.04	4.08	0.04
VII	13169.67	5.39	0.02
VIII	12.50	0.01	0.94

Arikara sites have smaller transverse midpelvis volumes than those from the later sites. A gradual overall decrease in mean factor score was noted. It should be pointed out, however, that the Oahe village sample presents a lower than expected mean factor score. The extremely small sample size employed may have been the primary contributor to this unexpected result. Only two specimens were included in this sample.

Factor V. As can be seen in Figure 12 and Table 14, an overall increase through time in mean factor score for this factor is evident. This trend is consistent for all sites except Stony Point, Leavitt, and Four Bear. The sample of articulated specimens in each of these sites is very small. High factor scores were

Table 14. Articulated Pelvis Regression: Mean Factor Scores for Significant Factors

Site	Median Date	Factor II	Factor V	Factor VI	Factor VII	N
Rygh, M01	1625.0	0.7986	-0.3557	0.6453	-0.8108	23
Sully A, D	1662.5	0.6989	0.0844	0.6614	-0.3640	9
Sully E, M02	1687.5	-0.0451	-0.1044	-0.0406	0.0059	30
Swan Creek	1700.0	0.0169	-0.6235	-0.7904	0.6277	5
Larson	1706.0	0.3420	0.0531	-0.3397	0.2420	61
Oahe Village	1727.5	-1.2475	1.2100	1.0572	0.7113	2
Leavitt, Four Bears	1766.0	0.0305	-0.5011	0.4752	0.6589	3
Stony Point	1767.5	-1.4012	0.8185	1.3064	-0.3686	1
Leavenworth	1817.0	-1.2525	0.3778	0.1245	0.0673	19

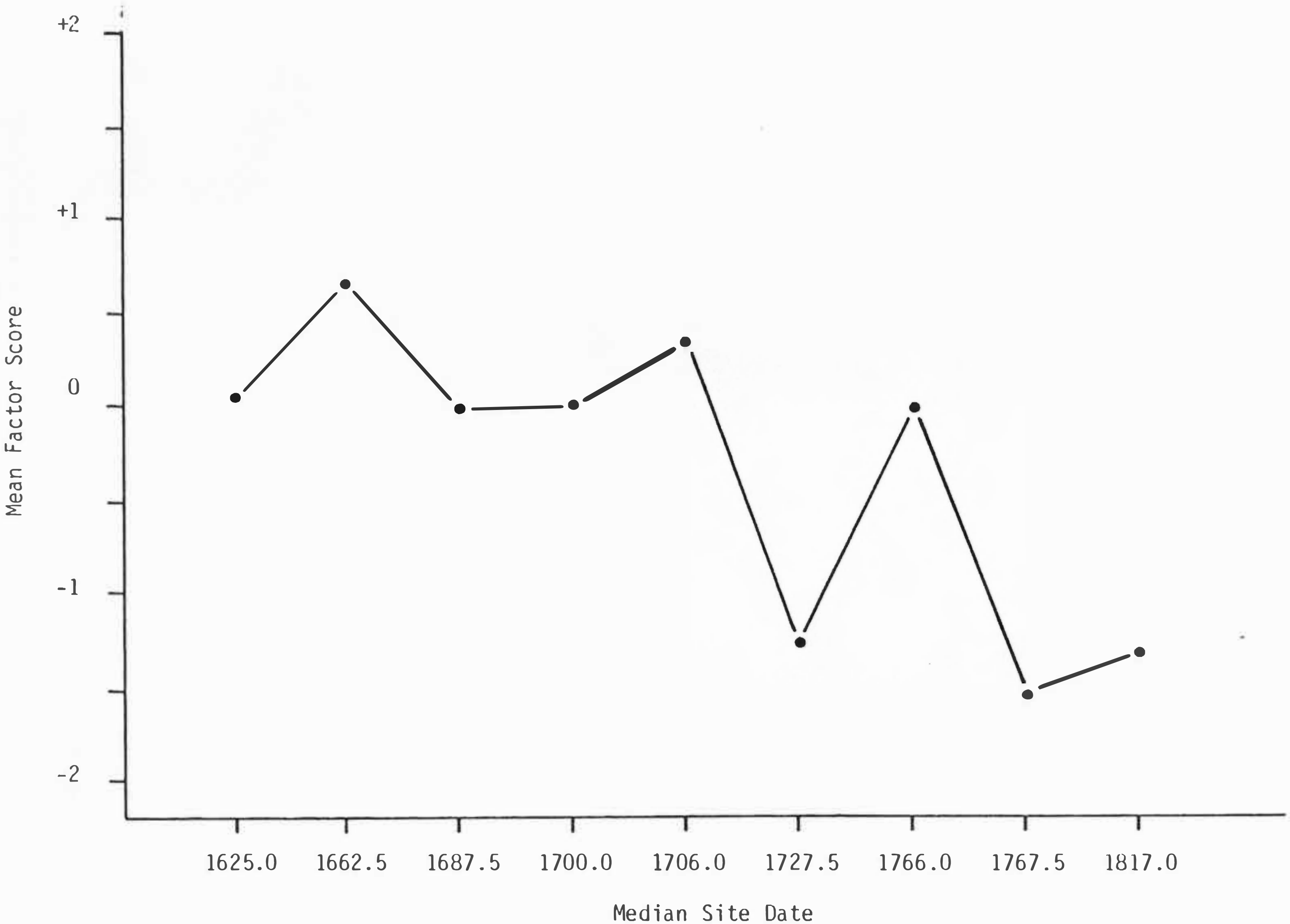

Figure 11. Articulated Pelvis--Factor II: Mean Factor Score Plotted Against Median Site Date

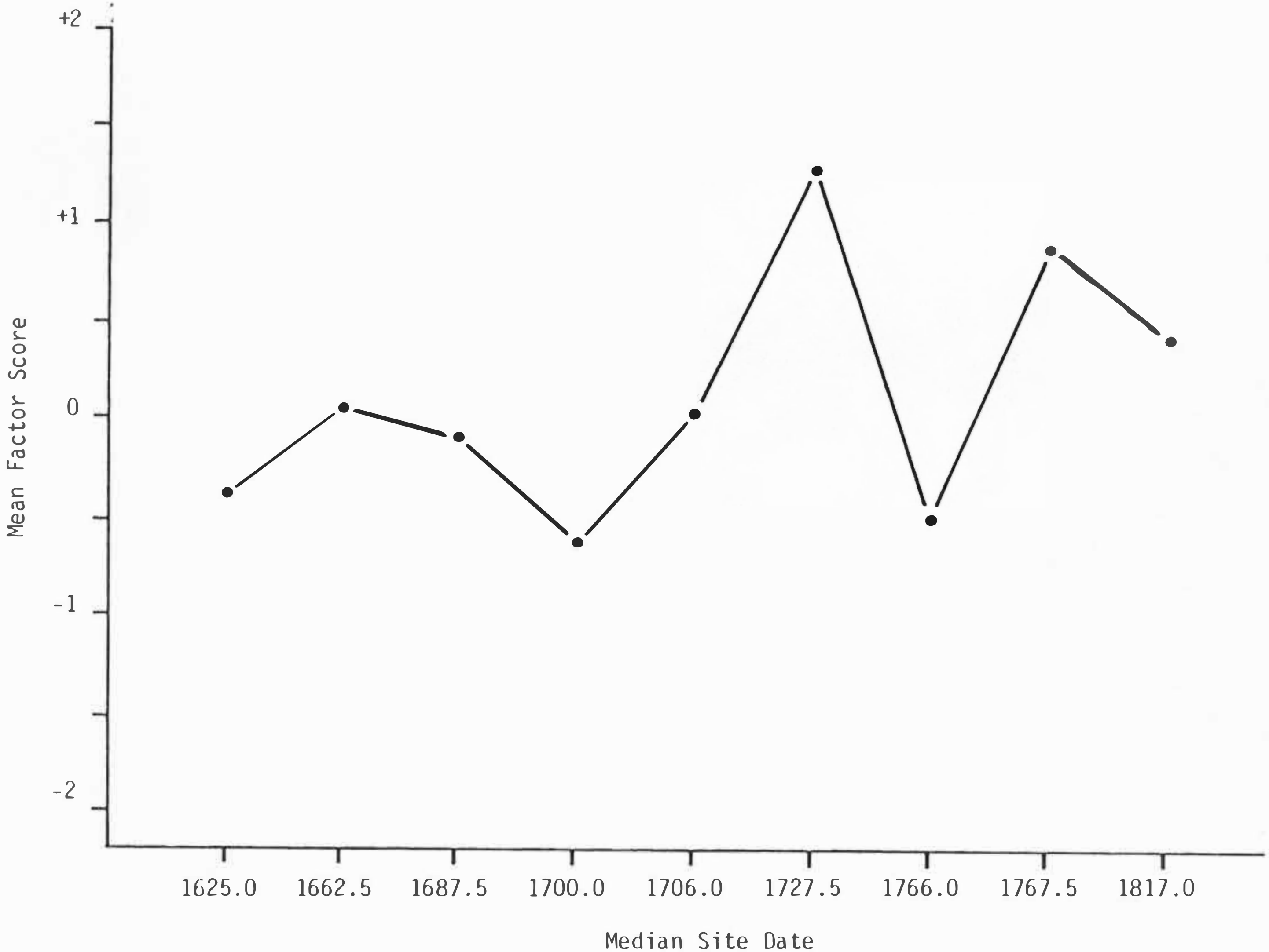

Figure 12. Articulated Pelvis--Factor V: Mean Factor Score Plotted Against Median Site Date

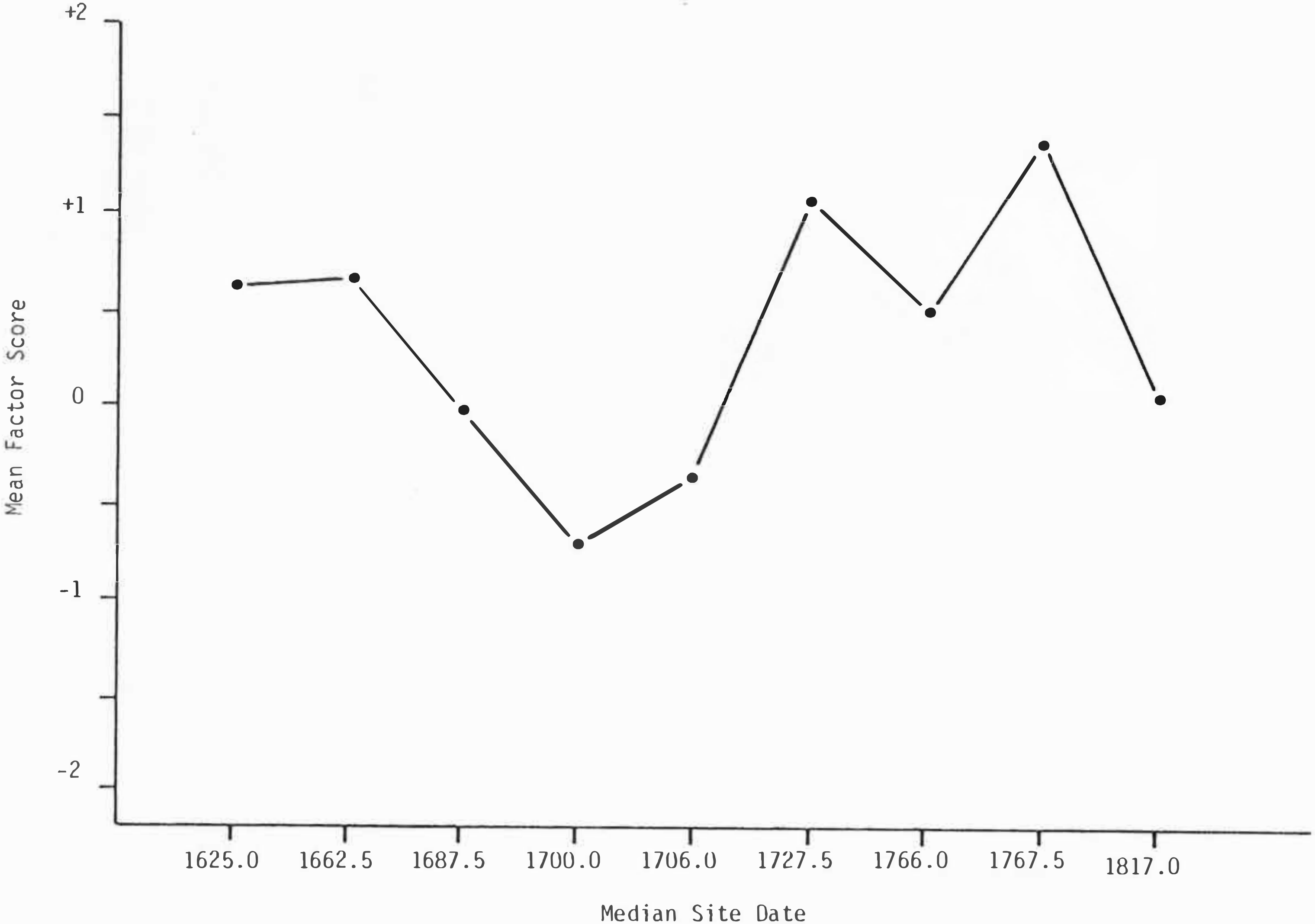

Figure 13. Articulated Pelvis--Factor VI: Mean Factor Score Plotted Against Median Site Date

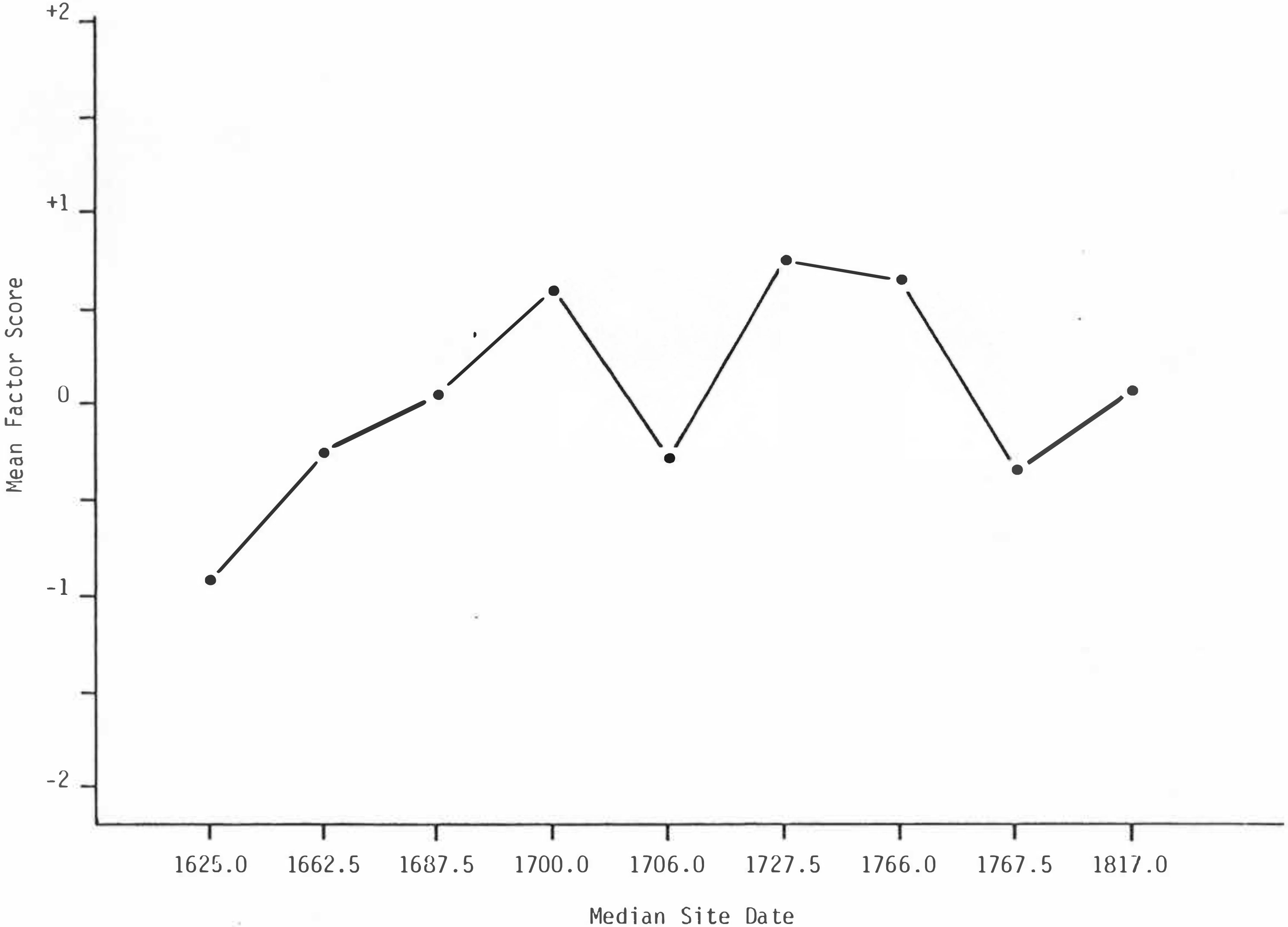

Figure 14. Articulated Pelvis--Factor VII: Mean Factor Score Plotted Against Median Site Date

identified as being indicative of pelves in which a lesser degree of sacral encroachment upon the midpelvis is observed. These pelves would, therefore, exhibit greater anteroposterior midpelvis capacities, while those specimens from later sites exhibit comparably less midpelvis volume in this dimension.

Factor VI. This factor was previously described as reflecting the prominence of the ischial spine. An examination of the results presented in Table 14, page 76, and Figure 13 reveals that an overall increase in mean factor scores for this factor can be noted. This trend is not as clear cut as those described previously. There appears to be a decrease in mean score evident in those sites representing the earliest portion of the Post Contact Coalescent. There is a subsequent increase and a stabilization observed for those later sites included in the analysis. The lowest mean factor score was obtained for Swan Creek. It should be pointed out, in those sites representing this time period, the number of articulated pelves available for measurement was quite low.

High factor scores for this component were previously described as being indicative of pelves which exhibit greater ischial spine prominence. Therefore, given the temporal trend noted above, this dimension is reduced in earlier Arikara sites when compared to those from later sites.

Factor VII. An examination of the results presented in Table 14 and Figure 14 reveals an overall temporal increase in the mean factor score for this factor. This factor was previously described as reflecting the shape of the pelvic outlet. High factor scores were interpreted as being indicative of pelves with wider pelvic outlets. Given the above, it can be concluded, therefore, that the width of the pelvic outlets of the later Arikara is greater than their earlier counterparts.

In summary, shape changes in the Arikara articulated pelvis have been noted. More importantly, there appears to be temporal patterning in the variation present. Earlier sites can be described as having more narrow, but longer midpelves and less wide pelvic outlets than the later Arikara groups examined. In addition, the degree to which the ischial spines project in the former is less than that observed in the later groups.

Innominate Analysis

Temporal patterning in innominate factor score variation can also be observed. In contrast with the articulated data set, only two factors, Factor I and Factor IX, were delineated as contributing to the observed patterned variation in site data. The overall multiple regression results for the 292 innominates examined are presented in Table 15. A total of 7.92% of the variation in pelvic morphology defined by site data can be explained in terms of the factors employed. Univariate regression results are shown in Table 16. Mean factor scores for Factors II and IX are presented in Table 17. Mean score plotted against median site date for Factors I and IX are illustrated in Figures 15 and 16, respectively.

Table 15. Innominate: Overall Multiple Regression Results

Type IV Sum of Squares	F Value	PR > F	R-Square
62995.12	1.84	0.037	0.0792

Table 16. Innominate: Univariate Regression Results

Factor	Type IV SS	F Value	PR > F
I	14040.45	5.33	0.02
II	920.31	0.35	0.55
III	508.93	0.19	0.66
IV	5256.51	2.00	0.16
V	529.73	0.20	0.65
VI	1048.39	0.40	0.53
VII	0.20	0.00	0.99
VIII	73.59	0.03	0.87
IX	29517.31	11.21	0.00
X	2818.50	1.07	0.30
XI	1728.63	0.66	0.42
XII	173.39	0.07	0.80
XIII	1506.66	0.57	0.45

Table 17. Innominate Regression: Mean Factor Scores for Significant Factors

Site	Median Date	Factor I	Factor IX	N
Rygh, M01	1625.0	-0.1818	0.5430	42
Sully A, D	1662.5	0.0410	-0.2620	27
Sully E, M02	1687.5	-0.1612	0.0128	61
Swan Creek	1700.0	-0.1203	-0.7252	3
Larson	1706.0	0.0343	0.4196	110
Oahe Village	1727.5	-0.4147	-1.0071	4
Leavitt, Four Bears	1766.0	-0.1170	-0.5054	6
Stony Point	1767.5	1.0312	-0.3247	6
Leavenworth	1817.0	0.2907	-0.5459	33

Following is a description of the temporal trends observed.

Factor I. As previously mentioned, this factor was interpreted as describing the shape of the pubis bone. High factor scores were associated with pelves exhibiting greater antero-medial curvature of the superior pubic ramus. Such an increase would apparently increase the transverse and anteroposterior dimensions of the pelvic inlet, at least in its most anterior portion. An examination of the results presented in Table 17 and Figure 15 reveals that an overall increase through time in the mean score for this factor can be observed. Therefore, the amount of curvature of the superior pubic ramus in the later Arikara sites is greater than

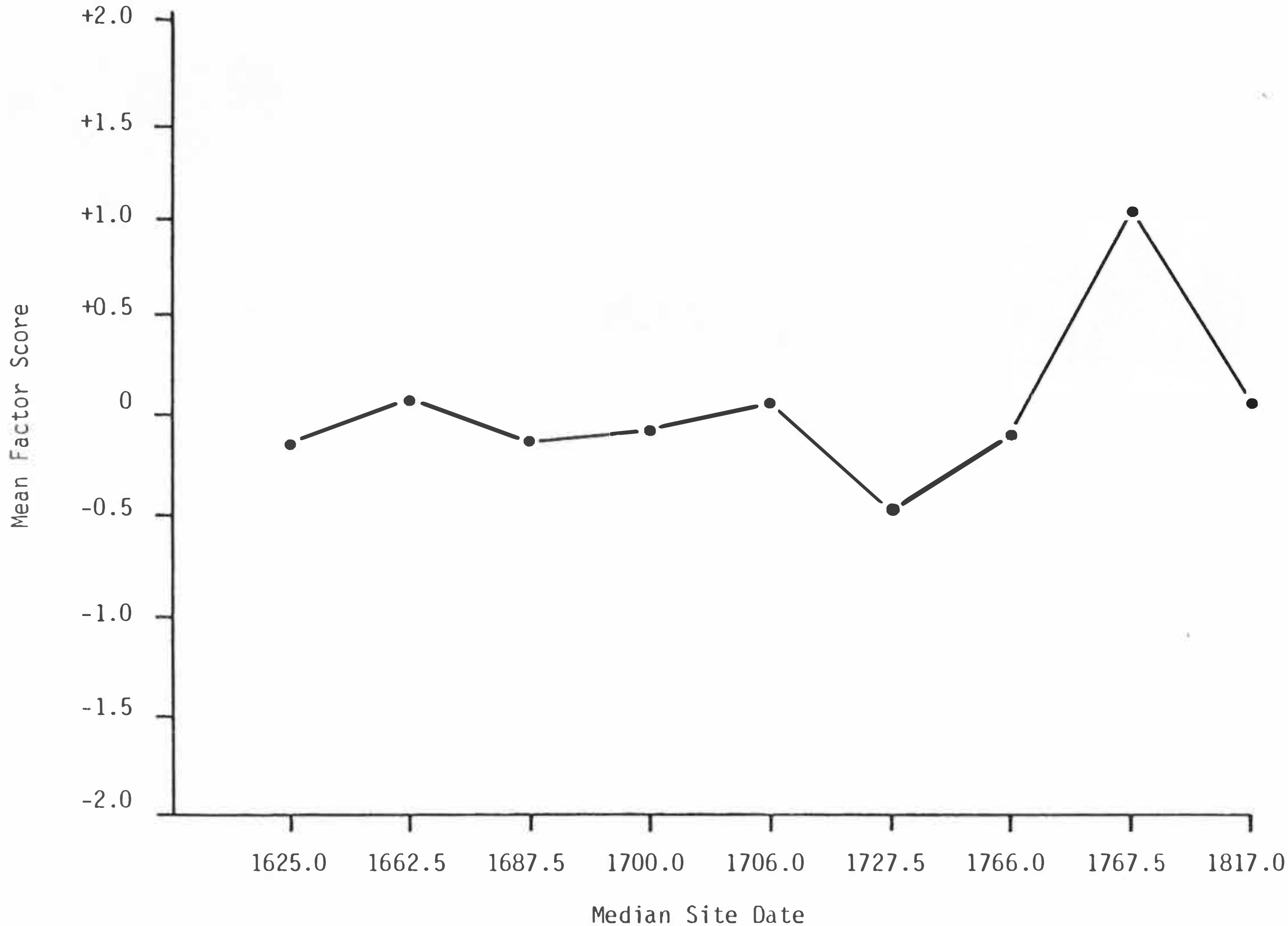

Figure 15. Innominate--Factor I: Mean Factor Score Plotted Against Median Site Date

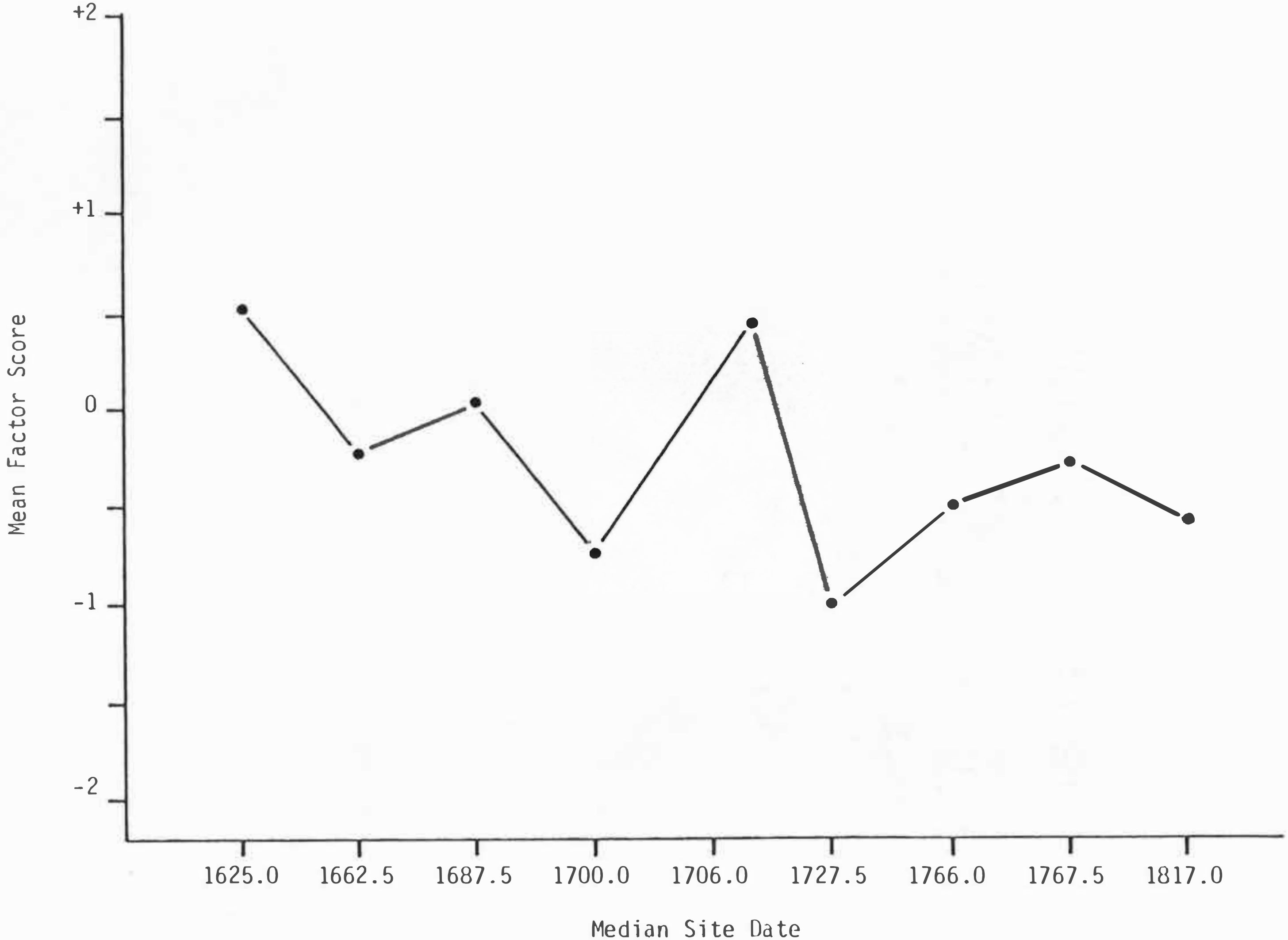

Figure 16. Innominate--Factor IX: Mean Factor Score Plotted Against Median Site Date

that observed in the earlier groups. From this it can be concluded that the anterior portion of the pelvic inlet is increasing in dimensions through time.

Factor IX. An examination of the results presented in Table 17 and Figure 16 reveals that a temporal decrease in the overall mean score for this factor can be observed. This factor reflects the height of the upper portion of the iliac blade. High factor scores are interpreted as being indicative of pelves with greater upper iliac height. Given the above results, it can be concluded that pelves from earlier Arikara groups have larger upper iliac height dimensions than their counterparts in later sites.

In summary, like the articulated pelvis, several temporal trends were noted in the Arikara innominate.

An increase in the curvature of the superior pubic ramus and a decrease in upper iliac height through time was observed. Earlier Arikara innominates may be characterized as having greater upper iliac height coupled with less antero-medial curvature of the superior pubic ramus than their later counterparts.

Multiple Analysis of Variance

A MANOVA was calculated to test whether systematic group, sex, and interaction differences could be noted. Archaeological temporal variant (i.e. Extended Coalescent, Post-Contact Coalescent, and Disorganized Coalescent) was employed as the grouping variable.

Only the articulated pelvis and innominate data sets were analyzed. The following general model was employed:

Factor Scores = Group + Sex + Interaction

Articulated Pelvis Analysis

The overall MANOVA results for the articulated pelvis are presented in Table 18. As can be seen from an examination of these results, the group effect is significant, while that for the sex and interaction effects was found to be non-significant. The overall result for the interaction effect, however, closely approaches the 0.05 level of significance.

The ANOVA results are given in Table 19. Five factors express significant group heterogeneity. These include Factors I, II, V, VI, and VII. The mean scores for each of these components, separated by group, are presented in Table 20. Factor VII contributes most to group heterogeneity, followed by Factors VI, V, II, and I in that order.

Table 18. Articulated Pelvis: Overall MANOVA Tests of Significance

Effect	Wilk's Criterion	F	D.F.	PR > F
Group	0.6711	3.81	16,276	0.0001
Sex	0.9393	1.12	8,138	0.3568
Interaction	0.8413	1.56	16,276	0.0804

Table 19. Articulated Pelvis: ANOVAs for Group, Sex, and Interaction Effects

Factor	Source	Sum of Squares	F	PR > F
I	Model	6.5407	1.56	0.1741
	Group	5.5683	3.32	0.0390
	Sex	1.4308	1.71	0.1936
	Interaction	2.0004	1.19	0.3605
II	Model	15.4131	2.96	0.0143
	Group	8.0556	3.86	0.0232
	Sex	0.1606	0.15	0.6953
	Interaction	1.4844	0.71	0.4925
III	Model	2.1114	0.44	0.8249
	Group	0.4010	0.21	0.8135
	Sex	0.0022	0.00	0.9624
	Interaction	1.9305	0.99	0.3723
IV	Model	1.3398	0.28	0.9220
	Group	0.6929	0.36	0.6956
	Sex	0.0073	0.01	0.9306
	Interaction	0.6184	0.32	0.7233
V	Model	14.9344	2.81	0.1870
	Group	12.3316	5.80	0.0038
	Sex	1.2035	1.90	0.2085
	Interaction	8.2988	3.90	0.0223
VI	Model	19.2948	3.84	0.0028
	Group	18.7535	8.82	0.0002
	Sex	0.9184	0.91	0.3409
	Interaction	1.6880	0.84	0.4342
VII	Model	27.6596	5.04	0.0003
	Group	22.2539	10.13	0.0001
	Sex	0.7926	0.72	0.3970
	Interaction	8.6616	3.94	0.0215
VIII	Model	1.2128	0.26	0.9336
	Group	0.4590	0.25	0.7830
	Sex	0.4679	0.50	0.4808
	Interaction	1.0450	0.56	0.5737

Table 20. Articulated Pelvis: Mean Factor Score by Temporal Variant

Temporal Variant	Factor I	Factor II	Factor V	Factor VI	Factor VII	N
EC	-0.1687	0.2540	-0.0232	0.6499	-0.6852	32
PCC	-0.0487	0.1608	0.0065	-0.1902	0.1947	100
DC	0.4820	-1.2525	0.3779	0.1246	0.0673	19

Several temporal trends can be noted. An increase in the mean factor score for Factors I, V, and VII from EC to DC times is observed. Factors II and VI express the opposite trend. Therefore, the articulated pelves representing Extended Coalescent sites may be characterized as having greater transverse and oblique dimensions of the pelvis above the midpelvis, longer, but narrower midpelves, less prominent ischial spines, and narrower pelvic outlets, when compared to their Disorganized Coalescent counterparts.

The Interaction effect in this analysis may be interpreted as reflecting differences in the degree of sexual dimorphism expressed in the groups examined. Significance should, therefore, denote varying levels of sexual dimorphism. Although the overall MANOVA test of significance for this effect was not found to be significant at the 0.05 level, it closely approaches this chosen level of acceptance. Therefore, a discussion of the _general_ trends observed will be conducted.

Two factors exhibit significant interaction effects. These are Factor V (anteroposterior dimension of the midpelvis) and Factor VII (shape of the pelvic outlet). Mean factor scores obtained for each sex by group are presented in Table 21. Male vs. female means for Factors V and VI plotted against temporal variant are illustrated in Figures 17 and 18, respectively. An examination of these results reveals that, not unexpectedly, females exhibit greater anteroposterior dimensions of the midpelvis. The degree of sexual dimorphism appears to be greatest during Disorganized Coalescent times and least during the Post-Contact Coalescent. An increase through time in this dimension can be observed in both sexes.

Factor VII reflects the shape of the pelvic outlet. During the Post-Contact and Disorganized Coalescent, female pelves are characterized as having wider outlets. This is not surprising. However, during the Extended Coalescent period, the male mean factor score is greater than that of the females. Recalling the initial interpretation of the variable loadings, both shape as well as size information was expressed in this factor. The variable contributing most of the size information expressed was biacetabular breadth (ACC). Examining the means of the original variables which load on this factor (see Table 22) reveals that biacetabular breadth in males during the EC exceeded that of the females.

An examination of Table 21 and Figure 18 reveals that the degree of sexual dimorphism expressed in Factor VII is greatest, once again, during Disorganized Coalescent times and at least for

Table 21. Articulated Pelvis: Mean Scores on Factors V and VII by Temporal Variant and Sex

Temporal Variant	Factor V Males	N	Factor V Females	N	Factor VII Males	N	Factor VII Females	N
EC	-0.6005	17	0.1857	15	-0.3999	17	-1.008	15
PCC	-0.1305	54	0.1673	46	0.1149	54	0.2884	46
DC	-0.0346	15	1.9249	4	-0.2058	15	1.0916	4

those sites representing the Post-Contact Coalescent. In general, both males and females exhibit a tendency for the pelvic outlet to increase in capacity from earlier to later times.

Disarticulated Analysis

Overall MANOVA results are presented in Table 23. The Group, Sex, and Interaction effects were found to be non-significant. However, the overall group effect closely approached significance. The ANOVA results are given in Table 24. An examination of these results reveals that only one of the thirteen factors employed, IV, expressed a significant degree of Group heterogeneity. This factor reflects upper iliac height. An examination of the mean factor scores for each group presented in Table 25 indicates that an overall decrease through time is evident. Low factor scores were previously interpreted to be indicative of innominates which express smaller upper iliac height values.

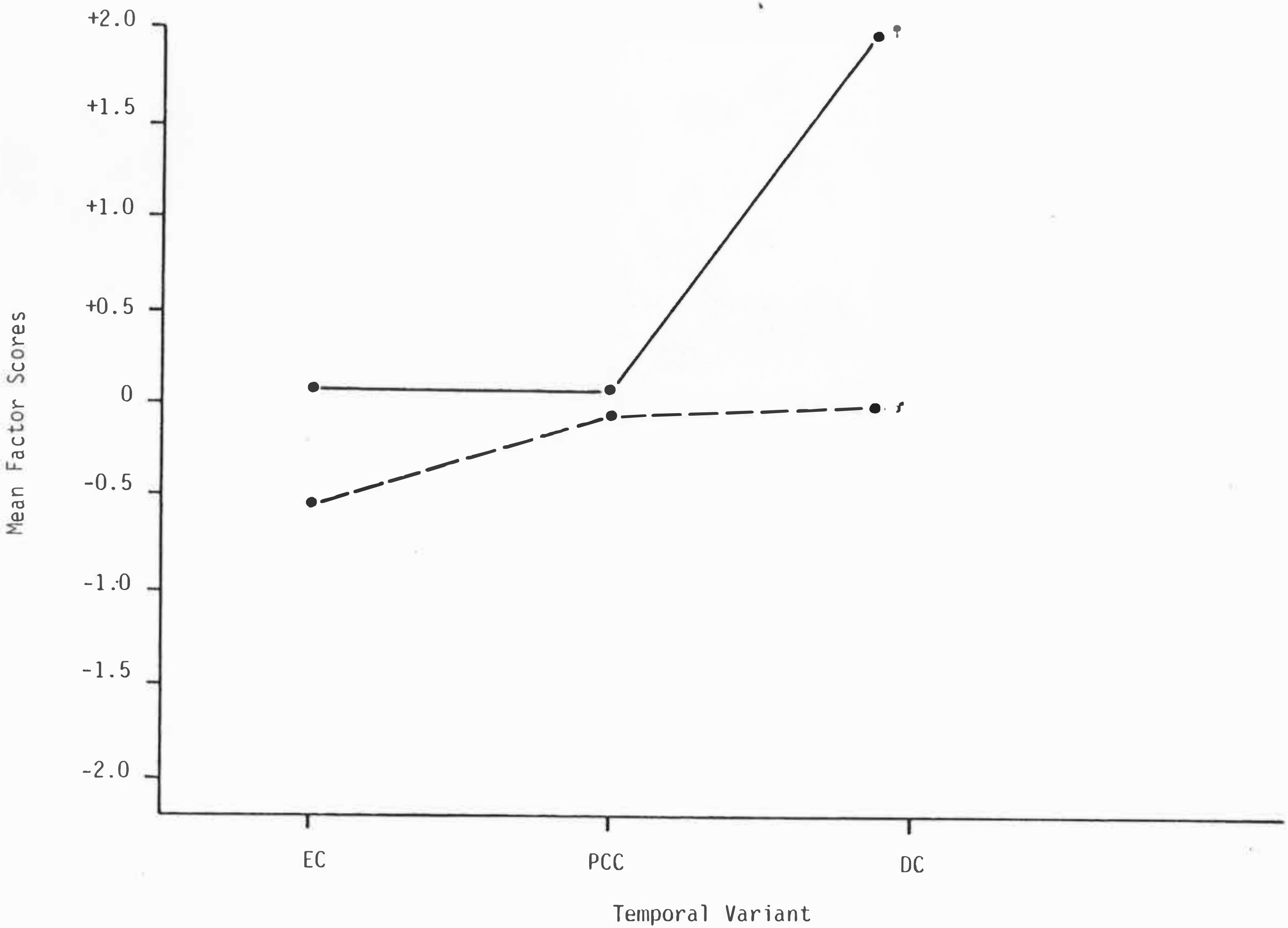

Figure 17. Articulated Pelvis--Factor V: Male and Female Mean Factor Scores Plotted Against Temporal Variant

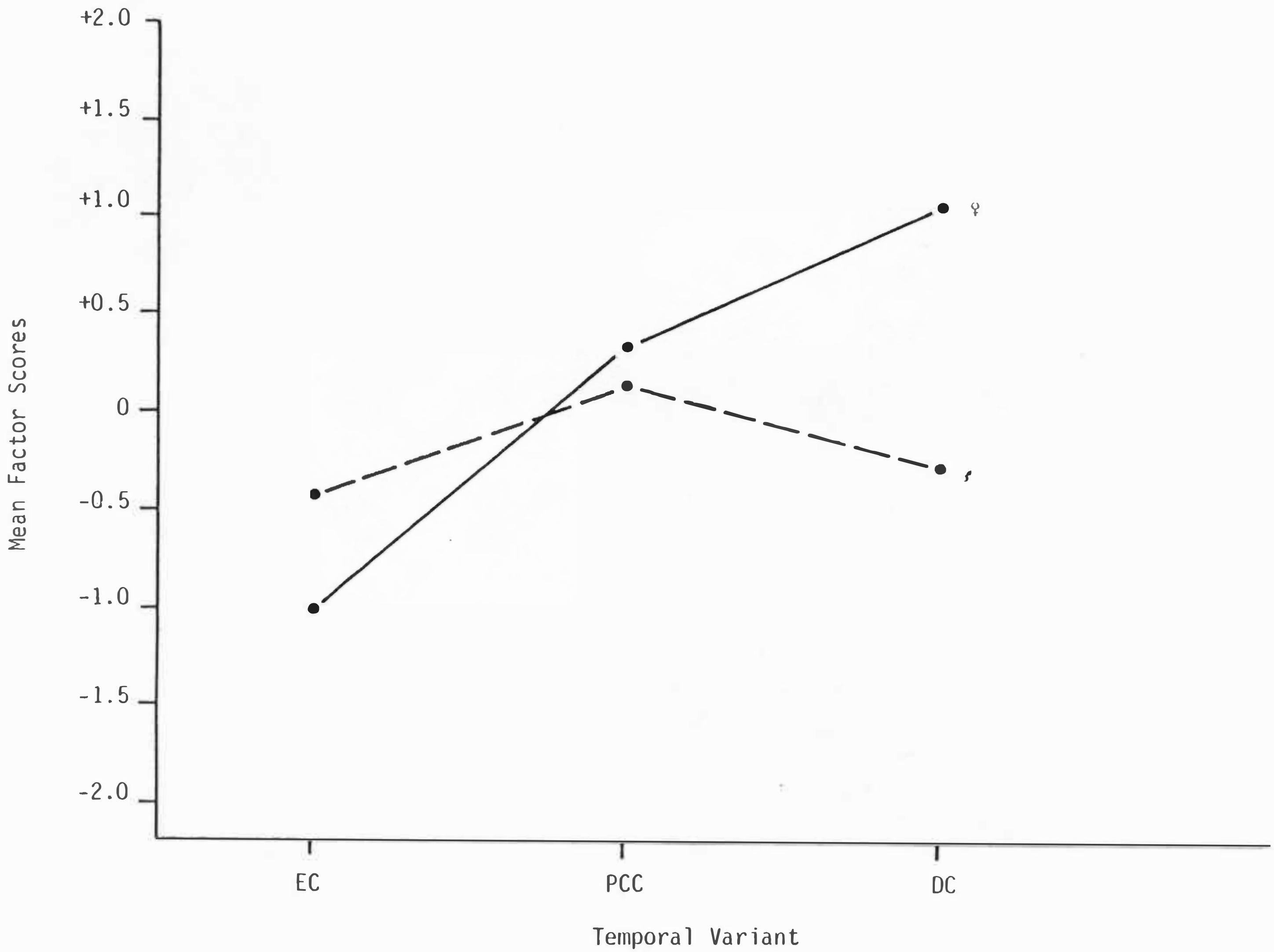

Figure 18. Articulated Pelvis--Factor VII: Male and Female Mean Factor Scores Plotted Against Temporal Variant

Table 22. Articulated Pelvis: Original Means by Temporal Variant for Those Variables Loading on Factor VII

	Temporal Variant					
	EC		PCC		DC	
Variable	♂	♀	♂	♀	♂	♀
POA	92.9	94.4	97.1	96.3	96.6	100.2
ACC	205.7	203.2	209.6	211.2	207.5	221.6
PIA	122.5	118.4	123.9	122.7	122.7	124.6

Table 23. Innominate: Overall MANOVA Tests of Significance

Effect	Wilk's Criterion	F	D.F.	PR > F
Group	0.8795	1.40	26,548	0.0926
Sex	0.9793	0.45	13,274	0.9511
Interaction	0.9166	0.94	26,548	0.5543

Table 24. Innominate: ANOVAs for Group, Sex, and Interaction Effects

Factor	Source	Sum of Squares	F	PR > F
I	Model	3.9556	0.55	0.7411
	Group	3.1569	1.10	0.3356
	Sex	0.7508	0.52	0.4708
	Interaction	1.6498	0.57	0.5646
II	Model	2.7554	0.46	0.8040
	Group	0.9004	0.038	0.643
	Sex	0.2880	0.24	0.6224
	Interaction	1.2113	0.51	0.6004
III	Model	0.4358	0.09	0.9918
	Group	0.3150	0.16	0.8489
	Sex	0.0970	0.10	0.7509
	Interaction	0.2020	0.11	0.9003
IV	Model	11.6306	0.95	0.4526
	Group	1.2430	0.25	0.7768
	Sex	2.4388	0.99	0.3202
	Interaction	9.5602	1.94	0.1450
V	Model	10.1599	0.96	0.4441
	Group	1.3826	0.33	0.7218
	Sex	1.4896	0.70	0.4024
	Interaction	8.7322	2.06	0.1292
VI	Model	6.4629	1.33	0.2493
	Group	0.353	0.02	0.9819
	Sex	0.8175	0.84	0.3593
	Interaction	6.0478	3.12	0.0457
VII	Model	1.7520	0.36	0.8752
	Group	0.9598	0.51	0.6020
	Sex	0.3142	0.33	0.5644
	Interaction	1.0176	0.54	0.5839
VIII	Model	3.5644	0.61	0.6933
	Group	1.9050	0.82	0.4425
	Sex	0.4350	0.37	0.5416
	Interaction	1.3835	0.59	0.5529

Table 24. (Continued)

Factor	Source	Sum of Squares	F	PR > F
IX	Model	15.5685	2.63	0.0242
	Group	14.3024	6.03	0.0027
	Sex	1.9502	1.64	0.2007
	Interaction	4.1169	1.74	0.1781
X	Model	6.4891	1.13	0.3433
	Group	3.3197	1.45	0.2368
	Sex	0.7985	0.70	0.4046
	Interaction	2.4390	1.06	0.3465
XI	Model	6.9019	1.36	0.2395
	Group	6.1834	3.04	0.0694
	Sex	0.1128	0.11	0.7393
	Interaction	0.7375	0.36	0.6962
XII	Model	3.3595	0.63	0.6806
	Group	2.9489	1.38	0.2534
	Sex	0.1068	0.10	0.7521
	Interaction	0.5296	0.25	0.7807
XIII	Model	3.8773	0.77	0.5766
	Group	3.6480	1.80	0.1667
	Sex	0.0371	0.04	0.8484
	Interaction	0.0837	0.04	0.9595

Table 25. Innominate: Mean Factor Score for Factor IX by Temporal Variant

Temporal Variant	Factor IX
EC	0.2280
PCC	0.1882
DC	-0.5460

Age Changes: Larson Females

In addition to sexual dimorphism, a potentially important component of intragroup pelvic variation is age related variability. Changes in the pelvis attributed to age have previously been demonstrated for the pubic symphyseal region (Gilbert and McKern 1973; McKern and Stewart 1957; Suchey et al. 1979) and sacro-iliac joint (Lovejoy et al. n.d.). However, to the best of my knowledge, at present, no attempts have been made to examine whether or not the overall morphology of the adult pelvis, as a unit, is modified during the aging process.

Furthermore, it has recently been suggested by Hamilton (1982) that age specific modifications in bone morphology may mask other aspects of intragroup variability, such as levels of sexual dimorphism. Although it has not as yet been documented, there are indications that significant differences in the age structure of the various Arikara sites employed in the present analysis do exist (Owsley, personal communication). Therefore, it is hoped that the identification of age related patterns of variation in pelvic morphology, if they do in fact exist, can potentially aid in the interpretation of the results obtained.

To explore the potential existence of age change in the Arikara adult pelvis specifically, only one site, Larson (39WW2), was employed. This was necessitated due to the small sample sizes available at the other sites examined. Larson was the only site which had a sample size large enough to warrant an age analysis. Furthermore, to control for potential sex differences, only female specimens were utilized. The sample size for each age range employed is presented in Tables 26 and 27.

The employment of Larson females as a data base also allows the testing of a hypothesis regarding propositions put forth to explain specific demographic phenomena observed at this site. In a recent demographic analysis of Larson, Owsley and Bass (1979) demonstrated the peak mortality rate for females at this PCC site occurred during the age interval of 15-19 years. The number of females dying during this interval was greater than that for males of the same age. Owsley and Bass (1979) postulated the difference in the number of deaths noted between males and females assessed to be 15-19 years of age could potentially be attributed to problems encountered during the childbirth process in females. The authors further suggest, in support of their proposition, the age interval of 15-19 years is the potential age at which Arikara females would be experiencing first births.

Table 26. Articulated Pelvis: Larson Sample Sizes by Age Category

Age Range (In Years)	N
15.5-16.5	0
16.5-17.5	0
17.5-18.5	0
18.5-19.9	2
20.0-24.0	5
25.0-29.0	2
30.0-34.0	6
35.0-39.0	7
40.0-44.0	6
45.0-49.0	1
50.0-54.0	3
55.0-59.0	0
60.0 +	0

Table 27. Innominate: Larson Female Sample Sizes by Age Category

Age Range (In Years)	N
15.5-16.5	0
16.5-17.5	0
17.5-18.5	0
18.5-19.5	5
20.0-24.0	8
25.0-29.0	4
30.0-34.0	8
35.0-39.0	14
40-0-44.0	8
45.0-49.0	1
50.0-54.0	6
55.0-59.0	0
60.0 +	0

If this contention is valid, and assuming a female's potential for a normal birth is reflected in the bony pelvis, then one would expect the pelvic morphology of young Larson females (15-19 years of age) to differ in those areas of the pelvis deemed as significant indicators of childbirth potentials from the rest of the females in the population. Furthermore, it is assumed that the females at Larson between 20 and 60+ years of age survived the initial childbearing years and their death can be attributed to other, unknown causes. Employing the pelvic data available, an attempt will be made to further examine the hypothesis outlined above.

Several statistical procedures were employed to analyze age change variation in the pelvis of Larson females. As in the overall group analysis, a principal components analysis was conducted initially. Employing age as the criterion variable and the factor scores generated as the independent variables, a multiple regression analysis was performed. T-tests were employed to determine whether pelvic morphology of young (15.5-19.9 years of age) Larson females differed significantly from that of older (20.0-60+ years of age) females. Only the articulated pelvis and innominate data sets were employed. Thirty-two articulated pelves and 54 innominates were analyzed. A description of the results obtained follows.

Principal Components Analysis

The SAS (SAS Institute, Inc. 1979) procedure FACTOR with options PA1, MINEIGEN = 1.0, and VARIMAX rotation was employed. Nine articulated and thirteen disarticulated components were extracted and accounted for 91.8% and 84.8%, respectively, of the total variance present in the sample. The structure of the factors extracted differed only slightly from those generated employing the overall sample from all groups. As a result, a detailed description of all factors will not be presented. Only those components deemed as significant in subsequent analyses will be discussed in detail.

Multiple Regression Analysis

The overall multiple regression results for the articulated pelvis factors are shown in Table 28. Although 42.25% of the variance in age could be explained in terms of the nine factors, the overall test was found to be non-significant. Univariate results are shown in Table 29. Therefore, no evidence of linear age changes in the articulated pelvis of Arikara females can be documented.

Not unexpectedly, the overall results for the innominate data set were also found to be non-significant. These results are presented in Table 30. Slightly more than 33% of the variance present in the criterion variable, age, could be explained by the 13 factors employed. Univariate results are presented in Table 31.

T-tests

As previously mentioned, a series of t-tests were conducted in order to determine whether differences in pelvic morphology exist between young (15.5-19.9 years of age) and old (20.0-60+ years of age) Larson females. The SAS (SAS Institute, Inc. 1979) procedure TTEST was utilized to perform the necessary

Table 28. Articulated Pelvis: Overall Multiple Regression Results for Larson Females

Model Sum of Squares	F Value	PR > F	R-Square
48.11	1.79	0.1280	0.4225

Table 29. Articulated Pelvis: Univariate Age Regression Results for Larson Females

Factor	Type IV SS	F Value	PR > F
I	3.85	1.29	0.27
II	16.21	5.42	0.03
III	0.90	0.30	0.59
IV	1.18	0.40	0.53
V	4.19	1.40	0.25
VI	2.10	0.70	0.41
VII	0.11	0.04	0.85
VIII	14.58	4.88	0.04
IX	4.97	1.66	0.21

Table 30. Innominate: Overall Multiple Regression Results for Larson Females

Model Sum of Squares	F Value	PR > F	R-Square
75.73	1.52	0.1532	0.3304

Table 31. Innominate: Univariate Results for Larson Females

Factor	Type IV SS	F Value	PR > F
I	40.59	10.58	0.00
II	2.12	0.55	0.46
III	3.31	0.86	0.36
IV	0.52	0.14	0.71
V	0.00	0.00	0.98
VI	0.44	0.11	0.74
VII	2.49	0.65	0.42
VIII	1.83	0.48	0.49
IX	12.79	3.33	0.08
X	0.27	0.07	0.79
XI	9.26	2.41	0.13
XII	1.70	0.44	0.51
XIII	0.40	0.10	0.75

calculations. Only one factor, VI, was found to be significant at the $\alpha = 0.05$ level. This factor accounted for 8.35% of the variance and reflects the antero-posterior capacity of the midpelvis. Only two variables, MSA (midpelvis sacral angle) and IPA (ischial spine posterior angle) were highly correlated with this factor. Their salient loadings were 0.9751 and -0.9751, respectively. High factor scores are indicative of pelves with greater antero-posterior capacity of the midpelvis.

An examination of the means for this factor (see Table 32) indicates that the mean score for the older females is higher than that calculated for the young sample. Given the above interpretation, older females may be described as exhibiting larger midpelves in its anterio-posterior dimension.

T-test results for the innominate factors are presented in Table 33. As in the articulated tests, all sample variances were determined to be equal. Two of the thirteen components employed, I and IX, were found to exhibit significant differences. These factors are comparable to components VII and III, respectively, of the overall analysis.

Factor I accounts for 25.05% of the sample variance and clearly reflects pubic length. Nine variables exhibited salient loadings. The loadings, in order of magnitude, are:

PLG	0.8686
SMS	0.8367
SIT	0.8231

Table 32. Articulated Pelvis: Larson Female T-Test Results

Factor	Age Range	N	Mean	T	PR > /T/
I	15.5-19.9	2	-0.0643	-0.092	0.927
	29.0-60+	30	0.0043		
II	15.5-19.9	2	1.0684	1.599	0.120
	20.0-60+	30	-0.0712		
III	15.5-19.9	2	-0.3045	-0.439	0.664
	20.0-60+	30	0.2020		
IV	15.5-19.9	2	-1.0692	-1.601	0.120
	20.0-60+	30	0.0713		
V	15.5-19.9	2	-0.8016	-1.178	0.248
	20.0-60+	30	0.0534		
VI	15.5-19.9	2	-1.8133	-2.962	0.006
	20.0-60+	30	0.1209		
VII	15.5-19.9	2	0.5552	0.806	0.426
	20.0-60+	30	-0.0370		
VIII	15.5-19.9	2	-0.8188	-1.204	0.238
	20.0-60+	30	0.0546		
IX	15.5-19.9	2	-0.6918	-1.011	0.320
	20.0-60+	30	0.0461		

Table 33. Innominate: Larson Female T-Test Results

Factor	Age Range	N	Mean	T	PR > /T/
I	15.5-19.9 20.0-60+	5 49	-0.9628 0.0982	-2.355	0.022
II	15.5-19.9 20.0-60+	5 49	0.1191 -0.0122	0.277	0.783
III	15.5-19.9 20.0-60+	5 49	0.3530 -0.0360	0.826	0.412
IV	15.5-19.9 20.0-60+	5 49	0.4370 -0.0446	1.026	0.309
V	15.5-19.9 20.0-60+	5 49	0.2225 -0.0227	0.577	0.606
VI	15.5-19.9 20.0-60+	5 49	0.1636 -0.0167	0.381	0.705
VII	15.5-19.9 20.0-60+	5 49	-0.5819 0.0594	-1.377	0.174
VIII	15.5-19.9 20.0-60+	5 49	-0.3109 0.0317	-0.726	0.471
IX	15.5-19.9 20.0-60+	5 49	1.0174 -0.1038	2.504	0.015
X	15.5-19.9 20.0-60+	5 49	-0.1335 0.0136	-0.311	0.757
XI	15.5-19.9 20.0-60+	5 49	-0.5068 0.0517	-1.194	0.238
XII	15.5-19.9 20.0-60+	5 49	-0.0069 -0.0007	-0.016	0.987
XIII	15.5-19.9 20.0-60+	5 49	0.6372 -0.0650	1.514	0.136

IPD	0.8178
SAI	0.8133
MXW	0.7906
SBB	0.7839
MXH	0.7818
SPS	0.7231

High factor scores are indicative of innominates with longer pubes.

An examination of the means for this factor presented in Table 33 indicates that the mean factor score for the older females is larger than that for the younger sample. Therefore, older Larson females may be described as having longer pubes than their younger counterparts.

T-test results for Factor IX were also found to be significant. This factor accounts for 5.22% of the total sample variance present and appears to reflect the curvature of the iliac blade. Two variables, IFA (iliac flare angle at the level of the anterior superior spine) and SBB (superior iliac breadth) exhibit the highest correlations with this factor. High scores are indicative of innominates with more curved or flared ilia. High loadings are:

IFA	0.8685
SBB	0.6893

An examination of the means for Factor IX given in Table 33 reveals that Larson females within the age range of 15.5-19.9 years express, on the average, higher factor scores than those aged 20.0

to 60+ years. In other words, the ilia of young Larson females are more curved or flared than their older counterparts.

In summary, no linear age changes could be noted in either the Larson female innominate or articulated pelvis. T-test results, however, indicate that young Larson females exhibit a smaller antero-posterior capacity of the midpelvis, shorter pubes, and more curved ilia when compared to the rest of the female sample.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

The present analysis had two general goals. These were to examine the nature of intra- as well as interpopulation variation in the Arikara pelvis. Principal components analysis, a multivariate technique, was chosen as the statistical tool to explore Arikara within-group pelvic variation. Multiple regression analysis and multiple analysis of variance (MANOVA) were employed to identify along which factors the Arikara groups considered differed and as such, examine the relationship of interpopulation variation to patterns of within-group variability. The present chapter will be an attempt to interpret the results obtained within the framework of the stated general goals of the analysis. In addition, a discussion of these results and how they pertain to the "answering" of the specific questions previously outlined in the Introduction will be conducted.

Intragroup Variation

A series of three principal component analyses were conducted in an attempt to identify patterns of intragroup variation in the Arikara sacrum, innominate, and articulated pelvis. As previously stated in Chapter IV, the principal component structures obtained are viewed as representing, at best, mathematical approximations of underlying genetic traits. Theoretically, these structures can be interpreted in morphologically meaningful terms. According to

Zobeck, however, "the production of interpretable components does not automatically confer biological reality upon them" (1983:77). A functional evaluation of the factors in light of the morphology they represent should be conducted. In other words, how well does the interpretation of the factors correspond to the functional morphology of the pelvis?

Not unlike the cranium, pelvic structure represents the complex interaction of a variety of individual bony elements. A change in a dimension of one element can potentially result in complex corresponding modifications in another or other elements. Supporting evidence can be found in studies concentrating on the growth patterns of the pelvis (Coleman 1969; Greulich and Thoms 1938, 1939, 1944, 1947; Thoms 1947). Coleman (1969), for example, attributes the difference between the sexes for overall size of the pelvic inlet to greater pubic growth in the female. Therefore, it is felt that establishing the biological reality of the factor interpretations can best be accomplished by concentrating upon the pelvic girdle as a unit. The discussion to follow will pertain mainly to the principal components results obtained from the articulated pelvis analysis. Prior to a discussion of the specific results obtained, a discussion concentrating upon the functional divisions of the bony pelvis will be presented.

Anatomists (Grant 1952) and obstetricians (Stander 1945) agree that the bony pelvis consists of two main elements, the false and true pelvis. The former is that portion of the pelvic girdle which lies above the pectineal lines (or linea terminalis). It is "bounded posteriorly by the lumbar vertebrae and laterally by the iliac fossa, while in front the boundary is formed by the lower portion of the anterior abdominal wall" (Stander 1945:228-29). The false pelvis is of no particular obstetrical significance; however, it does function to support the intestines of non-pregnant females and the uterus in pregnant women. In addition, various dimensions of this element play important roles in the distribution of body weight to the lower extremities (Burr et al. 1977; Lovejoy et al. 1973; McHenry 1975; Steudel 1981; Zihlman and Hunter 1972), and can vary in accordance with the flare of the iliac blades (Stander 1945).

In contrast, the true pelvis, or bony birth canal, which is that area lying beneath the pectineal line, is of primary obstetrical significance. The true pelvis is "bounded above by the promontory and the alae of the sacrum, the linea terminalis, and the upper margins of the pubic bones and below by the pelvic outlet" (Stander 1945:229). It can be further divided into three areas, which all appear to serve different functions during the course of childbirth. The three subdivisions are: (1) the pelvic inlet (or superior strait), (2) the midpelvis, and (3) the pelvic outlet (or inferior strait). Each of these areas is usually described in terms of their anteroposterior and transverse dimensions. Oblique diameters, however, are also employed in descriptions of the superior strait. Following is a description as well as functional interpretation of these three areas.

The superior strait or pelvic inlet is bounded posteriorly by the sacral promontory and alae, laterally by the pectineal lines, and anteriorly by the horizontal rami of the pubic bones and superior margin of the pubic symphysis (Stander 1945). Its anteroposterior diameter is measured from the mid-anterior promontory to the upper margin of the pubic symphysis. Perpendicular to this dimension is the transverse diameter which represents the greatest distance between the ilio-pectineal lines. Oblique diameters are usually defined as representing a straight line drawn from the sacro-iliac joint to the linea terminalis on the opposite side. Particular obstetrical importance is given to this anatomical region. It is this bony area which is initially encountered by the fetus during its descent. Oblique and transverse diameters of the fetus enter the inlet. Head, hands, feet, arms, and knees are usually flexed (Stander 1945).

The pelvic outlet represents the most inferior portion of the bony pelvis and is usually further divided, like the midpelvis, into anterior and posterior portions. It is bounded anteriorly by the inferior margins of the pubic arch, laterally by the ischial tuberosities, and posteriorly by the tip of the coccyx (Stander 1945). Its transverse dimension is the distance between the inner margins of the ischial tuberosities, while the anteroposterior diameter "extends from the lower margin of the pubic symphysis to the tip of the coccyx" (Stander 1945:233). From an obstetrical point of view, the inferior strait represents the exiting region of the fetus.

Normally the head exits first; however, it is not uncommon for the fetus to present itself in a breech position (i.e. rump first). The head is born by extension of the neck.

The area which lies in between the superior and inferior straits is the midpelvis. Both the greatest and least dimensions of the true pelvis are expressed in this region. The plane of greatest pelvic dimensions

> extends from the middle of the posterior surface of the pubic symphysis to the junction of the second and third sacral vertebrae and laterally passes through the ischial bones over the middle of the acetabulaum (Stander 1945:234)

and represents the "roomiest" area of the birth canal. The tip of the sacrum, the ischial spines, and the lower margin of the pubic symphysis define the smallest dimension of the true pelvis. It is within this bony area that the internal rotation of the fetus occurs. During this process, the largest diameters of the fetus are accommodated by the smallest diameters of the midpelvis (Linton, personal communication). Internal rotation is necessary so that the fetus is properly positioned for birth (i.e. occipit-anterior and under the pubic symphysis). Uterine contractions in this area as well as those of the pelvic outlet are critically important for normal birth. These two series of contractions appear to be highly related (Caldwell et al. 1935).

Given the above morphological and functional descriptions of the pelvic girdle, one should expect these aspects to be reflected in the factor interpretations derived in Chapter V. Eight factors were extracted from the articulated pelvis pooled within-groups correlation matrix. The factors together account for 81.4% of the total variance present in the articulated data. Factor I was interpreted as reflecting the transverse and oblique dimensions of the pelvis above the midpelvis. This would include the false pelvis as well as the pelvic inlet. The size of both areas is reflected by the various variables highly correlated with this component. Structurally, it is not surprising that dimensions of the false pelvis and the pelvic inlet should load on the same factor. Both areas share a common defined space, the iliopectineal lines. As previously mentioned, it is the transverse and oblique dimensions of the inlet through which the fetus initially passes on its descent through the bony birth canal.

Factor III was interpreted as reflecting the curvature or flare of the iliac blade. It will be recalled that this dimension reflects the overall size of the false pelvis. The greater the ilial flare, the smaller the capacity of the false pelvis. In addition, the ilia in general, and the anterior superior spines in particular, are related to functional adaptations for upright posture. The anterior superior spines represent the attachment areas for the muscles which rotate the pelvis internally as well as laterally, the anterior gluteus medius-minimus complex (Zihlman and Hunter 1972). According to McHenry, the flare of the iliac blade "is very important since it is related to the unique arrangement for the human gluteal muscles essential to lateral support during bipedal walking" (1975:251). It is also interesting to note that Factor III of the innominate analysis is comparable to this factor.

The anteroposterior dimension of the pelvic inlet is reflected in Factor IV. This represents the remaining dimension of the pelvic inlet. It is not surprising that this factor is separated from that representing the transverse and oblique diameters. The latter would appear to have greater obstetrical importance; however, the obstetrical role of the anteroposterior dimension may be a compensatory one. Evidence presented by Caldwell and co-workers (Caldwell and Moloy 1934; Caldwell et al. 1933, 1935) appears to indicate that an increase in anteroposterior dimension of the pelvic inlet occurs to compensate for smaller transverse and oblique diameters. Two factors identified in the disarticulated analysis, I and VII, appear to also reflect this dimension of the pelvic inlet. These factors reflect either pubis shape or pubis length. According to Steudel (1981) as well as Lovejoy et al. (1973), the size of the pubis bone appears to be related to the sagittal diameter of the pelvic girdle. In addition, it should be recalled that the interior boundary of the pelvic inlet is defined by the horizontal rami of the pubis.

Factors II, V, and VI all reflect dimensions of the midpelvis. To recapitulate, Factor II was interpreted as representing the transverse capacity of the midpelvis, while Factor V reflects its anteroposterior dimension. The prominence of the ischial spines is reflected in Factor VI. All three components together represent the overall capacity or volume of the midpelvis. It is not surprising that both the smallest and largest dimensions of the pelvis are represented. Factor V consists of variables reflecting the plane of least pelvic dimensions. From an obstetrical point of view, this dimension is functionally related to the internal rotation of the fetus which ultimately positions the fetus properly for birth (and is apparently related to the muscle contractions necessary for the continued passage of the fetus through the birth canal). If the midpelvis is not roomy enough to accommodate this rotation, potential complications would be encountered due to the improper orientation of the fetus (Linton, personal communication) and the inability of the cervix to dilate (Caldwell et al. 1935).

The shape of the pelvic outlet is identified in Factor VII. Obstetrically, it is the pelvic outlet from which the fetus exits. It should be recalled that muscle contractions in this area of the true pelvis appear to be related to those of the midpelvis.

Factor VIII of the articulated analysis reflects the relative orientation of the acetabulum and ischial spines. Although the functional interpretation of this factor is at present unclear, it would seem that the relative position of the acetabulum would be related to various dimensions of the femur, particularly the angulation of the femoral neck. The functional importance of this variable as well as femoral torsion is seen in the stabilization of the hip joint and in locomotion (Zobeck 1983).

Although the above discussion has concentrated primarily upon the functional interpretation of the articulated factor structure, a few brief comments will be made concerning one factor, IV, of the disarticulated analysis. This component was previously interpreted as reflecting lower iliac height. Recently, the functional importance of this dimension of the innominate has been discussed by Steudel (1981). Lower iliac height was noted by Steudel as one of the characteristics of the pelvis which separates humans from other primates. She presented two interpretations of the biomechanical significance of lower iliac height: (1) "its effect on the moment arm of the gluteus medius muscle . . . to extend the hindlimb" and (2) the "tendency for lower iliac height to decrease in heavy animals to reduce mechanical stress due to weight bearing" (Steudel 1981:409).

From the above discussion, it can be concluded that at least the articulated factor structure identified reflects a relatively high degree of biological reality. The measurement set employed was designed to delineate the general functional components of the pelvic girdle. Therefore, the results obtained are not surprising. The degree of difficulty encountered in interpreting the innominate components may be partially attributed to the general inability of the more traditional measurements to reflect functional importance. Until measurements are devised to more clearly identify the functional significance of the innominate elements, the full potential of employing a principal components analysis cannot be achieved. Unfortunately, data comparable to that of the present analysis do not exist. Therefore, an evaluation of the universality of the pelvic factor structure outlined cannot be conducted. A more complete evaluation must await further analysis.

Intergroup Variation

The second general goal of the present analysis was to examine the nature of interpopulation variation in the Arikara pelvis. This was accomplished employing two multivariate statistical procedures, multiple regression analysis and multiple analysis of variance (MANOVA). The factor scores generated were utilized in each analysis. Therefore, an attempt was made to identify along which factors the Arikara populations differed. Establishing these relationships allows the assessment of the congruence of the culture-historical picture presented by the pelvis and that derived through craniometric and postcraniometric analyses.

The regression results obtained in the articulated pelvis and innominate data sets indicate that several temporal trends in the Arikara pelvis can be observed. No corresponding changes in the sacrum were noted. In the articulated pelvis analysis four factors were identified as significant contributors to the overall amount of explained variance noted in median site date. To recapitulate, these were: (1) Factor II (transverse capacity of the midpelvis), (2) Factor V (anteroposterior capacity of the midpelvis), (3) Factor VI (prominence of the ischial spines), and Factor VII (shape of the pelvic outlet). An overall decrease through time in the mean score for Factors II and VI was noted, while the opposite trend was observed in Factors V and VII. In morphological terms, the articulated pelvis of earlier Arikara individuals can be described as having more narrow but longer midpelves, less wide pelvic outlets, and less prominent ischial spines.

Several temporal trends were also noted in the Arikara innominate. An overall increase through time in the mean score for Factor I was observed. This factor reflects the anteromedial curvature of the pubis and, therefore, pubis shape. Given the above, it can be concluded that the innominates from later Arikara sites exhibited more anteromedially curved pubes and, therefore, wider pelvic inlets, at least in its anterior dimension, than those from the later Arikara sample.

A decrease through time in the mean score for Factor IX was also observed. This component was interpreted as reflecting upper iliac height. In light of this, not only were the later Arikara innominates described as expressing wider pelvic inlets anteriorly but they also exhibit smaller upper iliac height than their earlier counterparts.

MANOVA results for the articulated pelvis data are consistent with the results obtained through multiple regression analysis. The four factors discussed above also contributed to the significant overall degree of group heterogeneity. The general temporal trends noted in the regression analysis for each of these factors were also found to be consistent in the MANOVA. In addition to the four articulated pelvis factors discussed above, ANOVA results indicated that Factor I also contributed to the group heterogeneity present. This factor was previously interpreted as reflecting the size of the false pelvis and pelvic inlet in their transverse and oblique dimensions. An increase in the mean factor score was noted. Therefore, the articulated pelvis of individuals representing the Extended Coalescent sites have greater transverse and oblique dimensions of the pelvic girdle above the mid-pelvis, less prominent ischial spines, narrower pelvic outlets, and longer and narrower midpelves.

Unlike the results obtained employing regression analysis, the overall MANOVA results for Group effect in the disarticulated analysis were found to be non-significant. However, the overall significance level closely approached the chosen level of acceptance. An examination of the ANOVA results revealed that Factor IX significantly contributed to the group heterogeneity expressed. A decrease in mean factor score from EC to DC times was observed. This is consistent with the temporal patterning noted in the regression analysis for this factor. Disorganized Coalescent innominates, therefore, express greater upper iliac height than those of the Extended Coalescent.

How well do these results correspond with those derived employing craniometric and postcraniometric data? Temporal trends in the Arikara crania have been noted by several researchers. Jantz (1972) observed an increase through time in Arikara head length, while Jantz and Key (1981) demonstrated temporal patterning in components reflecting frontal profile flatness, transverse frontal flatness, and facial height. The microevolutionary trends noted in the Arikara cranium have been at least partially attributed to gene flow between this group and other neighboring populations such as the Sioux, Mandan, and Pawnee (Jantz and Key 1981).

The postcraniometric results presented by Zobeck (1983) do not agree with those of Jantz and Key (1981) for the cranium. In his analysis of the Arikara long bones, clavicle, and scapula, Zobeck was not able to demonstrate any significant intergroup differences. The lack of congruence between the results of these two data sets was attributed to the racially homogeneous nature of the postcranium (Zobeck 1983).

The results of the present analysis, in general, are in agreement with those derived employing craniometric data. Significant differences between the Arikara sites examined were noted. Although Jantz and Key (1981) attribute a large percentage of the microevolutionary changes observed in the cranium to the effects of gene flow, its effect upon Arikara pelvic morphology cannot be assessed at present. To accomplish this, comparable data bases from Sioux, Mandan, and Pawnee populations would be necessary. Unfortunately, at present, no such samples are available. Therefore, the degree to which gene admixture is responsible for the observed microevolutionary changes in the Arikara pelvis cannot yet be established.

Obstetrical Significance (?)

Thus far, the potential effects of gene flow from neighboring populations have been explored to explain the temporal patterning in variation noted in the Arikara innominate and articulated pelvis. The present section will concentrate upon the potential obstetrical significance of the various temporal trends observed.

To recapitulate, earlier Arikara groups were described as exhibiting the following pelvic characteristics when compared to their temporally later counterparts: (1) narrower, but longer mid-pelves, (2) narrower pelvic outlets, (3) less pronounced ischial spines, (4) narrower pelvic inlets in at least its anterior portion, and (5) greater upper iliac height. In combination, these changes appear to indicate that in overall dimensions, the pelves from earlier Arikara sites are smaller than those from the later groups. The obstetrical role as well as the functional significance of each of these changes is discussed in the paragraphs to follow.

As previously mentioned, the internal rotation of the fetus from an oblique to a more anteroposterior position occurs within the boundaries of the midpelvis. Although this area of the true pelvis represents both the greatest and least planes of pelvic dimensions, the measurements employed in the present analysis only reflect the latter. The anteroposterior capacity of the midpelvis identified in this study represents this dimension. It is the plane of least pelvic diameter which accommodates the largest dimensions of the fetus on its journey through the birth canal. Failure to accommodate this diameter of the fetus could potentially result in obstetrical complications (Caldwell et al. 1935). According to Caldwell and co-workers:

> Labor in pelves with a forward curvature of the lower sacral region is complicated frequently by the failure of the cervix to dilate and retract normally. The head, meeting the resistance of the lower sacrum and coccyx, is unable to descend far enough at the height of each contraction to bring pressure to bear against the dilatable cervix. As a result, dilation ceases usually with an appreciable rim of cervix around the head (1935:775-76).

For normal dilation and retraction of the cervix to occur:

> The head must be permitted to descend with each contraction unobstructed by the bony pelvis at any point, in order to make proper pressure against the cervix and then recede to a higher level through the elastic recoil of the soft parts as the contraction subsides (Caldwell et al. 1935:776).

The trend noted in the Arikara groups examined is a decrease in the antero-posterior capacity of the midpelvis through time. Stated another way, the degree to which the sacrum encroaches upon the midpelvis is greater in later Arikara groups. From this alone, it might be tempting to describe the bony pelvis from earlier Arikara sites as being more obstetrically efficient than their later counterparts.

Further potential support of this contention can be seen in the temporal trend noted in the variable representing the prominence of the ischial spines. The degree to which the ischial spines project appears to be related to the transverse capacity of the midpelvis. Less prominence would result in greater transverse capacity. The trend noted in the Arikara sample is for an increase in the prominence of the ischial spines through time. Therefore, the pelves from earlier Arikara sites, in addition to expressing less sacral encroachment, may be described as having greater transverse capacity of the midpelvis as measured by the distance between the ischial spines.

It is interesting to note, however, that, based on the present results, earlier Arikara pelves are also described as exhibiting narrower transverse capacity of the midpelvis as defined by Factor II of the articulated pelvis analysis. It will be recalled, however, that the shape information reflected not only the angle of the inferior pubis at the level of the ischial spine, but also subpubic angle. The obstetric significance of the subpubic angle was briefly commented upon by Caldwell et al. (1935) in their description of the potential difficulties encountered during labor in abnormal pelves. They state, "it became obvious that the size of the subpubic angle itself represented no reliable index to the ease or difficulty encountered even when narrowing existed" (Caldwell et al. 1935:777).

Three additional trends in the Arikara pelvis need to be discussed. These are: (1) an increase through time in the dimensions of the anterior portion of the pelvic inlet (or sometimes referred to as the fore pelvis), (2) a temporal increase in the size of the pelvic outlet, and (3) a decrease through time in upper iliac height. The obstetrical significance of each of these is discussed below.

In comparison to the pelves from later Arikara sites, those from earlier Arikara samples are characterized by smaller fore pelves. The obstetrical significance of this dimension is best seen as affecting the position of the fetus as it begins its descent, rather than restricting its passage (Caldwell et al. 1935), as in the antero-posterior midpelvis diameter.

According to Caldwell and co-workers (1935), the greatest diameter of the fore pelvis appears to correspond very closely to the size of the pelvic outlet as measured by the distance between the most inferior margin of each ischial tuberosity. As a result, one would expect trends in these two dimensions to be comparable. The results of the present analysis agree with this contention. Both the shape of the pelvic outlet and the size of the fore pelvis exhibit general increases through time.

It will be recalled from the Intragroup Variation section of this chapter that the pelvic outlet functions as the exit for the fetus. The degree to which the dimensions of this area can restrict the passage of the fetus is unclear. According to Linton (personal communication), once the fetus passes through the midpelvis, potential problems encountered that are attributed to the inability of the fetus to continue its descent are minimized.

The last trend in the Arikara pelves to be discussed is that of a decrease through time in upper iliac height. Unfortunately, whether this dimension plays any significant obstetric role is, at present, unknown. Therefore, a discussion of this temporal trend in light of the previously discussed results cannot be conducted.

Although the above discussion appears to point to the obstetrical importance of the trends noted in the Arikara pelvis, the exact reason(s) for this is, at present, unknown. It would be extremely tempting to relate these results to the microevolutionary trends noted in the Arikara cranium by Jantz and Key (1981). For several reasons, this would be a risky task indeed. These reasons would include: (1) the lack of information available pertaining to the relationship between adult and fetal cranial morphology, (2) the absence of studies concentrating upon the degree to which the size of the fetal skull as well as the overall size of the neonate can act as limiting factors during the birth process, and (3) the absence of information available pertaining specifically to the dimensions of the cranium and overall size of the Arikara neonate. As a result, specific conclusions concerning the reason(s) why the pelvis of the various Arikara groups examined would differ from an obstetrical perspective, cannot be drawn at present.

Age Changes

As previously mentioned in Chapter IV, there are indications that the demographic profiles of the various Arikara sites employed do differ (Owsley, personal communication). Therefore, it is possible that modifications in pelvic morphology attributable to the age of the individual may be responsible for the interpopulation differences noted. Due to sample size inadequacies, only one site, Larson, was employed. Furthermore, only females were examined.

Multiple regression results obtained for the articulated pelvis as well as the innominate were found to be non-significant. It can be concluded, therefore, that no specific age changes in the

Larson female pelvis, and potentially the Arikara female pelvis in general, can be identified. This appears to suggest that differences in site specific age structure do not play a primary role in the expression of the microevolutionary trends observed. An analysis employing a larger sample representing a greater number of sites would be necessary before the effects of age-related pelvic variation can be more thoroughly evaluated.

Although no significant age-related variation was noted, t-test results indicate that in several dimensions the articulated pelvis and innominate of young Larson females differed significantly from those representing the rest of the female sample. This appears to contradict the multiple regression results discussed above.

One possible explanation is the potential effect of growth related changes. The age category employed to represent the young Larson female sample was 15.5-19.9 years. During this period, growth of the pelvis is continuing. According to McKern and Stewart (1957), fusion of the ilial, ischial, and pubic portions of the innominate is complete by 17 years of age, while fusion of all epiphyses is complete when the individual is between 16 and 23 years of age. Therefore, it is possible that the difference noted in the pelves of young females and those representing the rest of the females in the sample could be potentially attributed to the continued growth of the pelvis in the former.

A close examination of the results presented in Tables 26 and 27, pages 100 and 101, reveals that those specimens representing the young female sample were restricted to the age category of 18.5 to 19.9 years. Based upon the growth information given above, acetabular synchondrosis as well as nearly complete fusion of the iliac crest epiphysis would have occurred in individuals within this age sample. According to Coleman (1969), the amount of pelvic growth possible following the fusion of the acetabular region is relatively small in comparison to that which has already occurred. Exactly how much growth remains and its contribution to adult morphology is at present unknown. Therefore, due to the relatively small quantity of growth which remains, growth related changes do not seem to completely resolve the above contradiction in results. However, such factors cannot be totally eliminated as potential contributors to the differences noted.

Another possible explanation for the lack of congruence between multiple regression and t-test results is non-random mortality. As stated earlier, an assumed difference between the young females and the rest of the female sample is the survival of the initial child-bearing years in the latter. Therefore, it is possible that the younger sample may represent those females who died during childbirth or as a result of complications which followed. As such, one would expect the pelves of young females to be less obstetrically efficient than those of older females. This proposition is explored below.

To recapitulate, the pelvic morphology of young Larson females differed significantly from the rest of the female sample in the following respects: (1) smaller anteroposterior diameter of the midpelvis, (2) shorter pubes and therefore a smaller fore pelvis, and (3) more curved or flared ilia and therefore a smaller false pelvis.

The obstetrical importance of the degree to which the sacrum encroaches upon the midpelvis (anteroposterior diameter) has been previously discussed. It is this dimension which accommodates the largest diameters of the descending fetus and appears to be indirectly related to the normal dilation and retraction of the cervix which is a critical element in delivery. In this one dimension, the greater degree of sacral encroachment expressed in the young female pelvis would suggest their relatively less obstetrically efficient nature. The smaller the anteroposterior diameter of the midpelvis, the greater the potential occurrence of delivery complications.

The obstetrical significance of having a smaller false and fore pelvis is at present unclear. The dimensions of the latter appear to be related to the proper positioning of the fetus prior to its descent through the bony birth canal. The degree to which improper positioning at this time can result in obstetrical complications is, at present, unclear.

The primary function of the false pelvis in a pregnant woman is supporting the uterus. The potential effect of size variation in this region and its relationship to normal delivery, is unknown. Therefore, in combination with the above information, no conclusions concerning the obstetrical significance of the trends noted in the size of the false and fore pelvis can be presented.

Although young Larson females appear to be less obstetrically efficient in their anteroposterior dimensions of the midpelvis, it is uncertain whether this alone may have produced non-random mortality. Furthermore, it is possible, given the restricted age range of the "young" specimens examined, that the sample of young Larson females employed may not represent the young females of the populations.

Unfortunately, neither of the propositions examined fully explain the difference in multiple regression and t-test results. Both, however, cannot be totally eliminated as potential contributors. Furthermore, it is possible that agents not as yet identified may also be responsible for the patterned variation noted.

Based upon the present data, therefore, the contention made by Bass and Owsley (1977) can be neither supported nor refuted. A more complete evaluation must await the results of analyses employing a much larger sample than the present.

Sexual Dimorphism

A variety of hypotheses have recently been proposed to explain varying degrees of sexual dimorphism in living as well as archaeological populations. A brief review of the recent literature on sexual dimorphism can be found in Zobeck (1983). Differences in the degree of sexual dimorphism expressed in human groups have been attributed to factors such as malnutrition and disease (or environmental variables in general) (Key 1980), genetic factors (Eveleth 1975; Stini

1975), some combination of these (Gray and Wolfe 1980), and factors of human behavior (Hall 1982).

The majority of studies examining sexual dimorphism have concentrated upon the general overall body size difference between males and females. Stature or estimates of stature (such as femoral length) have been employed to study this relationship. The potential use of the pelvis to explore the nature of sexual dimorphism in this context has yet to be evaluated. The present analysis will be one such attempt.

The pelvis is considered, for reasons outlined in Chapter I, to be the most highly sexual dimorphic element of the adult human skeleton. Coleman has suggested that sex differences in the pelvis "develop from complicated variations in rates and direction of growth of local areas of the pelvic complex" and "the patterns of growth show the same individual variability and male-female overlap as the adult configuration of pelves" (1969:125). The effect of severe malnutrition on the morphology of the bony pelvis has been described by several researchers (Dunham and Thoms 1945; Greulich and Thoms 1944, 1947; Stander 1945; Thoms 1947). Primary emphasis, however, has been placed upon describing those changes which occur in the pelvic inlet. The role of minor nutritional fluctuations in pelvic morphology has yet to be satisfactorily explored. However, Thoms suggested that "nutrition, especially during the puberal period of growth, apparently plays a major etiologic role" (1947:62) in the expression of pelvic variation.

The information on Arikara culture-history presented in Chapter II appears to indicate, at least indirectly, that the nutritional level and health status of the Arikara during the various temporal variants of the Coalescent Tradition was not consistent. More specifically, of the three temporal variants considered, the Postcontact Coalescent groups appear to have experienced relatively more favorable nutritional and general health conditions in comparison to the Extended and Disorganized Coalescent groups (Jantz and Owsley 1982).

Given the above and assuming that nutritional factors play an important role in the expression of sexual dimorphic differences in pelvic morphology between human groups, the following trend in Arikara pelvic sexual dimorphism would be expected: Postcontact Coalescent groups would express greater sexual dimorphism than either the Extended or Disorganized Coalescent groups.

The Interaction effect of the MANOVAs were examined to test whether the Arikara groups considered (i.e. Extended Coalescent, Postcontact Coalescent, and Disorganized Coalescent) differeed in the degree of sexual dimorphism expressed. It will be recalled that the factor scores employed were standardized by sex to remove as much of the size-related variation as possible. Therefore, a great majority of the variation which remains is shape related.

Two factors of the articulated pelvis analysis, Factors V and VII, were shown to exhibit significant Interaction effects. To recapitulate, Factor V was interpreted as reflecting the anteroposterior capacity of the midpelvis, while Factor VII reflects the shape of the pelvic outlet. The latter was shown to contribute most to the heterogeneity present in the Interaction effect. This factor also contributed most to the significant amount of group heterogeneity present.

Plotting the mean factor score for each group by sex allowed the visual examination of the degree of sexual dimorphism expressed. These results were presented in Figures 17 and 18 on pages 93 and 94, respectively. The degree of sexual dimorphism, therefore, is defined as the magnitude of difference in mean factor scores noted for each sex in each group. It will be recalled from the results of this analysis discussed in Chapter V that the difference between the sexes noted in both factors examined was smaller in the Postcontact Coalescent, intermediate in the Extended Coalescent, and greatest in the Disorganized Coalescent. For both factors, a marked increase in the difference between the male and female mean factor scores occurred during Disorganized Coalescent times. Given the relatively small sample size employed for this group, it is quite possible that the degree of sexual dimorphism expressed may be distorted.

The pattern of Arikara intergroup differences in sexual dimorphism, as expressed in the pelvis, is not in agreement with that expected. The opposited trend was documented. Postcontact Coalescent groups expressed the lowest, rather than the highest, degree of sexual dimorphism. In an analysis of the group patterns of sexual dimorphism expressed in the Arikara long bones, scapula and clavicle, Zobeck (1983) derived essentially similar results even though his analysis was conducted employing the individual Arikara sites as the grouping variable. If the initial assumptions outlined previously are correct, the above results do not appear to support the contention that varying levels of sexual dimorphism among the various Arikara groups examined are primarily the result of nutritional differences. It will be recalled that Postcontact times were characterized by relatively more favorable nutritional and general health conditions.

Evidence suggesting the relatively greater contribution of genetic factors may be presented upon an examination of the nature of the pelvic variables employed. In principal components analysis, the extracted factors may be interpreted to reflect size or shape variation or a combination of both. To eliminate as much of the size related variation as possible, the calculated factor scores were standardized according to sex. Such a procedure should, theoretically, produce variables which reflect greater shape than size variation.

The relatively high genetic nature of cranial shape variables has been suggested by Howells (1973). Those cranial variables which reflected shape information more effectively discriminated human groups than those relating to size. It would be tempting to suggest that Howells' contention can be extended to include pelvic variables. Final evaluation, however, must await the results of studies employing a larger and wider geographically distributed sample than the present.

The relative contribution of genetic and nutritional factors to the intergroup pattern of sexual dimorphism noted in the Arikara pelvis cannot be accurately assessed based upon the present data. Future studies designed to delineate the environmental and genetic components of pelvic variables are greatly needed if we are to more completely understand the role of such factors in the expression of sexual dimorphism in the pelvis.

Summary and Conclusions

The present analysis was designed to examine the nature of intra- and interpopulation variation in the Arikara bony pelvis. Although inconclusive, the results do seem to indicate that morphologically and functionally meaningful patterns of intrapopulation variation can be identified. The assessment of the universal nature of the pelvic structure identified must await further analysis.

It can be concluded from the previous sections of this chapter that microevolutionary change in the Arikara pelvis can be identified. The specific agent(s) to which this observed patterning might be attributable is at present unknown. Several potential explanations were examined. However, none of these alone seems to successfully explain the trends noted. It is possible that the morphological changes noted in the Arikara pelvis are not the result of a single causal factor, but rather the result of a combination of a series of complex factors, some of which have yet to be identified.

From this analysis, it appears evident that additional studies concentrating upon intra- and interpopulation variation in the human bony pelvis are needed. Such studies might include those designed to: (1) delineate the genetic and environmental components of metric variants of the pelvis, (2) further examine the nature of age-related variation in the adult pelvis employing a larger sample size than was necessitated in the present analysis, (3) identify patterns of intra-population variation in other skeletal populations of the world to aid in the assessment of the universality of the factor structures identified, (4) examine the relationship of factors such as fetal cranial dimensions and overall size of the fetus to the mechanisms of labor and their relationship to the bony pelvic girdle, and (5) further examine the structural and functional interrelationships of the various elements of the human pelvis.

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APPENDICES

APPENDIX A

MEASUREMENT CODES, DEFINITIONS, AND SOURCES

Table A-1. Variable Code, Measurement, and Instrument Employed

Variable Code	Measurement	Instrument[a]
MXH	maximum height	A
MXW	maximum width	A
IPD	maximum ischio-pubic diameter	C
MNW	minimum ilial width	C
LOH	lower iliac height	C
UPH	upper iliac height	C
DRH	direct iliac height	C
SYH	symphysis height	C
SAS	pubic symphysis to anterior superior spine	C
SAI	pubic symphysis to anterior inferior spine	C
SAR	pubic symphysis to auricular surface	C
SMS	pubic symphysis to mid-sciatic notch	C
SPI	pubic symphysis to posterior inferior spine	C
SPS	pubic symphysis to posterior superior spine	C
SAB	pubic symphysis to acetabular border	C
SIT	pubic symphysis to inferior ischial tuberosity	C
PLG	pubis length	C
ILG	ischial length	C
APS	acetabulum to posterior superior spine	C
DAC	maximum diameter of the acetabulum	D
ACD	depth of the acetabulum	D
MXA	maximum length of the auricular surface	C
RMS	auricular surface to mid-sciatic notch	C
RAB	auricular surface to acetabular border	C
RAS	auricular surface to anterior superior spine	C
RAI	auricular surface to anterior inferior spine	C
RPS	auricular surface to posterior superior spine	C
RPI	auricular surface to posterior inferior spine	C
IFB	inferior iliac breadth	C
SBB	superior iliac breadth	C
WPR	middle width of the pubic ramus	C
OBH	obturator foramen height	C
OBW	obturator foramen width	C
ITL	length of the ischial tuberosity	C
ITB	breadth of the ischial tuberosity	C
SNB	breadth of the sciatic notch	D
SCT	sciatic notch subtense	D
SCF	sciatic notch fraction	D
ABB	breadth of the anterior border	D
AST	anterior border subtense	D
AFC	anterior border fraction	D

Table A-1. (Continued)

Variable Code	Measurement	Instrument[a]
MVS	mid-ventral straight length	D
SBT	sacral subtense	D
SFC	sacral fraction	D
ASB	anterior straight breadth	C
TRS	transverse diameter of the first sacral vertebra	C
APS	anteroposterior diameter of the first sacral vertebra	C
BWD	width of the terminal sacral vertebra	C
BCB	bicristal breadth	B
ISD	interspinous diameter	B
TCD	true conjugate diameter	C
OCD	obstetric conjugate diameter	C
TDB	transverse diameter of the pelvic brim	F or C
OBD	oblique diameter of the pelvic brim	C
APO	anteroposterior diameter of the pelvic outlet	C
BSD	bispinous diameter of the midpelvis	C
GBI	greatest breadth of the pelvic inlet	F
ASS	anterior superior spine to the superior symphysis	C
ASV	anterior superior spine to the midventral promontory	C
AIV	anterior inferior spine to the midventral promontory	C
AIS	anterior inferior spine to the superior symphyseal junction	C
ITO	intertuberal diameter of the outlet	C
ACC	biacetabular breadth (acetabular cord)	E
PSB	pubic symphyseal subtense	E
PFR	pubic symphyseal fraction	E
ITS	ischial tuberosity subtense	E
ITF	ischial tuberosity fraction	E
ISB	ischial spine subtense	E
ISF	ischial spine fraction	E
JOB	ischial spine to the midpoint of the terminal sacral vertebra	C

[a]Instruments needed:

A = osteometric board; B = spreading calipers (hinged calipers); C = sliding calipers; D = coordinate calipers; E = coordinate calipers--radiometer; F = anthropometer.

Table A-2. Innominate Measurements

Measurement	Description	Source
Maximum height (a)	maximum distance measured from the caudal point on the ischium to the most cephalic point on the iliac crest	Bass 1971
Maximum width (b)	widest distance across the iliac blade	Bass 1971
Maximum ischio-pubic diameter (e)	measured from the corner of the pubic symphysis to the most distant point on the ischial tuberosity	Comas 1960
Minimum ilium width (d)	shortest distance from the sacro-iliac notch to the point where the ilium forms the beginning of the pubic ramus. The specimen is positioned such that the measurer is looking directly into the acetabulum at eye level	Comas 1960
Lower iliac height (h)	distance along the iliopectineal line from the auricular surface to the ilio-pubic junction on the iliopectineal line	Straus 1927
Upper iliac height (g)	distance between the point where the ilio-pectineal line forms the auricular surface at the iliac crest at the attachment of the iliolumbar ligament; point at which this area thins out	Straus 1927
Direct iliac height (f)	distance between the ilioischiopubic tubercle and the iliac crest at the attachment of the iliolumbar ligament	Straus 1927
Height of the pubic symphysis (i)	upper to lower border of the symphyseal face	Howells and Hotelling 1936
Pubic symphysis to anterior superior spine (j)	from the upper border of the symphyseal face to the anterior superior spine at its most anterior projection	Present study

Table A-2. (Continued)

Measurement	Description	Source
Pubic symphysis to anterior inferior spine (k)	from the upper border of the symphyseal face to the anterior inferior spine at the midpoint of its most anterior projection	Present study
Pubic symphysis to auricular surface (t)	from the upper border of the symphyseal face to the pectineal line where it meets the auricular surface	Present study
Pubic symphysis to mid-sciatic notch (s)	from the upper border of the symphyseal face to the midpoint of the greater sciatic notch	Present study
Pubic symphysis to terminal tip of the auricular facet (r)	from the upper border of the symphyseal face to the terminal tip of the auricular surface	Steudel 1981
Pubic symphysis to posterior superior spine (cc)	from the upper border of the symphyseal face to the posterior superior spine at the most posterior projection	Present study
Pubic symphysis to nearest acetabular border (mm)	from the upper border of the symphyseal face to the nearest acetabular border	Day and Pitcher-Wilmont 1975
Pubic symphysis to inferior ischial tuberosity (a)	from the upper border of the symphyseal face to the most inferior portion of the ischial tuberosity	Present study
Pubis length (ff)	from the point at which the ischium and pubis meet in the acetabulum to the furthest extension of the symphysis	Washburn 1948
Ischial length (gg)	from the point at which the ischium and pubis meet in the acetabulum to the most inferior extension of the ischial tuberosity	Washburn 1948

Table A-2. (Continued)

Measurement	Description	Source
Acetabulum to posterior superior spine (dd)	from the point at which the ischium and pubis meet in the acetabulum to the posterior superior spine	Present study
Acetabulum to posterior inferior spine (hh)	from the point at which ischium and pubis meet in the acetablum to the terminal tip of the auricular facet	Present study
Acetabulum to anterior superior spine (ee)	from the point at which the ischium and pubis meet in the acetablum to the anterior superior spine	Present study
Acetablum to anterior inferior spine (aa)	from the point at which the ischium and pubis meet in the acetablum to the anterior inferior spine	Present study
Maximum diameter of the acetabulum (ii)	maximum diameter of the acetablum measured from inner border to inner border	Day and Pitcher-Wilmott 1975
Depth of the acetabulum	the perpendicular distance between the plane of the acetabular rim and the center of the acetabulum (cannot be illustrated)	McHenry 1976
Maximum length of the auricular surface (c)	greatest length across the auricular surface	Comas 1960
Auricular surface to mid-sciatic notch (bb)	measured from the point where the pectineal line meets the auricular surface to the midpoint of the greater sciatic notch	Present study
Auricular surface to acetabular border (z)	measured from the point where the pectineal line meets the auricular surface to the nearest acetabular border	Present study

Table A-2. (Continued)

Measurement	Description	Source
Auricular surface to anterior superior spine (v)	measured from the point where the pectineal line meets the auricular surface to the anterior superior spine	Present study
Auricular surface to anterior inferior spine (u)	measured from the point where the pectineal line meets the auricular surface to the anterior inferior spine	Present study
Auricular surface to posterior superior spine (w)	measured from the point where the pectineal line meets the auricular surface to the posterior superior spine	Present study
Auricular surface to terminal tip of the auricular surface (aa)	measured from the point where the pectineal line meets the auricular surface to the terminal tip of the auricular surface	Present study
Inferior iliac breadth (y)	taken from the terminal end of auricular surface to a point on the most anterior margin of the anterior inferior spine	Steudel 1981
Superior iliac breadth (x)	measured from anterior superior spine to posterior superior spine	Steudel 1981
Middle width of the pubic ramus (ll)	from a point halfway down to the pubis ramus to the nearest point on the obturator foramen, parallel to the superior ramus	Day and Pitcher-Wilmott 1975
Height of the obturator foramen (jj)	maximum vertical of the obturator foramen perpendicular to the superior pubis ramus	Day and Pitcher-Wilmott 1975
Width of the obturator foramen (kk)	maximum horizontal diameter of the obturator foramen parallel to the superior pubic ramus	Day and Pitcher-Wilmott 1975

Table A-2. (Continued)

Measurement	Description	Source
Length of the ischial tuberosity (l)	taken from the most superior extent of the tuberosity at its most medial extent in a straight line	Steudel 1981
Breadth of the ischial tuberosity (m)	maximum breadth across the ischial tuberosity	Steudel 1981
Breadth of the sciatic notch (sciatic notch chord) (n)	inside distance between the deepest points in the curve formed by the sides of the notch	Howells and Hotelling 1936
Sciatic notch subtense (o)	maximum depth of the sciatic notch perpendicular to the above	Present study
Sciatic notch fraction (p)	point of maximum depth on the sciatic notch chord	Present study
Anterior border breadth (anterior border chord) (mm)	measured from anterior superior spine to anterior inferior spine	Present study
Anterior border subtense (pp)	maximum depth of the anterior border perpendicular to the above	Present study
Anterior border fraction (oo)	point of maximum depth on the anterior border chord	Present study

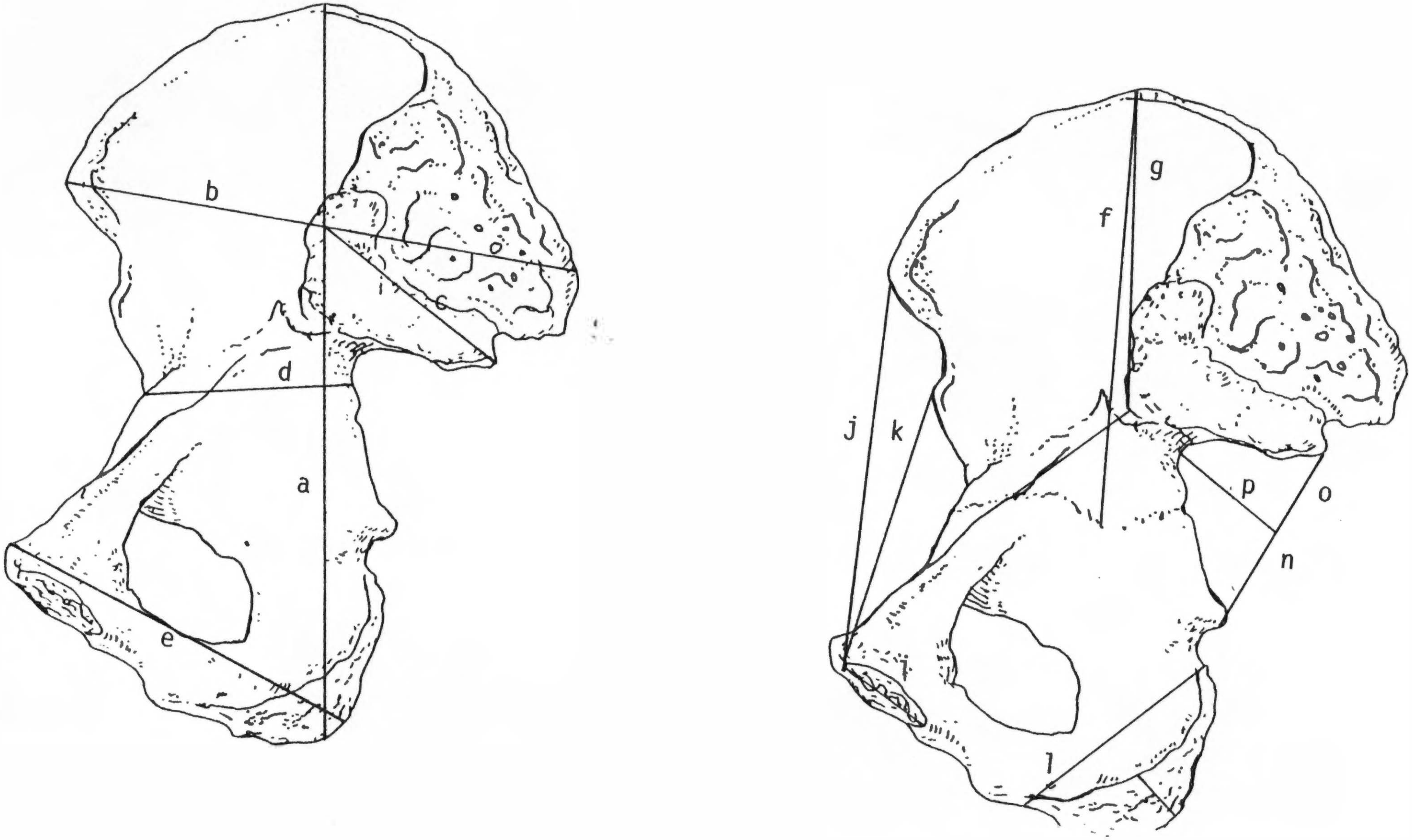

Figure A-1. Innominate Measurement Illustrations (a-p)

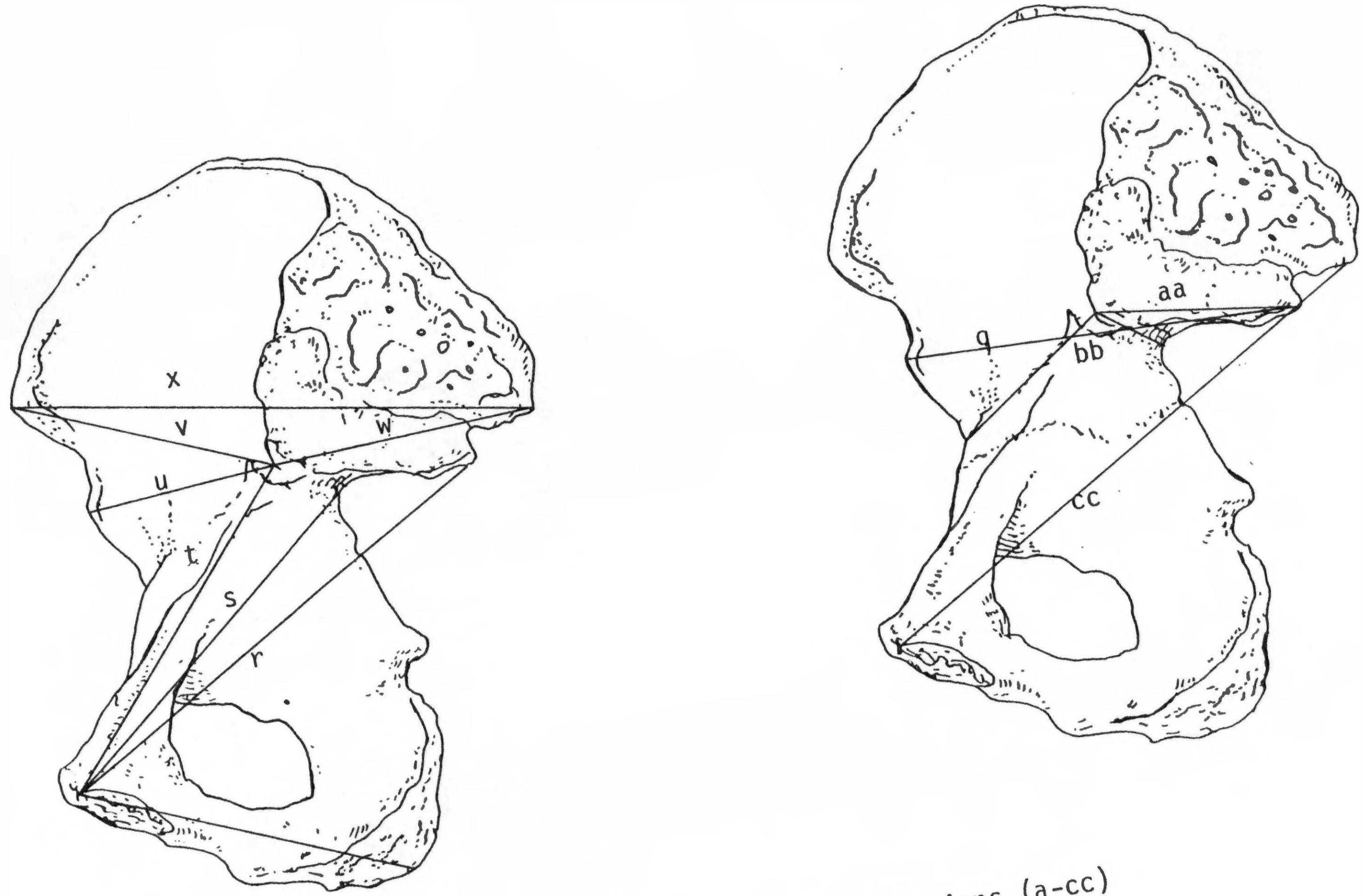

Figure A-2. Innominate Measurement Illustrations (a-cc)

Figure A-3. Innominate Measurement Illustrations (dd-aa)

Table A-3. Articulated Pelvic Measurements

Measurement	Description	Source
Bicristal breadth (a)	maximum breadth of the pelvis from the outer edges of the iliac crest	Howells and Hotelling 1936
Interspinous diameter (b)	breadth of the pelvis measured from the external surface of one anterior superior iliac spine to the other	Caldwell and Maloy 1933
True conjugate diameter (c)	measured from the midpoint of the ventral lip of the sacral promontory to the suprasymphyseal point; at the level of the iliopectineal line	Nicholson 1945
Obstetric conjugate diameter (f)	shortest diameter of the pelvic brim from the midpoint of the ventral lip of the sacral promontory to the inner surface of the pubis; somewhat below supra-symphyssion	Howells and Hotelling 1936
Transverse diameter of pelvic brim (d)	maximum breadth between the ilio-pectineal lines perpendicular to the axis of the true conjugate diameter	Nicholson 1945
Oblique diameter of the pelvic brim (e)	measured from the sacroiliac and point on one side at level of the iliopectineal line to the opposite eminence	Howells and Hotelling 1936
Anteroposterior diameter of outlet (g)	from the inferior border of the symphysis to the anterior-inferior margin of the last sacral vertebra in midline	Molsted-Pederson 1974
Bispinous diameter of the midpelvis (i)	the distance between the inner edges of the ischial spines	Caldwell et al. 1935
Greatest breadth of the pelvic inlet (j)	maximum transverse distance between the pectineal lines	Schultz 1930

Table A-3. (Continued)

Measurement	Description	Source
Anterior superior spine to symphysis (k)	anterior superior spine to the most superior border of the pubic symphysis	Present study
Sacrum to anterior superior spine (l)	midpoint of the sacral promontory of the anterior superior spine	Present study
Sacrum to anterior inferior spine (m)	midpoint of the sacral promontory to the anterior inferior spine	Present study
Anterior inferior spine to symphysis (n)	anterior inferior spine to superior border of the pubic symphysis	Present study
Intertuberal diameter (o)	distance between the most inferior portions of each ischial tuberosity	Present study
Biacetabular breadth (acetabular chord) (p)	distance between the acetabulae at the point where the three elements of the pelvis unite	Present study
Pubic subtense	maximum depth from biacetabular chord to the most superior part of the pubic symphysis	Present study
Ischial tuberosity subtense	maximum depth from biacetabular chord to the most inferior part of the ischial tuberosity	Present study

Table A-3. (Continued)

Measurement	Description	Source
Ischial tuberosity fraction	point of maximum depth of the inferior tuberosity on acetabular chord	Present study
Ischial spine subtense	maximum depth from biacetabular chord to the inner edge of the ischial spine	Present study
Ischian spine fraction	point of maximum depth of the ischial spine on the acetabular chord	Present study
Ischial spine to last sacral vertebra (h)	from the inner edge of the ischial spine to the midpoint of the last sacral vertebrae	Present study

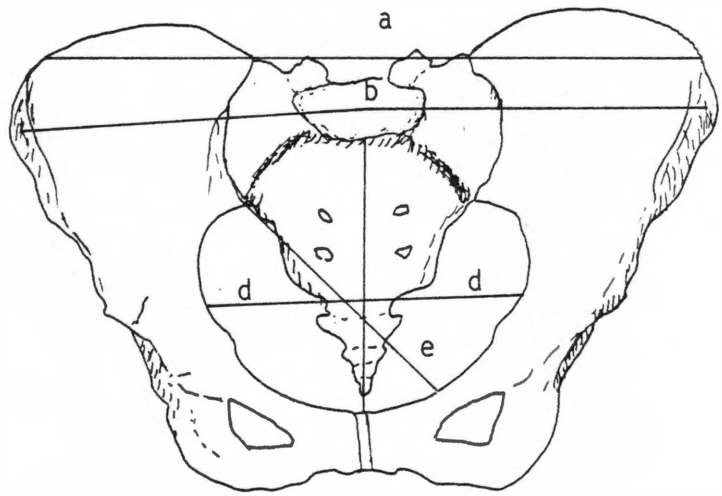

Figure A-4. Articulated Pelvis Measurement Illustrations (a-e)

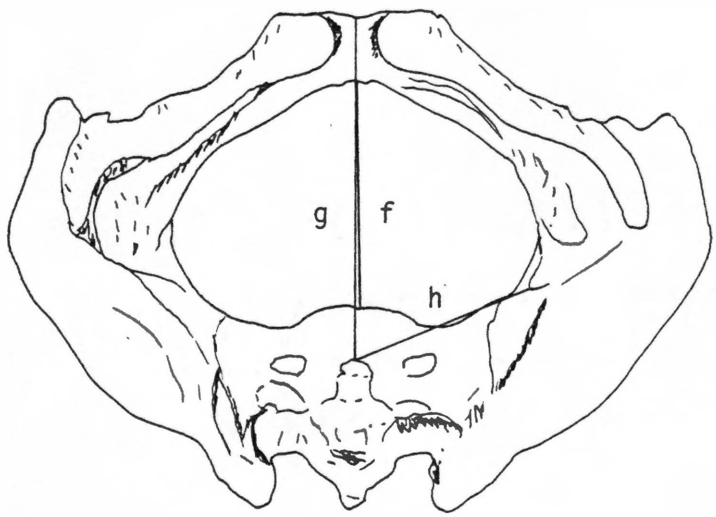

Figure A-5. Articulated Pelvis Measurement Illustrations (f-h)

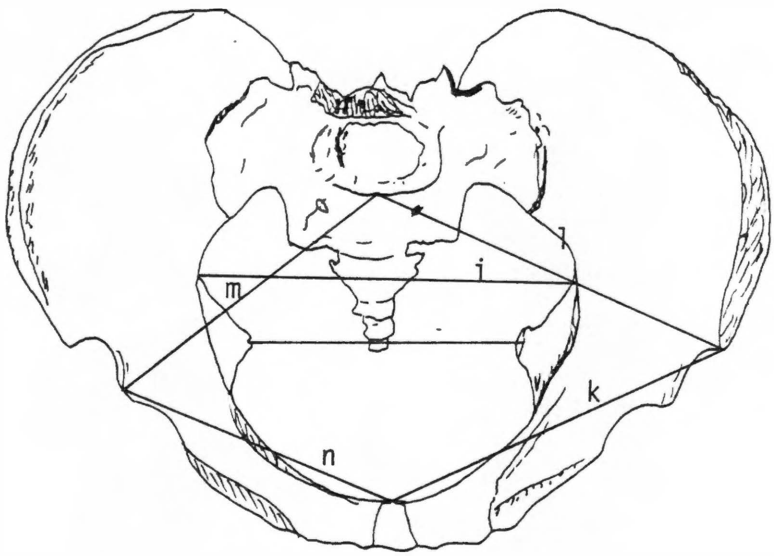

Figure A-6. Articulated Pelvis Measurement Illustrations (i-n)

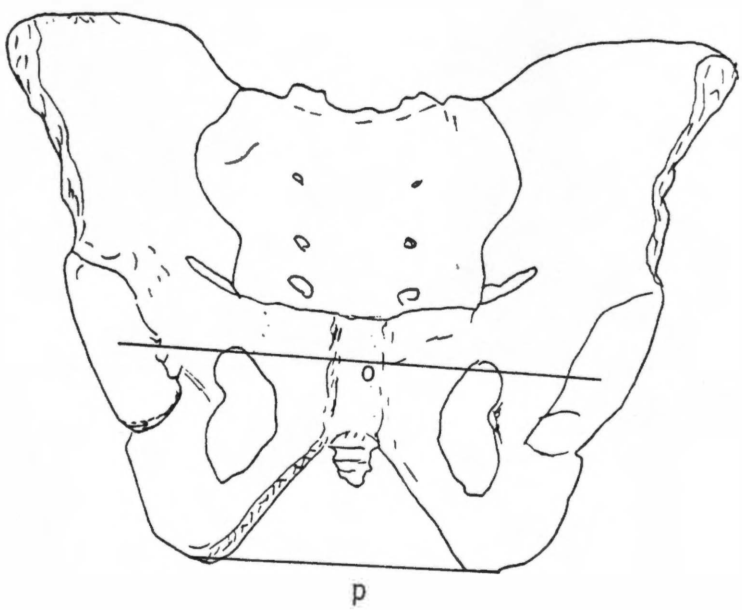

Figure A-7. Articulated Pelvis Measurement Illustrations (o-p)

Table A-4. Sacral Measurements

Measurement	Description	Source
Mid-ventral straight length (a)	Maximum distance measured from the midpoint of the sacral promontory to the most distant point on the last sacral vertebra (sacral chord)	Fawcett 1938
Sacral sub-tense (f)	maximum depth of curvature measured perpendicular to the mid-ventral straight length	Present study
Sacral fraction (b)	point of maximum curvature measured on the sacral chord	Present study
Anterior straight breadth (f)	maximum breadth taken as the maximum transverse distance across the sacral ala	Fawcett 1938
Transverse diameter of the first sacral vertebra (d)	maximum transverse distance across the centrum of the first sacral vertebra	Flanders 1978
Anteroposterior diameter of the first sacral vertebra (e)	maximum anteroposterior diameter of the first sacral vertebra	Flanders 1978
Basal width (g)	maximum transverse distance across the last sacral vertebra at the coccygeal articulation	Fawcett 1938

Figure A-8. Sacral Measurement Illustrations (a-e)

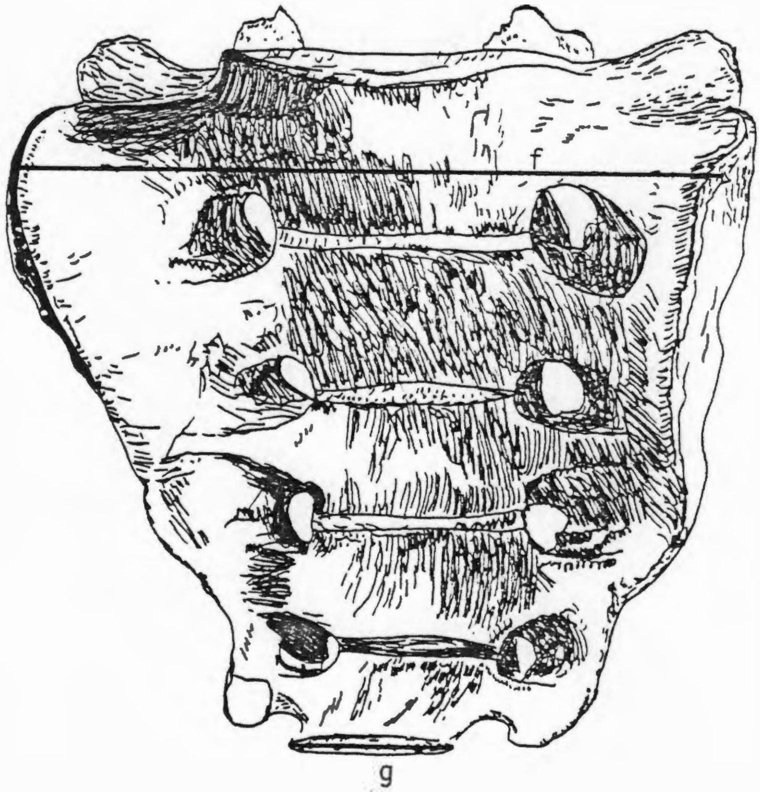

Figure A-9. Sacral Measurement Illustrations (f-g)

APPENDIX B

DESCRIPTIVE STATISTICS

Table 5-1. Innominate Means and Standard Deviations by Site and Sex

Variables

Site	Sex		MXH	MXW	IPD	MNW	LOH	UPH	DRH	SYH	SAS	SAI	SAR	SMS	SPI	SPS	SAB	SIT	FLG	ILG	APS
Stony Point	♂	X̄	222.3	169.3	129.7	55.7	31.0	85.7	127.3	40.0	146.3	108.0	123.0	123.7	151.7	163.0	85.0	122.3	95.7	89.0	101.0
		SD	11.0	7.2	6.5	3.2	2.0	2.5	5.0	5.3	15.0	10.6	15.7	10.0	12.6	15.1	3.0	5.5	3.8	2.0	7.5
	♀	X̄	214.5	156.4	124.5	50.0	34.8	76.0	118.4	40.7	143.7	104.5	129.5	125.0	157.5	169.3	82.3	118.7	94.7	77.0	103.4
		SD	6.7	2.2	6.2	3.5	8.3	3.2	3.2	2.2	5.3	3.4	11.1	10.4	16.6	13.9	9.0	6.4	6.5	3.5	6.7
Mobridge F	♂	X̄	222.1	162.9	122.9	58.5	47.6	77.5	131.1	45.3	143.0	102.8	124.1	120.7	149.3	162.6	75.7	118.9	89.7	85.2	101.7
		SD	8.2	8.0	6.4	3.8	6.5	5.3	8.2	5.2	8.9	5.3	7.2	4.7	5.2	9.9	5.6	7.1	4.0	4.0	6.1
	♀	X̄	204.6	154.7	116.1	55.4	50.3	71.1	121.3	43.1	139.5	102.7	124.3	121.1	154.2	166.4	78.0	117.3	91.5	78.5	101.4
		SD	9.5	5.8	9.1	2.6	7.4	6.7	8.3	3.4	6.3	4.5	9.1	6.0	7.4	10.6	6.3	6.3	4.1	4.9	5.3
Mobridge F2	♂	X̄	220.6	163.7	123.2	53.4	36.5	83.6	125.9	42.6	139.0	102.4	119.6	118.5	143.8	157.6	77.3	118.3	91.2	85.5	101.0
		SD	8.4	6.1	5.1	3.9	6.4	5.9	6.3	4.4	9.1	4.6	7.1	6.0	9.1	9.6	6.0	5.5	4.9	3.7	5.1
	♀	X̄	203.4	150.8	117.6	46.9	41.9	70.8	116.0	40.2	134.8	100.1	120.4	116.6	146.0	157.3	77.3	111.4	90.5	79.2	100.0
		SD	8.5	7.1	6.3	7.7	9.3	12.1	6.6	3.8	7.4	5.3	7.8	6.0	9.5	8.6	6.6	6.2	6.1	4.4	5.5
Larson	♂	X̄	219.2	163.0	123.0	55.9	42.3	80.3	127.4	43.3	140.6	103.6	120.0	118.7	145.4	159.9	82.0	117.9	90.5	84.3	101.3
		SD	7.7	9.8	5.7	3.9	5.2	5.9	5.5	4.2	7.5	5.5	6.4	5.5	7.7	7.4	5.6	6.6	5.1	4.3	5.0
	♀	X̄	204.3	152.5	120.4	50.9	46.7	72.4	119.8	42.0	137.6	101.7	122.3	118.8	147.6	161.8	82.6	115.3	92.3	77.8	100.3
		SD	8.3	7.3	6.9	4.4	5.3	5.9	5.8	3.9	7.7	5.4	7.2	6.6	9.7	8.4	6.9	6.9	5.8	3.9	5.5
Four Bear	♂	X̄	-	-	-	60.0	35.0	89.0	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	198.7	147.0	12.0	47.0	38.0	74.7	113.0	42.0	130.3	97.7	115.3	113.0	142.7	155.7	79.7	114.7	91.3	73.7	98.7
		SD	3.1	1.7	4.0	2.2	1.6	2.6	6.3	3.0	3.1	2.5	3.1	2.0	5.0	10.4	2.5	5.0	2.1	1.3	7.8
Sully A	♂	X̄	219.1	162.6	119.5	52.4	32.3	83.7	122.7	42.4	139.0	103.5	117.5	117.1	132.6	156.1	75.4	114.2	88.5	81.9	100.3
		SD	6.1	8.0	4.8	3.8	3.6	4.5	4.4	4.0	9.5	6.2	5.0	4.7	36.7	3.2	3.2	5.3	4.0	3.4	5.2
	♀	X̄	199.4	153.8	116.9	46.6	39.7	74.6	113.0	39.9	132.9	99.7	121.6	117.2	147.1	159.8	77.0	111.7	90.1	73.7	102.1
		SD	11.1	7.5	8.9	5.9	7.9	6.2	4.0	3.4	10.3	8.2	5.7	6.1	9.2	4.5	5.1	9.3	6.5	4.1	2.3
Sully D	♂	X̄	217.3	160.1	122.8	56.0	35.8	83.6	120.4	41.8	133.8	107.9	117.1	118.5	142.2	157.1	76.5	118.1	87.8	82.3	100.0
		SD	10.7	11.6	6.1	8.7	7.4	6.9	8.6	3.1	14.1	14.6	6.5	7.2	8.9	8.7	4.3	6.3	6.0	5.6	6.2
	♀	X̄	205.9	154.7	118.9	53.8	38.3	76.0	111.3	41.4	137.0	104.3	123.3	121.6	148.5	160.8	76.5	114.9	91.1	77.6	101.2
		SD	9.4	5.1	7.0	4.4	5.4	5.5	7.3	4.9	8.9	5.0	5.3	3.4	7.3	6.4	5.3	5.9	5.7	4.1	4.3
Sully E	♂	X̄	217.7	163.5	122.1	58.9	43.2	80.5	116.9	43.8	137.4	103.6	121.4	119.6	147.4	162.9	73.3	117.3	88.6	85.2	103.3
		SD	7.9	6.3	4.3	3.8	5.8	7.1	8.0	4.5	10.2	5.6	4.3	4.9	5.3	5.8	5.3	3.7	5.8	4.8	4.6
	♀	X̄	204.0	155.7	118.0	57.8	49.5	73.2	112.6	40.6	134.3	98.0	122.2	118.5	148.6	163.7	72.8	114.0	89.2	77.5	107.6
		SD	10.6	7.4	9.5	5.1	6.4	6.1	9.1	3.4	9.9	5.2	10.3	8.1	10.5	12.0	2.4	8.5	5.4	5.1	7.3
Leavitt	♂	X̄	216.3	162.2	122.0	54.0	31.4	83.0	122.6	40.7	132.3	97.3	123.3	120.7	148.0	161.7	77.3	118.0	89.7	84.6	104.5
		SD	8.0	5.6	5.2	4.5	1.3	4.7	5.2	5.0	22.4	9.3	3.2	4.5	2.6	4.5	4.0	5.0	5.7	3.2	3.9
	♀	X̄	212.0	155.5	127.0	53.0	34.0	74.5	114.0	39.0	134.0	106.0	127.0	123.0	157.0	164.0	84.0	126.0	96.0	76.5	103.5
		SD	-	7.8	-	0.0	0.0	12.0	12.7	-	-	-	-	-	-	-	-	-	-	4.9	0.7
Oahe Village	♂	X̄	217.2	115.3	120.7	49.5	33.7	86.0	128.0	41.2	141.5	107.0	117.0	119.0	142.7	151.7	82.5	117.0	92.5	82.0	97.0
		SD	11.9	6.7	4.8	4.4	1.5	8.2	7.5	4.8	10.5	5.1	4.8	3.6	6.4	4.7	1.3	5.8	3.4	7.1	1.0
	♀	X̄	216.0	155.0	127.0	50.0	43.0	80.0	125.0	41.0	140.0	101.0	134.0	125.0	169.0	181.0	76.0	123.0	95.0	83.0	111.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swan Creek	♂	X̄	225.3	173.3	127.7	50.7	33.0	83.7	122.0	42.3	144.7	106.7	120.2	120.2	151.0	163.3	80.5	123.0	90.3	83.0	103.3
		SD	4.7	4.9	5.9	2.2	2.4	8.9	6.7	3.0	9.6	8.4	8.4	9.1	3.6	6.3	2.6	4.3	4.9	5.2	2.1
	♀	X̄	202.5	147.5	115.5	47.0	34.3	76.0	114.7	37.0	131.0	96.5	124.5	118.5	150.0	160.5	79.5	114.5	88.5	70.5	100.0
		SD	3.5	2.1	0.7	0.0	1.5	3.6	5.0	1.4	4.2	0.7	2.1	0.7	5.6	7.8	2.1	0.7	4.9	6.4	5.7
Rygh	♂	X̄	215.2	161.7	124.3	53.9	33.5	86.2	123.1	40.1	135.5	99.9	115.6	118.9	143.9	155.2	80.0	118.3	91.9	84.3	98.1
		SD	7.5	5.3	6.0	4.3	3.4	3.9	5.4	3.2	10.3	5.6	7.5	7.2	9.3	10.4	5.4	4.8	4.4	5.6	6.1
	♀	X̄	206.0	153.4	118.0	48.0	36.9	76.3	115.5	39.6	134.4	99.6	120.3	118.2	149.1	160.0	78.7	112.2	90.9	76.6	100.1
		SD	9.9	7.6	8.6	3.9	5.9	4.3	6.9	3.5	7.2	5.2	6.0	4.4	6.6	6.7	4.6	6.0	7.4	5.3	4.9
Leavenworth	♂	X̄	218.9	162.0	122.8	54.5	37.2	84.3	125.8	42.1	137.9	104.2	119.1	119.9	145.5	158.6	77.0	118.0	90.0	85.5	101.0
		SD	9.9	7.8	5.4	3.6	5.6	5.9	6.3	4.7	12.0	6.9	7.9	6.8	7.8	9.2	7.3	5.3	5.9	4.8	6.0
	♀	X̄	205.1	154.0	122.5	49.6	40.6	76.7	118.6	41.8	138.0	102.9	123.6	122.3	151.8	161.1	80.7	115.6	94.9	78.4	98.7
		SD	14.3	9.8	9.3	5.1	6.3	5.5	7.3	3.1	11.0	8.8	10.3	9.4	10.1	12.0	9.0	8.6	8.7	4.1	7.3

Site	Sex		API	AAS	AA1	DAC	ACD	MXA	RMS	RAB	RAS	RAT	RPS	RPI	IFB	SBB	WPR	OBH
Stony Point	♂	X̄	80.0	92.0	53.3	54.0	26.3	60.7	27.7	72.3	99.7	76.3	69.4	57.7	125.3	165.7	19.3	35.3
		SD	4.0	6.2	5.0	1.7	0.6	3.8	1.1	4.0	7.0	8.5	4.9	3.8	8.3	7.6	0.6	1.2
	♀	X̄	87.6	90.4	49.6	49.0	21.7	58.0	32.2	75.0	96.0	75.8	62.2	55.4	122.8	154.8	16.3	34.7
		SD	8.8	2.1	2.3	2.9	1.7	3.4	6.9	6.6	2.9	6.1	4.0	4.1	4.8	1.9	1.9	1.3
Mobridge F	♂	X̄	78.1	96.6	54.1	51.7	24.5	58.9	31.3	76.8	98.6	77.0	63.7	55.8	120.5	158.9	18.1	36.9
		SD	5.6	6.5	3.3	2.3	1.9	3.6	4.3	5.3	6.9	7.0	4.1	3.6	6.3	7.8	3.0	2.6
	♀	X̄	81.9	89.9	50.1	48.1	23.1	55.9	31.0	75.0	95.5	75.4	61.1	52.3	119.0	151.9	14.6	33.4
		SD	5.1	5.3	3.6	1.9	2.4	3.7	4.7	7.2	7.2	7.3	4.4	3.7	5.7	5.7	1.7	2.2
Mobridge F2	♂	X̄	79.3	90.2	51.7	51.0	23.8	59.2	29.3	75.8	98.1	77.0	63.2	54.5	120.7	160.2	18.3	36.4
		SD	6.0	5.6	3.0	2.3	1.7	3.8	3.7	5.2	5.6	4.8	3.1	3.6	5.3	5.8	2.5	2.8
	♀	X̄	81.5	83.8	46.6	46.8	21.8	53.9	29.5	73.5	93.2	73.7	58.8	50.0	115.7	148.4	13.8	34.2
		SD	6.1	4.3	3.6	2.3	1.9	2.5	4.3	6.4	6.8	6.5	4.3	3.3	6.0	7.1	1.7	2.9
Larson	♂	X̄	78.7	91.3	53.5	51.4	24.4	58.8	29.1	75.5	96.7	76.4	63.9	54.1	120.9	159.0	16.7	36.4
		SD	5.0	4.5	3.9	2.3	2.4	4.9	3.3	4.6	5.0	5.1	3.8	4.8	6.4	8.9	2.5	2.8
	♀	X̄	80.4	87.6	48.3	47.3	22.1	54.8	29.5	73.9	93.5	74.4	59.4	49.8	116.4	150.4	12.7	34.0
		SD	6.7	4.6	3.6	2.5	1.7	4.7	3.8	5.5	5.2	5.0	4.7	5.4	7.3	6.7	2.0	2.4
Four Bear	♂	X̄	-	-	54.0	55.5	28.0	-	35.0	85.0	-	84.0	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	81.0	83.7	46.5	45.5	21.7	53.5	28.2	70.5	89.7	70.2	57.3	50.0	113.2	145.7	13.3	33.2
		SD	4.2	3.0	2.4	1.3	1.5	5.3	3.3	5.4	5.0	5.6	4.2	2.2	4.7	2.1	2.1	2.4
Sully A	♂	X̄	80.3	89.4	52.6	51.5	23.7	60.4	28.2	72.7	96.1	73.7	64.5	54.7	116.3	159.7	18.5	34.4
		SD	5.3	6.9	3.7	2.0	1.2	5.4	2.4	4.8	6.1	5.2	5.1	5.0	13.8	7.3	2.2	2.5
	♀	X̄	81.4	82.1	46.7	47.5	21.2	51.9	29.1	74.6	95.7	76.0	58.1	46.9	113.6	151.6	14.7	34.9
		SD	4.2	4.3	3.5	1.9	1.2	5.1	3.1	3.0	4.5	3.5	2.3	3.3	3.7	5.9	2.3	2.7
Sully D	♂	X̄	75.3	88.7	57.2	52.2	24.7	59.2	29.8	76.9	96.2	78.5	62.7	52.5	120.1	156.2	17.8	35.4
		SD	8.6	9.0	9.3	3.3	2.1	4.8	3.2	6.0	6.9	6.4	4.9	6.3	8.1	9.7	2.8	2.9
	♀	X̄	83.5	85.5	50.3	48.5	22.3	55.4	28.7	74.5	95.6	75.8	60.1	50.9	119.8	152.2	14.4	34.7
		SD	6.9	4.5	3.4	2.4	1.4	3.1	4.1	6.0	6.7	6.3	3.7	3.6	6.1	5.1	2.0	2.3
Sully E	♂	X̄	80.2	91.8	54.9	51.2	23.3	60.5	29.2	74.5	96.5	76.5	64.6	55.7	121.0	159.0	19.0	37.1
		SD	4.0	8.1	3.7	2.5	1.9	5.6	3.6	4.3	4.7	4.9	3.7	4.4	6.1	6.7	2.4	3.3
	♀	X̄	83.5	85.4	46.4	47.7	22.3	56.4	31.0	76.7	95.2	76.3	61.7	52.6	120.7	153.3	15.6	34.6
		SD	8.6	3.6	3.9	2.6	3.2	3.8	4.7	7.5	6.5	7.1	2.0	4.9	8.3	7.0	2.9	5.2
Leavitt	♂	X̄	81.6	89.7	52.5	51.3	25.0	55.6	28.6	76.7	98.5	76.0	62.0	52.0	121.0	159.5	17.7	35.0
		SD	4.3	8.3	2.4	1.1	2.6	3.2	2.8	5.0	3.9	7.4	2.7	2.1	8.2	5.6	0.6	1.0
	♀	X̄	84.0	88.0	49.0	51.0	22.5	52.0	32.5	79.5	95.5	78.0	59.5	49.0	117.5	156.5	15.0	37.0
		SD	7.1	2.8	1.4	1.4	2.1	2.8	2.1	3.5	9.2	2.8	3.5	1.4	7.8	4.9	-	-
Oahe Village	♂	X̄	77.3	89.2	52.0	50.5	23.5	61.0	25.5	70.5	95.5	73.7	61.3	54.3	119.7	152.3	20.0	37.2
		SD	2.5	5.8	3.2	2.1	1.0	5.3	2.1	4.2	10.5	7.9	1.1	0.6	13.3	9.0	2.9	2.6
	♀	X̄	97.0	78.0	44.0	50.0	22.0	61.0	30.0	77.0	98.0	77.0	61.0	56.0	128.0	115.0	16.0	36.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swan Creek	♂	X̄	79.3	92.3	55.3	52.0	25.7	58.0	30.0	75.2	99.3	78.0	65.3	55.3	124.3	167.0	19.3	35.5
		SD	3.2	5.7	6.2	2.9	2.6	2.6	3.8	7.1	9.6	7.7	3.2	3.1	3.5	1.0	2.9	2.1
	♀	X̄	80.0	66.0	42.5	46.3	20.3	54.0	27.0	72.7	89.5	71.0	56.5	49.0	113.5	146.0	13.0	33.5
		SD	2.8	1.4	0.7	1.5	1.5	1.4	2.0	2.5	2.1	0.0	0.7	1.4	2.1	2.8	1.4	2.1
Rygh	♂	X̄	76.9	87.8	52.1	50.7	24.4	57.4	27.9	72.7	96.6	75.5	61.5	52.8	118.6	156.5	17.4	35.6
		SD	5.2	6.1	2.6	1.9	1.0	3.7	2.6	3.0	5.5	3.8	4.2	3.9	6.2	4.9	1.9	2.1
	♀	X̄	82.0	83.8	47.9	46.9	21.3	55.7	29.0	71.8	92.7	73.5	59.1	50.8	118.3	151.2	14.3	33.7
		SD	7.3	5.4	2.8	2.5	1.6	3.4	2.7	5.9	7.5	7.1	3.4	3.3	7.6	6.7	2.2	2.0
Leavenworth	♂	X̄	79.3	88.6	53.0	51.9	24.1	58.5	28.6	75.0	95.5	76.7	63.9	54.9	120.9	156.2	18.3	35.3
		SD	5.7	6.9	3.9	2.6	2.1	4.4	4.0	4.4	6.1	4.9	4.1	4.1	6.5	7.7	2.4	3.1
	♀	X̄	82.5	85.8	46.4	47.7	21.7	53.0	28.3	71.8	96.7	75.9	58.6	50.2	120.0	153.1	14.7	35.3
		SD	6.3	5.5	3.9	1.4	2.0	4.3	4.5	6.8	8.0	7.7	7.1	4.8	7.4	8.9	4.5	4.3

Site	Sex		OBW	ITB	SNB	SCT	SCF	ABB	AST	AFC	IPA	PAA	SIA	IFA	AIA	AFA	ABA	SNA
Stony Point	♂	X̄	47.0	30.0	42.3	33.7	27.7	44.0	9.3	25.3	82.7	51.0	62.3	64.7	56.3	42.7	133.0	57.3
		SD	3.6	2.6	5.0	1.1	16.7	4.0	1.1	1.5	3.2	1.0	2.3	4.2	3.2	4.2	1.7	4.7
	♀	X̄	50.7	25.3	50.2	31.4	23.0	45.0	7.2	24.2	86.7	52.7	68.5	59.0	61.7	41.2	144.6	75.0
		SD	2.2	0.9	4.3	2.1	9.2	3.9	2.0	2.4	5.5	4.5	5.3	3.8	4.6	3.9	8.2	8.3
Mobridge F	♂	X̄	47.3	30.0	42.3	30.7	21.8	46.0	8.5	22.4	85.2	48.9	63.7	62.7	58.4	42.5	138.3	62.8
		SD	3.8	2.5	3.4	3.4	13.8	5.7	1.2	5.5	6.0	3.3	2.7	2.7	4.8	2.5	5.7	6.9
	♀	X̄	44.6	26.7	48.0	29.3	26.2	44.2	7.6	22.8	87.0	51.2	69.7	58.7	60.4	41.9	140.6	74.3
		SD	4.1	2.0	4.7	3.8	11.0	4.6	1.5	4.9	4.9	2.7	4.9	2.2	4.9	2.6	8.3	6.0
Mobridge F2	♂	X̄	47.9	29.2	41.4	29.9	20.6	42.6	8.4	22.2	84.3	49.8	63.3	64.9	57.3	43.6	135.6	63.3
		SD	3.8	2.3	4.1	3.5	12.8	5.0	2.1	4.8	5.0	3.0	3.2	2.7	4.3	2.3	10.8	8.5
	♀	X̄	44.3	26.1	48.3	28.6	25.7	41.2	7.2	21.3	81.5	53.7	67.5	60.7	60.3	42.3	140.5	76.7
		SD	3.4	2.1	5.3	3.5	10.0	3.6	1.8	3.8	3.9	2.8	3.9	2.7	4.2	2.6	8.5	7.3
Larson	♂	X̄	47.7	29.8	41.2	29.8	23.1	41.3	8.4	21.0	85.4	49.5	64.5	63.1	57.2	42.6	134.7	63.5
		SD	3.8	3.8	4.8	3.3	12.3	4.3	1.8	4.6	4.7	3.1	3.1	3.4	3.9	2.7	8.7	6.9
	♀	X̄	45.2	25.9	47.3	28.2	26.4	43.0	7.5	22.3	85.2	52.8	68.8	59.4	60.2	41.8	140.0	77.3
		SD	3.6	2.3	5.4	4.2	8.7	7.0	1.4	4.1	4.6	3.2	5.2	3.4	4.3	2.5	7.7	9.1
Four Bear	♂	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	43.5	25.5	48.0	27.0	29.0	39.7	8.0	20.5	87.0	52.7	68.3	60.3	60.0	43.0	135.7	82.5
		SD	4.7	1.3	4.9	5.4	3.6	3.9	1.4	3.7	5.6	4.2	4.7	3.1	3.0	1.7	5.4	15.4
Sully A	♂	X̄	45.3	29.0	41.7	29.5	16.7	41.0	8.7	19.3	85.0	50.0	62.0	65.7	57.3	42.5	133.7	66.1
		SD	2.7	1.5	4.2	4.3	11.1	3.8	1.9	2.3	2.2	1.3	3.7	3.8	5.3	2.5	8.5	7.0
	♀	X̄	43.7	25.3	48.4	26.6	24.5	38.4	7.3	19.0	85.7	53.5	67.7	61.6	61.7	43.9	137.5	78.9
		SD	4.3	1.6	5.1	2.3	11.9	3.7	1.6	3.0	3.7	2.8	3.1	2.2	4.1	2.9	8.5	9.9
Sully D	♂	X̄	47.1	29.6	44.2	30.5	20.5	39.0	8.2	19.3	88.8	47.8	65.0	64.0	59.0	42.8	133.2	64.3
		SD	4.8	3.2	4.0	3.3	14.9	4.7	2.3	5.5	3.0	2.1	4.4	3.5	8.9	2.8	10.8	6.1
	♀	X̄	44.4	27.3	50.9	30.0	24.1	38.1	7.4	18.7	86.2	51.2	68.5	61.2	60.2	42.5	136.5	75.9
		SD	2.3	2.7	5.2	4.5	11.0	4.0	1.6	3.8	3.7	2.2	4.2	2.5	4.2	3.1	8.3	7.5
Sully E	♂	X̄	48.8	31.2	40.9	30.1	16.3	38.3	7.7	19.5	84.8	49.1	66.1	62.8	59.6	43.0	134.9	62.7
		SD	3.6	2.4	5.5	3.2	11.7	5.1	1.7	3.0	6.0	4.0	3.7	2.1	4.8	2.4	10.3	6.6
	♀	X̄	42.8	27.5	52.1	29.5	25.6	42.0	7.5	21.3	85.8	51.2	71.3	61.0	61.3	43.7	137.8	81.1
		SD	6.6	3.5	4.6	2.4	7.9	4.8	1.2	6.8	6.3	3.8	4.9	4.6	3.8	2.7	9.5	4.9
Leavitt	♂	X̄	46.0	28.0	47.0	30.6	26.2	41.7	9.7	21.0	85.7	49.3	66.5	64.0	63.3	44.0	129.5	68.6
		SD	3.6	2.1	4.8	2.4	16.2	7.9	2.7	5.3	1.5	2.9	7.8	5.7	10.5	4.0	6.4	3.0
	♀	X̄	45.0	27.5	51.5	28.5	23.5	41.5	7.5	19.0	96.0	49.0	67.0	64.0	63.0	46.0	138.5	81.0
		SD	-	2.1	2.1	2.1	13.4	2.1	0.7	7.1	-	-	-	-	-	-	-	-
Oahe Village	♂	X̄	46.0	27.7	38.7	26.7	19.3	40.2	10.2	20.0	83.7	52.0	63.0	63.3	55.3	42.0	126.0	67.0
		SD	3.4	3.3	1.1	3.2	11.6	4.9	1.9	3.7	4.4	2.9	2.0	1.1	3.5	2.3	4.9	3.5
	♀	X̄	48.0	28.0	52.0	28.0	24.0	41.0	9.0	19.0	80.0	54.0	90.0	39.0	66.0	42.0	132.0	86.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swan Creek	♂	X̄	47.3	28.7	43.7	30.7	16.0	41.5	7.5	20.3	91.0	48.0	61.5	65.5	53.7	42.3	137.7	63.0
		SD	2.2	1.1	5.5	3.2	14.0	3.9	1.9	6.9	4.2	1.4	0.7	4.9	1.1	4.0	11.3	1.0
	♀	X̄	45.5	24.5	56.5	28.0	24.0	46.0	9.5	22.0	91.5	50.5	71.0	59.0	66.0	41.0	134.0	86.5
		SD	3.5	2.1	4.9	2.8	11.3	1.4	0.7	5.7	9.2	4.9	5.6	2.8	4.2	0.0	2.8	6.4
Rygh	♂	X̄	47.1	29.0	39.7	29.7	27.7	39.3	8.1	20.2	85.0	50.6	63.6	65.2	56.9	43.6	133.5	61.3
		SD	4.6	3.2	4.9	2.6	10.9	6.1	1.3	5.0	3.6	2.4	3.2	3.5	4.4	3.1	8.2	6.7
	♀	X̄	43.1	25.2	49.9	28.4	26.6	40.7	7.5	21.8	82.5	54.3	67.3	61.2	60.6	42.3	138.2	80.2
		SD	3.7	1.7	5.5	3.6	9.0	5.0	1.5	2.8	5.6	3.3	2.6	2.4	3.3	3.7	10.4	9.1
Leavenworth	♂	X̄	47.3	29.8	42.7	29.8	24.2	40.4	8.8	21.6	84.7	49.6	63.5	64.1	57.5	42.7	131.9	64.5
		SD	3.7	2.7	5.1	3.8	13.9	4.4	1.5	3.5	4.2	2.7	3.3	2.9	4.4	2.8	8.5	6.2
	♀	X̄	43.9	25.9	48.7	27.4	24.8	42.5	7.1	22.7	83.3	53.9	66.1	61.1	59.1	42.3	142.5	79.6
		SD	5.9	1.9	4.2	3.5	9.3	5.1	1.8	3.6	5.6	3.1	3.5	3.3	3.1	3.4	7.6	9.0

Table B-2. Articulated Pelvis: Means and Standard Deviations by Site and Sex

Site	Sex		BCB	ISD	TCD	OCD	TDB	OBD	APO	BSD	GBI	ASS	ASV	AIV	AIS	ISS	ITO	ACC	PSB	ITS
Stony Point	♂	X̄	289.0	251.5	107.0	103.0	113.0	122.5	108.5	80.5	128.0	149.0	142.0	120.0	106.0	90.0	101.0	209.0	55.0	81.0
		SD	7.1	17.7	-	-	8.5	7.8	0.7	2.1	9.9	-	7.1	8.5	-	1.4	12.7	1.4	-	4.2
	♀	X̄	268.0	229.0	132.0	123.0	115.0	130.0	117.0	-	122.0	145.0	134.0	114.0	107.0	98.0	115.0	203.0	70.0	74.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mobridge F1	♂	X̄	285.3	242.7	115.0	111.5	118.3	131.6	96.7	90.4	128.6	144.5	133.9	116.7	107.7	93.3	107.3	205.9	58.0	81.3
		SD	15.7	21.0	9.9	10.9	6.4	6.5	11.3	7.9	7.0	8.8	9.1	9.0	5.2	3.8	18.2	7.1	4.7	5.1
	♀	X̄	278.7	244.6	112.9	110.9	123.9	132.7	110.3	106.4	135.1	145.3	137.3	115.0	107.6	97.0	122.1	192.0	61.1	73.1
		SD	15.0	12.1	4.0	8.8	6.0	6.8	12.7	7.5	7.7	7.3	8.2	7.1	4.3	3.3	15.4	30.9	4.6	7.3
Mobridge F2	♂	X̄	286.1	251.8	109.7	101.7	121.2	128.8	106.1	89.3	131.7	145.0	138.4	116.9	110.5	90.8	103.0	209.9	55.7	79.8
		SD	12.2	14.9	9.9	9.3	6.3	4.8	9.4	5.6	7.0	9.0	9.3	6.9	4.9	5.1	9.0	6.1	3.6	3.7
	♀	X̄	270.4	234.9	113.2	108.3	123.3	129.3	110.5	104.5	132.4	139.5	131.5	113.5	105.3	95.3	115.6	208.7	57.8	76.3
		SD	14.8	14.2	8.7	9.0	6.7	7.1	8.9	8.1	8.2	5.8	9.0	6.3	4.7	4.5	15.0	7.7	4.9	3.4
Larson	♂	X̄	286.3	246.2	111.2	104.3	119.7	126.1	103.9	89.5	129.4	142.0	135.8	116.0	107.1	91.5	106.0	209.7	56.3	79.1
		SD	11.2	13.8	8.1	9.1	7.3	6.1	10.8	7.9	7.3	8.8	6.3	4.9	4.4	3.7	9.1	5.9	5.1	3.5
	♀	X̄	273.1	233.0	112.3	104.6	125.7	130.8	111.0	107.9	135.7	141.0	131.6	113.4	106.7	95.4	125.5	212.5	57.2	75.4
		SD	14.1	14.1	9.4	13.8	8.2	6.7	9.7	9.1	7.8	8.2	8.0	7.9	6.0	4.9	10.4	7.9	4.4	4.0
Four Bear	♂	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	263.5	236.0	105.0	101.0	119.5	122.5	108.0	102.0	127.5	139.5	132.0	111.5	104.5	90.0	120.0	213.0	55.0	81.0
		SD	2.1	1.4	8.5	6.4	6.4	0.7	1.4	4.2	2.1	0.7	5.7	0.7	2.1	0.0	9.9	4.2	2.8	0.0
Sully A	♂	X̄	274.0	246.0	115.0	109.0	104.0	121.0	106.0	92.0	119.0	142.0	134.0	110.0	104.0	90.0	110.0	203.0	60.0	87.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	278.0	244.5	117.5	115.0	131.5	130.0	106.5	117.5	136.5	141.0	136.5	112.0	106.5	98.0	132.5	204.0	60.5	73.0
		SD	2.8	0.7	13.4	21.2	3.5	2.8	2.1	0.7	3.5	5.7	7.8	7.1	6.4	4.2	3.5	14.1	10.6	1.4
Sully D	♂	X̄	287.5	249.2	108.8	103.0	125.7	127.8	110.0	92.3	131.8	140.8	136.2	118.3	107.8	82.6	116.3	205.2	62.8	83.2
		SD	20.6	18.9	10.5	11.5	12.9	7.1	6.0	8.6	7.9	8.9	9.2	9.2	8.9	3.4	15.3	12.6	21.0	5.2
	♀	X̄	265.7	226.3	109.5	104.5	127.3	128.7	116.0	108.0	136.7	133.5	124.0	111.5	105.5	96.7	123.7	213.3	58.3	70.0
		SD	22.5	16.8	9.2	10.6	12.4	11.5	19.5	13.5	15.4	6.4	8.5	3.5	4.9	7.0	4.0	9.9	3.5	12.1
Sully E	♂	X̄	267.7	217.0	113.0	107.7	121.3	128.0	96.7	98.0	131.0	145.0	136.3	119.0	112.0	90.3	118.7	205.0	59.7	74.0
		SD	38.5	9.0	6.5	7.0	6.4	4.3	7.2	5.6	8.5	12.3	10.7	14.8	7.0	5.1	10.1	11.5	1.1	7.5
	♀	X̄	252.0	205.0	107.0	100.0	115.0	120.0	110.0	110.0	124.0	130.0	127.0	109.0	102.0	95.0	143.0	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leavitt	♂	X̄	288.0	209.0	126.0	115.0	117.0	133.0	105.0	79.0	131.0	121.0	120.0	116.0	105.0	88.0	102.0	206.0	54.0	85.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oahe Village	♂	X̄	284.5	249.0	106.0	101.5	113.5	123.5	113.0	86.0	124.5	144.5	132.5	114.0	110.5	91.0	104.0	208.5	50.5	80.5
		SD	20.5	26.9	7.1	7.8	9.2	6.4	9.9	4.2	12.0	9.2	19.1	15.5	4.9	1.4	9.9	6.4	2.1	7.8
	♀	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swan Creek	♂	X̄	306.0	257.0	100.0	95.0	118.0	125.0	109.0	90.0	131.0	146.0	141.0	118.0	112.0	93.0	99.0	225.0	52.0	73.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	237.0	195.0	117.0	113.0	104.0	123.0	97.0	101.0	117.0	132.0	113.0	99.0	95.0	92.0	117.0	199.0	60.0	73.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rygh	♂	X̄	282.0	239.0	106.0	103.0	116.0	116.0	100.5	82.0	122.0	136.0	133.0	115.5	99.5	91.0	96.0	207.0	53.5	80.0
		SD	8.5	11.3	1.4	1.4	7.1	1.4	6.4	1.4	4.2	4.2	14.1	9.2	0.7	2.8	1.4	0.0	3.5	7.1
	♀	X̄	274.0	228.6	113.8	106.4	121.8	129.8	114.2	100.4	133.2	138.2	133.0	113.8	104.8	96.6	111.4	212.4	56.4	82.2
		SD	15.2	18.5	5.5	6.9	6.5	3.2	10.4	8.2	7.5	7.0	8.7	8.6	4.5	5.1	10.4	7.8	6.2	4.1
Leaven-worth	♂	X̄	291.3	255.8	110.2	104.3	119.0	128.5	106.6	81.7	129.4	146.9	139.5	118.1	110.3	91.5	100.3	207.5	56.7	81.4
		SD	16.9	21.9	10.5	9.6	7.1	7.1	6.3	5.6	8.8	10.4	8.8	5.9	5.7	3.7	9.6	7.8	6.7	4.9
	♀	X̄	287.2	246.2	116.4	108.4	130.6	138.2	126.4	106.7	139.8	147.8	136.2	117.2	113.6	99.5	119.0	221.6	58.4	76.7
		SD	8.6	15.3	8.4	7.6	8.6	7.3	18.1	8.5	7.3	11.6	3.3	3.8	6.6	5.8	9.0	3.4	5.7	3.0

Site	Sex		ITF	ISB	ISF	JOB	PFR	PBA	IPA	IIA	ALA	SPA	MPA	MSA	ISA	POA	PIA	OSA
Stony Point	♂	X̄	58.5	50.0	63.5	49.0	104.0	70.0	68.0	53.0	73.0	63.5	53.5	34.5	111.0	97.5	125.0	123.0
		SD	7.8	4.2	4.9	2.8	-	-	-	-	-	0.7	0.7	2.1	4.2	4.9	-	5.7
	♀	X̄	47.0	-	-	59.0	102.0	66.0	58.0	51.0	56.0	-	-	-	-	97.0	110.0	-
		SD		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mobridge F1	♂	X̄	49.2	51.2	56.7	48.5	101.2	70.7	60.6	55.3	63.0	61.0	58.1	20.0	140.0	93.5	121.3	118.8
		SD	10.3	3.5	7.7	5.7	6.0	6.3	4.7	4.3	4.8	2.6	5.7	9.0	17.9	4.2	4.2	4.5
	♀	X̄	40.7	49.1	50.9	60.0	101.4	61.8	70.1	56.3	62.7	56.6	66.6	27.3	125.4	92.3	112.3	115.7
		SD	7.3	4.5	4.1	5.9	2.6	13.2	4.3	2.0	3.5	2.8	5.8	9.5	19.0	6.8	15.5	5.1
Mobridge F2	♂	X̄	55.1	49.4	61.3	51.1	103.5	70.0	64.8	58.5	64.5	60.4	59.0	27.9	124.3	97.2	124.1	123.9
		SD	6.9	7.0	3.8	6.7	4.8	3.6	4.3	5.3	4.9	1.7	3.5	17.7	8.9	4.1	3.4	5.0
	♀	X̄	47.2	47.4	50.8	61.6	104.0	59.1	61.7	55.2	62.3	56.6	66.5	31.6	116.7	96.2	122.1	120.4
		SD	8.4	5.1	6.1	6.7	4.7	4.1	4.0	3.8	4.0	2.5	4.8	8.8	17.7	4.3	3.9	5.4
Larson	♂	X̄	53.4	47.9	59.7	51.6	103.3	69.3	63.5	56.2	64.0	60.7	58.8	29.4	121.2	97.0	123.6	124.3
		SD	6.1	5.3	4.1	6.3	3.3	6.1	4.6	3.6	3.0	2.5	5.1	8.1	16.1	3.1	4.7	4.3
	♀	X̄	44.8	46.3	52.8	62.2	105.8	70.1	61.4	56.4	62.2	55.8	68.4	28.0	124.0	96.5	123.3	122.6
		SD	5.2	3.1	3.6	6.4	4.5	4.3	3.8	3.6	3.9	2.6	5.2	7.5	15.1	3.1	3.6	3.0
Four Bear	♂	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	48.5	51.0	58.5	58.0	106.0	71.0	63.0	57.5	64.0	55.5	69.0	28.5	123.0	95.0	125.0	121.0
		SD	6.4	2.8	3.5	1.4	2.8	4.2	1.4	3.5	1.4	2.1	2.8	2.1	4.2	2.8	1.4	4.2
Sully A	♂	X̄	46.0	57.0	57.0	53.0	103.0	69.0	62.0	55.0	60.0	59.0	61.0	-	-	89.0	119.0	114.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	36.5	54.0	46.0	65.5	101.5	56.5	63.5	55.0	60.5	53.5	74.0	21.0	138.0	93.0	118.5	122.0
		SD	12.0	14.0	0.0	3.5	10.6	2.1	9.2	1.4	10.6	2.1	4.2	-	-	7.1	12.0	-
Sully D	♂	X̄	45.3	51.7	56.0	51.2	101.0	69.4	64.4	56.4	66.2	60.2	59.4	26.4	127.2	91.2	125.3	118.3
		SD	10.2	6.0	3.2	6.2	8.8	5.4	4.4	3.8	2.3	3.8	6.9	8.6	17.3	5.3	5.9	3.9
	♀	X̄	41.7	44.3	59.3	63.7	108.3	69.5	60.0	57.0	62.5	56.0	68.0	31.0	118.0	98.7	122.7	127.0
		SD	8.5	6.0	8.5	11.1	5.0	3.5	4.2	4.2	3.5	2.0	4.0	6.1	12.2	3.1	3.8	6.1
Sully E	♂	X̄	43.7	45.7	55.0	47.3	101.3	70.3	62.0	57.7	63.7	57.0	66.0	13.7	152.7	96.0	119.7	123.3
		SD	7.5	5.0	6.6	1.5	4.7	3.8	2.0	2.5	4.9	3.0	5.6	5.5	11.0	7.9	2.3	8.1
	♀	X̄	-	-	-	69.0	-	67.0	64.0	56.0	53.0	55.0	71.0	37.0	106.0	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leavitt	♂	X̄	52.0	50.0	61.0	42.0	102.0	59.0	58.0	51.0	59.0	63.0	53.0	20.0	140.0	93.0	125.0	122.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oahe Village	♂	X̄	54.0	52.5	61.5	56.0	106.5	73.5	61.5	60.0	63.0	62.0	56.5	39.5	101.0	96.0	128.5	120.0
		SD	2.8	0.7	3.5	5.7	4.9	4.9	6.4	4.2	5.7	1.4	2.1	3.5	7.1	2.8	0.7	2.8
	♀	X̄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swan Creek	♂	X̄	65.0	43.0	65.0	54.0	111.0	72.0	67.0	61.0	67.0	61.0	58.0	34.0	112.0	107.0	130.0	131.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	♀	X̄	32.0	48.0	51.0	52 0	100.0	70.0	54.0	51.0	54.0	57.0	67.0	14.0	152.0	90.0	118.0	119.0
		SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rygh	♂	X̄	55.0	51.5	61.5	45.5	102.5	68.5	65.5	53.0	68.5	63.0	54.0	22.5	135.0	97.0	125.5	120.5
		SD	2.8	4.4	0.7	6.4	3.5	9.2	9.2	2.8	4.9	1.4	2.8	19.1	38.2	5.6	3.5	6.4
	♀	X̄	52.2	50.4	55.6	61.0	106.4	67.8	62.8	54.8	62.4	58.7	62.8	34.0	112.0	95.2	124.2	118.5
		SD	6.8	3.0	4.5	6.5	2.3	5.3	5.0	2.4	3.9	2.7	4.8	2.9	5.9	4.9	5.2	2.6
Leaven-worth	♂	X̄	56.6	48.7	62.3	47.4	103.7	71.0	63.8	57.7	64.9	63.5	53.1	29.0	122.0	96.6	122.7	123.4
		SD	6.2	4.0	5.6	4.2	4.5	5.3	3.9	3.6	3.6	1.6	3.6	8.9	17.9	4.5	5.8	3.6
	♀	X̄	53.5	46.7	59.0	71.0	109.0	71.0	60.8	58.2	61.2	57.5	65.0	40.7	98.5	100.3	124.6	125.7
		SD	7.0	5.8	7.3	9.1	2.9	6.0	4.9	4.5	3.9	2.6	5.6	4.3	8.5	3.6	4.3	7.3

Table B-3. Sacrum: Means and Standard Deviations by Site and Sex

Site	Sex		Variable							
			MVS	SFC	SBT	ASB	TRS	APS	BWD	SCA
Stony Point	♂	$\overline{X}$	106.0	60.0	16.0	123.3	53.0	34.7	14.3	146.0
		SD	10.6	9.8	5.6	6.0	4.6	1.5	2.1	10.6
	♀	$\overline{X}$	107.5	61.5	21.75	118.2	46.5	31.7	17.3	135.5
		SD	5.1	4.4	6.2	4.6	3.5	1.5	2.2	10.5
Mobridge F1	♂	$\overline{X}$	114.4	67.3	19.9	120.9	54.7	33.5	19.3	137.8
		SD	7.3	17.3	4.7	5.4	3.9	1.8	3.8	8.8
	♀	$\overline{X}$	102.1	61.8	21.7	119.5	49.3	30.8	18.7	130.8
		SD	14.3	13.2	4.1	4.7	3.9	1.8	4.0	8.7
Mobridge F2	♂	$\overline{X}$	106.9	69.5	19.2	120.2	50.9	33.3	19.0	136.7
		SD	11.5	11.9	5.1	5.0	4.4	1.9	3.1	10.9
	♀	$\overline{X}$	104.6	64.5	19.2	119.8	47.3	30.7	17.2	137.3
		SD	9.8	8.2	5.9	6.9	4.5	2.4	2.6	10.3
Larson	♂	$\overline{X}$	109.7	74.9	18.9	119.0	51.0	33.7	19.1	135.5
		SD	10.2	14.5	5.1	5.3	3.5	2.7	3.0	8.8
	♀	$\overline{X}$	104.3	69.1	20.7	119.4	47.7	31.6	17.8	131.6
		SD	12.6	14.4	5.5	6.5	3.7	2.3	2.5	11.7
Four Bear	♂	$\overline{X}$	-	-	-	-	-	-	-	-
		SD	-	-	-	-	-	-	-	-
	♀	$\overline{X}$	106.5	73.5	24.0	113.7	46.3	31.3	17.0	125.5
		SD	7.8	16.3	5.7	6.4	2.1	1.1	5.7	13.4
Sully A	♂	$\overline{X}$	113.0	66.7	19.7	117.0	51.3	32.7	18.0	141.0
		SD	7.0	5.1	7.4	6.5	3.3	2.5	3.6	11.1
	♀	$\overline{X}$	109.0	68.2	19.3	116.1	49.2	30.1	17.0	139.0
		SD	12.8	12.6	8.4	5.2	3.8	1.4	3.0	16.4
Sully D	♂	$\overline{X}$	112.7	69.0	18.7	120.1	51.9	33.9	19.1	141.2
		SD	8.7	10.0	6.1	6.6	3.6	2.9	4.0	12.5
	♀	$\overline{X}$	100.7	53.8	22.9	119.5	50.8	32.3	17.8	131.2
		SD	10.0	7.7	6.7	5.1	3.1	2.0	3.1	16.0
Sully E	♂	$\overline{X}$	107.3	68.2	20.4	117.7	52.8	32.3	18.7	135.4
		SD	9.2	9.1	4.1	6.1	5.0	2.1	2.1	9.7
	♀	$\overline{X}$	98.7	67.3	19.3	116.3	49.5	30.7	18.0	131.3
		SD	19.7	16.7	7.5	4.7	3.9	1.7	2.0	22.5

Table B-3. (Continued)

Site	Sex		Variable							
			MVS	SFC	SBT	ASB	TRS	APS	BWD	SCA
Leavitt	♂	$\bar{X}$	113.0	66.0	18.0	122.7	52.0	34.0	19.3	144.0
		SD	1.4	0.0	2.8	3.4	1.8	0.8	7.6	4.2
	♀	$\bar{X}$	118.0	74.0	29.0	120.0	50.5	32.5	14.0	12.5
		SD	-	-	-	2.8	2.1	3.5	-	-
Aohe Village	♂	$\bar{X}$	102.7	72.0	15.0	120.3	49.0	31.0	18.7	139.3
		SD	9.8	8.5	3.6	4.0	1.7	2.6	0.6	13.8
	♀	$\bar{X}$	-	-	-	120.0	52.0	31.0	-	-
		SD	-	-	-	-	-	-	-	-
Swan Creek	♂	$\bar{X}$	106.0	66.0	21.0	116.0	53.0	31.5	17.0	135.0
		SD	-	-	-	7.1	1.4	3.5	-	-
	♀	$\bar{X}$	96.5	56.0	23.0	115.0	49.7	32.0	15.5	127.5
		SD	13.4	8.5	2.8	3.5	1.1	1.0	3.5	12.0
Rygh	♂	$\bar{X}$	111.2	74.0	17.7	117.7	50.8	32.8	17.5	140.5
		SD	8.2	12.7	8.3	5.6	2.8	1.7	2.2	13.5
	♀	$\bar{X}$	104.7	59.7	21.5	117.1	48.3	31.1	17.6	133.9
		SD	13.4	3.9	7.1	5.8	4.2	2.6	2.7	16.1
Leaven-worth	♂	$\bar{X}$	107.2	70.6	17.5	118.7	50.4	33.0	19.0	139.4
		SD	11.4	11.6	4.8	4.8	3.6	2.5	3.2	9.6
	♀	$\bar{X}$	98.5	65.2	20.4	118.7	48.4	30.3	16.8	130.6
		SD	9.8	10.9	4.3	6.0	3.4	2.2	2.9	9.2

APPENDIX C

CORRELATION MATRICES

Table C-1. Sacral Correlation Matrix

	MVS	SBT	ASB	TRS	APS	BWD	SFC	SCA
MVS	1.00							
SBT	-0.53	1.00						
ASB	0.10	0.06	1.00					
TRS	0.15	-0.01	0.10	1.00				
APS	0.03	0.14	0.15	0.09	1.00			
BWD	-0.07	-0.12	0.04	0.07	-0.01	1.00		
SFC	0.28	-0.14	0.04	0.10	-0.02	0.01	1.00	
SCA	0.21	-0.43	-0.01	0.06	-0.10	0.07	0.13	1.00

Table C-2. Articulated: Pooled Within-Groups Correlation Matrix

Variable	BCB	ISD	TCD	OCD	TDB	OBD	APD	BSD	GBI	ASS	ASV	AIV	AIS	ISS	ITO	ACC	PSB	ITS	ITF	ISB	ISF	JOB	PFR	PBA	PBB	ALA	ALB	SPA	SPB	BSA	BSB	POA	PIA	POS
BCB	1.00																																	
ISD	0.77	1.00																																
TCO	0.03	-0.03	1.00																															
OCD	-0.00	-0.08	0.86	1.00																														
TDB	0.70	0.65	0.13	0.07	1.00																													
OBD	0.54	0.44	0.46	0.33	0.69	1.00																												
APO	0.12	0.11	0.13	0.10	0.26	0.26	1.00																											
BSD	0.04	-0.04	0.02	0.06	0.28	0.16	0.26	1.00																										
GBI	0.73	0.62	0.08	0.03	0.90	0.72	0.24	0.33	1.00																									
ASS	0.55	0.63	0.18	0.11	0.45	0.44	0.19	0.02	0.45	1.00																								
ASV	0.69	0.70	0.27	0.23	0.56	0.41	0.11	0.08	0.54	0.43	1.00																							
AIV	0.40	0.29	0.47	0.46	0.46	0.36	0.11	0.14	0.43	0.15	0.70	1.00																						
AIS	0.52	0.53	0.25	0.15	0.59	0.62	0.17	0.05	0.59	0.56	0.47	0.43	1.00																					
ISS	0.36	0.20	0.29	0.21	0.51	0.55	0.57	0.36	0.51	0.29	0.24	0.25	0.36	1.00																				
ITO	-0.09	-0.22	0.24	0.21	0.06	0.21	0.20	0.52	0.09	0.01	-006	0.01	0.05	0.30	1.00																			
ACC	0.34	0.29	0.01	0.04	0.38	0.33	0.10	0.15	0.44	0.22	0.27	0.32	0.45	0.26	0.02	1.00																		
PSB	0.26	0.17	0.42	0.32	0.30	0.50	0.16	-0.16	0.28	0.27	0.15	0.26	0.44	0.36	0.09	0.08	1.00																	
ITS	0.31	0.11	0.26	0.22	0.23	0.43	0.18	0.15	0.26	0.28	0.18	0.20	0.32	0.36	0.18	0.27	0.33	1.00																
ITF	0.37	0.41	-0.18	-0.16	0.23	0.05	-0.09	-0.35	0.24	0.22	0.27	0.14	0.28	-0.05	-0.74	0.21	0.06	0.03	1.00															
ISB	0.17	0.00	0.10	0.11	0.09	0.12	0.15	0.16	0.10	0.03	0.06	0.04	0.15	0.27	0.21	0.14	0.05	0.36	-0.05	1.00														
ISF	0.41	0.40	0.02	-0.00	0.29	0.19	-0.06	-0.46	0.27	0.34	0.34	0.24	0.34	-0.12	-0.34	0.21	0.16	0.03	0.56	-0.03	1.00													
JOB	0.02	-0.03	-0.00	0.03	0.20	0.13	0.60	0.69	0.25	0.05	-0.01	0.04	0.02	0.32	0.42	0.13	-0.11	0.18	-0.28	0.15	-0.41	1.00												
PFR	0.50	0.41	0.10	0.06	0.54	0.53	0.18	0.28	0.63	0.40	0.35	0.32	0.56	0.41	0.15	0.61	0.15	0.32	0.27	0.13	0.28	0.20	1.00											
PBA	0.08	0.18	-0.47	-0.46	0.04	-0.04	0.06	-0.04	0.07	0.58	-0.35	-0.52	0.14	0.02	-0.07	0.04	-0.02	0.04	0.13	-0.06	0.10	0.06	0.12	1.00										
IPA	0.31	0.28	-0.21	-0.15	0.21	-0.06	-0.05	0.08	0.21	-0.34	0.63	0.44	-0.02	-0.08	-0.15	0.12	-0.20	-0.12	0.19	0.01	0.09	-0.02	0.04	-0.62	1.00									
IIA	0.18	0.28	-0.65	-0.65	0.15	0.02	0.00	-0.05	0.20	0.26	-0.17	-0.48	0.41	-0.02	-0.10	0.17	-0.05	0.00	0.26	0.02	0.14	-0.01	0.23	0.68	-0.14	1.00								
ALA	0.21	0.12	-0.36	-0.22	0.16	-0.22	-0.05	0.13	0.16	-0.22	0.37	0.57	-0.14	-0.09	-0.20	0.16	-0.22	-0.11	0.18	-0.08	0.10	0.05	0.03	-0.27	0.68	-0.22	1.00							
SPA	0.19	0.17	0.15	0.06	0.03	0.16	0.06	-0.82	-0.02	0.17	0.06	-0.00	0.17	0.21	-0.37	0.01	0.39	0.07	0.34	0.01	0.41	-0.53	-0.04	0.06	-0.13	0.06	-0.19	1.00	-1.98					
MPA	-0.19	-0.17	-0.15	-0.06	-0.03	-0.16	-0.06	0.82	0.02	-0.17	-0.06	0.00	-0.17	-0.21	0.37	-0.01	-0.39	-0.07	-0.34	-0.01	-0.41	0.53	0.04	-0.06	0.13	-0.06	0.19	-1.00	1.00					
MSA	-0.05	0.02	0.01	0.02	-0.04	0.01	0.52	-0.01	-0.00	0.08	-0.10	-0.09	-0.01	0.07	0.04	0.06	-0.04	0.06	-0.03	0.03	-0.11	0.66	0.03	0.14	-0.15	0.03	-0.09	0.05	-0.05	1.00				
ISA	0.05	-0.02	-0.01	-0.02	0.04	-0.01	-0.52	0.01	0.00	-0.08	0.10	0.09	0.01	-0.07	-0.04	-0.06	0.04	-0.06	0.03	-0.03	0.11	-0.66	-0.03	-0.14	0.15	-0.03	0.09	-0.05	0.05	-1.98	1.00			
POA	0.14	0.28	-0.30	-0.24	0.11	-0.16	-0.15	-0.31	0.11	0.01	0.15	0.08	0.11	-0.19	-0.64	0.36	-0.17	-0.55	0.72	-0.22	0.42	-0.28	0.17	0.06	0.26	0.22	0.27	0.20	-0.20	-0.04	0.04	1.00		
PIA	-0.10	-0.05	-0.34	-0.23	-0.12	-0.28	-0.10	0.14	-0.08	-0.17	-0.03	-0.07	-0.15	-0.18	-0.10	0.57	-0.73	-0.12	0.04	0.04	-0.06	0.11	0.14	0.02	0.21	0.12	0.25	-0.26	0.26	0.06	-0.06	0.36	1.00	
	0.04	0.18	-0.07	-0.08	0.08	0.02	-0.14	-0.29	0.08	0.12	[illegible]	0.12	0.06	-0.24	-0.31	0.24	0.03	-0.26	0.28	-0.87	0.42	-0.27	0.11	0.08	0.05	0.04	0.15	0.15	-0.15	-0.06	0.06	0.46	0.13	1.00

Table C-3. Disarticulated: Pooled Within-Groups Correlation Matrix

Variable	MXH	MXW	IPD	MNW	LOH	UPH	ORH	SYH	SAS	SAI	SAR	SMS	SPI	SPS	SAC	SIT	PLG
MXH	1.00																
MXW	0.61	1.00															
IPD	0.60	0.53	1.00														
MNW	0.35	0.28	0.28	1.00													
LOH	0.23	0.17	0.19	0.38	1.00												
UPH	0.55	0.33	0.28	0.14	-0.16	1.00											
ORH	0.75	0.44	0.39	0.27	0.37	0.56	1.00										
SYH	0.26	0.18	0.31	0.20	0.11	0.10	0.20	1.00									
SAS	0.48	0.30	0.31	0.25	0.14	0.33	0.39	0.04	1.00								
SAI	0.52	0.37	0.47	0.22	0.12	0.27	0.36	0.10	0.48	1.00							
SAR	0.63	0.45	0.57	0.24	0.38	0.04	0.42	0.15	0.37	0.49	1.00						
SMS	0.69	0.51	0.69	0.28	0.20	0.27	0.46	0.27	0.46	0.60	0.84	1.00					
SPI	0.52	0.43	0.54	0.24	0.20	0.18	0.33	0.22	0.22	0.37	0.64	0.66	1.00				
SPS	0.61	0.47	0.52	0.31	0.30	0.16	0.44	0.24	0.34	0.41	0.82	0.78	0.66	1.00			
SAC	0.38	0.34	0.47	0.16	0.13	0.22	0.26	0.10	0.27	0.46	0.34	0.48	0.25	0.29	1.00		
SIT	0.60	0.52	0.82	0.33	0.25	0.25	0.43	0.31	0.29	0.43	0.58	0.68	0.56	0.54	0.45	1.00	
PLG	0.62	0.54	0.69	0.21	0.14	0.39	0.45	0.18	0.40	0.60	0.59	0.75	0.51	0.54	0.66	0.64	1.00
ILG	0.62	0.48	0.59	0.31	0.18	0.30	0.47	0.27	0.32	0.42	0.41	0.53	0.40	0.45	0.38	0.47	0.56
APS	0.49	0.47	0.39	0.27	0.26	0.14	0.39	0.18	0.27	0.28	0.55	0.52	0.48	0.72	0.20	0.40	0.36
API	0.34	0.32	0.35	0.10	0.11	0.08	0.24	0.10	0.16	0.15	0.41	0.35	0.53	0.50	0.03	0.30	0.20
AAS	0.49	0.27	0.26	0.15	0.19	0.32	0.44	0.19	0.69	0.43	0.34	0.42	0.18	0.33	0.22	0.30	0.30
AAI	0.38	0.29	0.32	0.48	0.19	0.32	0.32	0.15	0.28	0.30	0.25	0.32	0.26	0.28	0.19	0.34	0.30
OAC	0.60	0.45	0.49	0.41	0.14	0.33	0.45	0.26	0.28	0.42	0.35	0.46	0.40	0.38	0.25	0.47	0.45
ACO	0.50	0.44	0.48	0.32	0.07	0.30	0.35	0.20	0.23	0.30	0.32	0.44	0.36	0.40	0.27	0.46	0.37
MXA	0.32	0.35	0.34	0.22	0.07	0.17	0.19	0.07	0.17	0.17	0.27	0.29	0.29	0.29	0.14	0.28	0.21
RSN	0.27	0.27	0.35	0.14	0.31	-0.16	0.22	0.10	0.10	0.17	0.46	0.32	0.20	0.31	0.20	0.40	0.26
RAB	0.52	0.48	0.47	0.31	0.47	0.04	0.46	0.14	0.23	0.31	0.65	0.49	0.44	0.54	0.27	0.50	0.42
RAS	0.54	0.64	0.46	0.32	0.38	0.26	0.46	0.18	0.45	0.36	0.50	0.45	0.38	0.48	0.28	0.59	0.47
RAI	0.44	0.53	0.48	0.30	0.41	0.11	0.38	0.12	0.19	0.30	0.54	0.44	0.38	0.47	0.28	0.51	0.42
RPS	0.38	0.45	0.31	0.25	-0.06	0.23	0.25	0.17	0.19	0.23	0.16	0.33	0.30	0.40	0.24	0.29	0.30
RPI	0.22	0.30	0.29	0.10	-0.10	0.10	0.09	0.12	0.07	0.14	0.17	0.24	0.37	0.24	0.06	0.23	0.18
IFB	0.47	0.58	0.52	0.30	0.10	0.25	0.33	0.18	0.24	0.31	0.43	0.48	0.56	0.51	0.20	0.50	0.43
SBB	0.59	0.94	0.52	0.30	0.20	0.30	0.44	0.20	0.34	0.38	0.47	0.52	0.46	0.51	0.35	0.52	0.54
WPR	0.37	0.38	0.30	0.12	0.02	0.22	0.21	0.07	0.06	0.25	0.23	0.31	0.27	0.20	0.16	0.28	0.30
DBH	0.36	0.16	0.26	0.12	0.11	0.17	0.24	0.11	0.28	0.26	0.26	0.24	0.12	0.18	0.23	0.23	0.25
DBW	0.22	0.14	0.42	0.09	0.18	-0.04	0.14	0.13	0.19	0.11	0.30	0.24	0.14	0.24	0.12	0.30	0.19
ITB	0.32	0.28	0.32	0.19	0.17	0.16	0.25	0.01	0.16	0.25	0.21	0.28	0.24	0.26	0.24	0.23	0.28
SNB	0.28	0.13	0.12	0.09	0.24	0.02	0.21	0.06	0.13	0.10	0.32	0.23	0.25	0.29	0.08	0.16	0.07
SCT	0.14	0.19	0.16	-0.00	0.03	0.12	0.11	-0.02	0.11	0.12	0.09	0.10	0.08	0.04	0.11	0.21	0.13
SCF	0.15	0.01	0.00	0.11	0.14	0.23	0.21	-0.05	0.04	-0.04	0.00	0.03	-0.03	0.02	0.26	0.10	0.18
ABB	0.23	0.07	0.07	0.07	0.13	0.17	0.26	0.07	0.54	0.19	0.14	0.17	0.06	0.14	0.05	0.07	0.11
AST	0.30	0.22	0.12	0.18	0.11	0.13	0.20	0.04	0.31	0.17	0.23	0.17	0.11	0.14	0.07	0.14	0.16
AFC	0.21	0.07	0.11	0.04	0.10	0.22	0.22	0.11	0.31	0.09	0.10	0.16	0.07	0.11	0.18	0.14	0.19
IPA	-0.09	-0.06	0.14	0.08	0.09	-0.15	-0.08	0.10	-0.12	-0.17	0.04	-0.04	0.07	-0.01	-0.15	0.45	-0.29
PAA	0.11	0.07	-0.01	-0.42	0.12	0.24	0.15	-0.10	0.10	0.17	0.07	0.12	-0.03	0.11	0.34	-0.14	0.52
SIA	0.05	-0.21	0.09	0.03	0.12	-0.17	0.01	0.12	-0.37	-0.04	0.41	0.30	0.33	0.60	-0.04	0.11	0.05
IFA	-0.07	0.48	-0.00	-0.05	-0.08	0.02	-0.07	0.00	-0.41	-0.15	-0.30	-0.27	-0.12	-0.37	0.01	-0.00	-0.03
AIA	0.06	0.04	0.17	-0.06	0.15	-0.29	-0.02	0.07	-0.60	-0.01	0.50	0.29	0.33	0.38	0.02	0.20	0.11
AFA	-0.01	0.31	0.06	0.06	0.19	-0.01	0.04	0.09	-0.47	-0.19	-0.06	-0.15	0.04	-0.01	-0.02	0.11	-0.02
ABA	-0.15	-0.19	-0.08	-0.15	-0.03	-0.03	-0.05	-0.01	-0.00	-0.06	-0.13	-0.07	-0.06	-0.05	-0.04	-0.10	-0.19
SNA	0.11	-0.04	-0.04	0.07	0.35	-0.03	0.10	0.06	0.04	-0.02	0.15	0.05	0.14	0.17	-0.01	-0.01	-0.05

Variable	ILG	APS	API	AAS	AAI	OAC	ACO	MXA	RSN	RAB	RAS	RAI	RPS	RPI	IFB	SBB	WPR
ILG	1.00																
APS	0.37	1.00															
API	0.30	0.56	1.00														
AAS	0.23	0.25	0.11	1.00													
AAI	0.28	0.14	0.06	0.19	1.00												
OAC	0.54	0.33	0.22	0.25	0.38	1.00											
ACO	0.43	0.29	0.24	0.26	0.30	0.54	1.00										
MXA	0.35	0.24	0.48	0.13	0.17	0.30	0.25	1.00									
RSN	0.29	0.27	0.27	0.07	0.14	0.15	0.22	0.35	1.00								
RAB	0.42	0.55	0.43	0.24	0.26	0.40	0.36	0.30	0.62	1.00							
RAS	0.43	0.46	0.33	0.42	0.29	0.38	0.33	0.23	0.30	0.69	1.00						
RAI	0.41	0.48	0.36	0.18	0.39	0.38	0.31	0.27	0.47	0.82	0.74	1.00					
RPS	0.35	0.45	0.29	0.14	0.16	0.33	0.36	0.43	0.11	0.06	0.06	0.04	1.00				
RPI	0.28	0.20	0.55	0.03	0.10	0.21	0.25	0.72	0.33	0.10	-0.00	0.02	0.60	1.00			
IFB	0.47	0.51	0.73	0.17	0.38	0.41	0.39	0.58	0.28	0.49	0.51	0.63	0.44	0.62	1.00		
SBB	0.49	0.51	0.36	0.34	0.30	0.44	0.42	0.36	0.26	0.50	0.67	0.55	0.46	0.30	0.61	1.00	
WPR	0.26	0.12	0.15	0.03	0.23	0.34	0.33	0.30	0.18	0.19	0.13	0.18	0.23	0.29	0.30	0.32	1.00
DBH	0.30	0.27	0.09	0.29	-0.00	0.16	0.04	0.00	0.07	0.22	0.29	0.22	0.02	-0.09	0.12	0.18	-0.18
DBW	0.27	0.18	0.12	0.24	0.05	0.23	0.08	0.06	0.19	0.25	0.26	0.27	0.04	-0.04	0.13	0.16	-0.16
ITB	0.34	0.21	0.17	0.17	0.16	0.24	0.19	0.25	0.17	0.17	0.20	0.21	0.29	0.22	0.28	0.28	0.20
SNB	0.14	0.31	0.31	0.18	0.12	0.15	0.08	0.05	0.14	0.30	0.22	0.28	0.02	-0.04	0.21	0.14	0.05
SCT	0.13	0.05	0.25	0.11	0.16	0.19	0.17	0.32	0.07	0.20	0.17	0.25	0.12	0.24	0.31	0.21	0.16
SCF	0.18	0.06	-0.01	0.08	0.12	0.11	0.06	0.09	0.05	0.17	0.13	0.18	-0.01	-0.12	0.02	0.04	-0.02
ABB	0.10	0.11	0.09	0.62	-0.07	0.02	0.05	0.05	0.02	0.07	0.25	-0.04	0.03	0.00	-0.01	0.14	-0.06
AST	0.12	0.10	0.06	0.19	0.12	0.17	0.08	0.15	0.10	0.18	0.29	0.10	0.04	0.04	0.08	0.22	0.12
AFC	0.15	0.01	0.07	0.42	-0.01	0.06	0.13	0.09	0.05	0.15	0.22	0.03	-0.03	-0.01	-0.00	0.13	-0.04
IPA	-0.42	0.00	0.03	0.02	0.03	-0.08	0.03	-0.02	0.11	0.05	0.01	0.07	-0.06	-0.01	0.01	-0.06	-0.05
PAA	0.21	0.10	0.03	-0.07	0.26	0.09	-0.04	-0.04	-0.06	-0.03	0.02	-0.02	0.02	-0.06	0.00	0.09	0.02
SIA	0.03	0.32	0.24	-0.20	-0.02	0.00	0.06	0.01	0.12	0.16	-0.12	0.08	0.06	0.04	0.07	-0.22	-0.01
IFA	0.01	-0.12	-0.07	-0.25	-0.04	0.03	0.02	0.08	-0.00	0.02	0.11	0.13	0.10	0.10	0.13	0.49	0.16
AIA	0.02	0.19	0.18	-0.34	-0.06	0.01	0.03	0.05	0.28	0.28	-0.09	0.21	-0.03	0.09	0.10	0.02	0.12
AFA	0.06	0.12	0.10	-0.24	0.01	0.06	0.06	0.04	0.10	0.35	0.53	0.48	-0.14	-0.11	0.22	0 31	0.03
ABA	-0.06	-0.04	-0.01	0.17	-0.15	-0.16	-0.07	-0.12	-0.08	-0.13	-0.16	-0.11	-0.03	-0.04	-0.08	-0.15	-0.15
SNA	[illegible]	0.20	0.12	0.04	-0.04	-0.06	-0.06	-0.24	0.04	0.08	-0.21	-0.03	-0.08	-0.21	-0.03	-0.03	-0.12

Variable	DBH	DBW	ITB	SNB	SCT	SCF	ABB	AST	AFC	PAA	PAB	SIA	SIB	NNA	NNB	ABA	SNA
DBH	1.00																
DBW	0.35	1.00															
ITB	0.07	0.12	1.00														
SNB	0.21	0.14	0.03	1.00													
SCT	0.06	0.04	0.02	0.31	1.00												
SCF	0.04	0.09	0.10	0.19	0.13	1.00											
ABB	0.15	0.11	0.01	0.10	0.06	0.03	1.00										
AST	0.14	0.08	-0.02	0.11	0.02	-0.04	0.19	1.00									
AFC	0.11	0.11	0.05	0.05	0.09	0.45	0.59	0.11	1.00								
IPA	-0.08	0.19	-0.13	0.08	-0.10	-0.04	-0.02	-0.05	-0.05	1.0u							
PAA	0.08	-0.15	0.08	-0.05	-0.09	0.07	-0.03	0.02	0.08	-0.60	1.00						
SIA	-0.05	0.06	0.02	0.15	-0.13	-0.03	-0.21	-0.14	-0.12	0.08	-0.06	1.00					
IFA	-0.10	-0.10	0.03	-0.12	0.12	0.02	-0.26	-0.03	-0.11	0.01	-0.04	-0.49	1.00				
AIA	-0.05	0.05	0.02	0.14	-0.04	-0.05	-0.37	-0.11	-0.20	0.14	-0.07	0.72	0.06	1.00			
AFA	0.01	0.03	0.02	0.04	0.06	0.11	-0.26	-0.01	-0.08	0.10	-0.16	0.05	0.56	0.27	1.00		
ABA	-0.04	-0.03	0.03	0.04	-0.02	0.05	0.32	0.84	0.21	-0.02	-0.00	0.04	-0.13	-0.08	-0.15	1.00	
SNA	0.11	0.08	-0.04	0.56	-0.48	0.04	0.02	0.08	-0.03	0.03	-0.05	0.18	0.17	0.08	0.04	-0.06	1.00

APPENDIX D

PRINCIPAL COMPONENT MATRICES AND COMMUNALITY ESTIMATES

Table D-1. Articulated: VARIMAX Rotated Principal Component Matrix.

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI	Factor VII	Factor VIII	Communality
BCB	0.84	-0.14	0.21	-0.07	-0.01	0.14	-0.02	0.02	0.81
ISD	0.83	-0.17	0.14	-0.14	0.06	-0.04	-0.05	-0.17	0.80
TCD	0.15	-0.02	-0.21	0.92	0.01	0.07	-0.09	0.13	0.94
OCD	0.08	0.02	-0.14	0.90	0.03	0.08	-0.01	0.03	0.85
TDB	0.81	0.07	0.17	-0.02	0.03	-0.03	0.04	0.30	0.80
OBD	0.68	0.02	-0.17	0.27	0.01	0.05	0.00	0.43	0.76
APO	0.18	0.07	0.03	0.02	0.68	0.09	-0.05	0.42	0.69
BSD	0.18	0.90	0.10	-0.01	0.07	0.11	0.12	0.14	0.91
GBI	0.83	0.13	0.16	-0.06	0.04	-0.03	0.10	0.31	0.85
ASS	0.77	-0.06	-0.44	-0.01	0.11	-0.00	-0.08	-0.18	0.83
ASV	0.71	-0.06	0.49	0.30	-0.02	0.04	-0.03	-0.12	0.86
AIV	0.46	0.01	0.50	0.58	-0.03	-0.04	0.10	0.07	0.83
AIS	0.75	-0.11	-0.19	0.07	-0.04	0.07	0.16	0.18	0.68
ISS	0.38	0.06	-0.02	0.09	0.19	0.24	0.04	0.72	0.77
ITO	-0.01	0.64	-0.21	0.18	0.02	0.19	-0.08	0.36	0.67
ACC	0.39	-0.02	0.02	0.05	0.03	-0.00	0.82	0.19	0.87
PSB	0.36	-0.26	-0.22	0.29	-0.06	-0.00	-0.35	0.47	0.68
ITS	0.35	0.04	-0.21	0.21	0.04	0.50	0.05	0.18	0.50
ITF	0.38	-0.59	0.16	-0.19	-0.01	-0.09	0.22	-0.26	0.68

Table D-1 (continued)

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI	Factor VII	Factor VIII	Communality
ISB	0.08	-0.01	0.02	0.02	0.03	0.94	0.12	0.03	0.90
ISF	0.45	-0.55	0.01	0.03	-0.13	-0.16	0.12	-0.21	0.60
JOB	0.10	0.62	0.04	-0.03	0.73	0.10	0.07	0.11	0.95
PFR	0.63	0.10	-0.08	0.01	0.02	0.02	0.49	0.22	0.71
PBA	0.21	-0.02	-0.62	-0.64	0.12	-0.06	-0.00	-0.12	0.88
IPA	0.13	0.01	0.92	-0.02	-0.09	0.01	0.05	-0.05	0.88
IIA	0.27	-0.08	-0.31	-0.81	-0.02	0.03	0.13	0.02	0.85
ALA	0.07	0.06	0.82	-0.09	-0.01	-0.12	0.12	-0.10	0.73
SPA	0.05	-0.91	-0.12	0.05	0.03	0.04	-0.11	0.28	0.94
MPA	-0.05	0.91	0.12	-0.05	-0.03	-0.04	0.11	-0.28	0.94
MSA	-0.04	-0.03	-0.10	0.01	0.96	0.01	0.04	-0.05	0.95
ISA	0.04	0.03	0.10	-0.01	-0.96	-0.01	-0.04	0.05	0.95
POA	0.12	-0.46	0.27	-0.24	-0.02	-0.39	0.46	-0.22	0.77
PIA	-0.18	0.14	0.17	-0.18	0.05	0.01	0.83	-0.25	0.87
OSA	0.14	-0.22	-0.01	0.02	-0.07	-0.90	0.18	-0.05	0.92

Table D-2. Disarticulated: VARIMAX Rotated Principal Components Matrix

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI	Factor VII	Factor VIII	Factor IX	Factor X	Factor XI	Factor XII	Factor XIII	Communality
MXH	0.57	0.31	0.22	0.22	-0.06	0.18	0.16	0.37	-0.06	0.13	0.06	-0.02	0.24	0.81
MXW	0.51	0.14	0.33	0.66	-0.02	0.11	0.06	0.14	0.02	-0.10	-0.06	-0.03	-0.04	0.88
IPD	0.74	0.03	0.25	0.16	0.19	0.01	-0.07	0.18	0.07	0.01	0.23	0.04	0.16	0.80
MNW	0.08	0.08	0.16	0.04	0.24	0.09	0.03	0.73	0.25	0.03	0.05	-0.21	-0.00	0.75
LOH	0.05	0.13	-0.11	0.16	-0.02	0.01	0.12	0.27	0.65	0.12	0.05	-0.08	0.15	0.61
UPH	0.28	0.27	0.07	0.17	-0.19	0.05	0.05	0.37	-0.53	0.24	-0.06	0.10	-0.02	0.72
DRH	0.33	0.35	0.07	0.24	-0.13	0.08	0.13	0.41	-0.01	0.23	0.01	-0.01	0.21	0.61
SYH	0.14	0.09	0.08	0.18	0.22	0.01	-0.18	0.21	-0.18	0.09	0.19	-0.26	0.29	0.43
SAS	0.33	0.75	0.11	-0.15	-0.12	0.12	0.12	0.26	0.08	-0.18	0.15	0.10	-0.17	0.92
SAI	0.65	0.25	0.06	-0.05	-0.16	0.05	0.01	0.20	0.07	-0.19	0.03	0.07	0.02	0.61
SAR	0.58	0.18	0.10	0.06	0.01	0.13	0.16	0.05	0.37	-0.10	0.05	0.07	0.56	0.90
SMS	0.75	0.22	0.18	0.01	-0.01	0.05	0.07	0.15	0.10	-0.06	0.03	0.01	0.44	0.87
SPI	0.46	0.08	0.32	0.14	0.09	0.02	0.17	0.11	0.06	-0.08	-0.05	0.01	0.48	0.64
SPS	0.43	0.20	0.26	0.09	-0.06	0.02	0.17	0.20	0.17	-0.09	0.06	-0.05	-0.68	0.88
SAC	0.73	-0.01	0.02	0.01	-0.19	-0.03	0.05	0.01	0.11	0.22	0.08	-0.01	-0.12	0.65
SIT	0.72	0.06	0.15	0.19	0.41	0.02	-0.01	0.20	0.10	0.07	0.16	0.10	0.19	0.88
PLG	0.82	0.10	0.09	0.14	-0.32	0.04	-0.05	0.11	0.03	0.08	0.06	0.04	0.15	0.87
ILG	0.45	0.06	0.35	0.18	-0.29	0.04	-0.06	0.33	0.07	0.20	0.28	-0.08	0.12	0.71
APS	0.21	0.16	0.33	0.29	-0.11	-0.03	0.31	0.16	0.12	-0.14	0.17	-0.05	0.45	0.68
API	0.03	0.11	0.62	0.20	-0.04	-0.02	0.26	-0.02	0.09	-0.08	0.09	0.26	0.41	0.77
AAS	0.29	0.78	0.02	0.01	0.08	-0.03	0.08	0.15	0.01	0.02	0.12	0.02	-0.01	0.75
AAI	0.27	-0.01	0.01	0.02	-0.07	0.04	0.04	0.71	0.09	-0.06	-0.13	0.21	-0.01	0.66
DAC	0.40	0.03	0.22	0.16	-0.02	0.12	-0.05	0.55	-0.08	0.09	0.10	0.05	0.11	0.60
ACD	0.39	0.10	0.24	0.18	0.13	0.01	-0.07	0.40	-0.09	0.10	-0.12	0.01	0.15	0.49
MXA	0.10	0.05	0.76	0.06	0.01	0.14	-0.13	0.11	0.19	0.13	-0.04	0.23	0.04	0.75
RSN	0.27	-0.02	0.27	0.09	0.12	0.09	-0.01	-0.05	0.66	0.08	-0.01	0.03	0.13	0.63
RAB	0.29	0.12	0.09	0.45	0.01	0.09	0.10	0.21	0.55	0.08	0.10	0.20	0.33	0.83
RAS	0.28	0.36	0.01	0.65	-0.04	0.13	0.09	0.26	0.28	-0.02	0.18	0.13	0.12	0.87
RAI	0.30	-0.00	0.04	0.54	-0.00	-0.01	0.12	0.31	0.46	-0.01	0.15	0.30	0.20	0.86
RPS	0.27	0.03	0.71	0.02	-0.01	-0.04	0.04	0.17	-0.19	-0.04	-0.03	-0.21	0.00	0.69
RPI	0.11	-0.02	0.90	-0.04	0.05	0.03	-0.12	-0.03	-0.00	-0.05	-0.13	0.09	0.06	0.87
IFB	0.25	0.03	0.63	0.37	-0.01	-0.03	0.11	0.27	0.08	-0.12	0.06	0.28	0.20	0.82
SBB	0.48	0.20	0.35	0.67	-0.04	0.08	0.07	0.13	0.06	-0.09	-0.03	-0.03	-0.04	0.90
WPR	0.39	-0.06	0.24	0.12	0.04	0.13	-0.02	0.16	-0.02	0.04	-0.55	0.07	0.02	0.58
OBH	0.23	0.16	-0.04	0.09	-0.12	0.08	0.14	0.02	-0.05	-0.00	0.70	0.05	0.02	0.62
OBW	0.26	0.04	0.03	0.01	0.25	0.03	0.01	0.01	0.15	0.07	0.70	-0.00	0.04	0.65
ITB	0.31	-0.02	0.35	0.01	-0.14	-0.17	0.04	0.20	0.24	0.09	0.02	-0.21	-0.12	0.43
SNB	0.08	0.05	0.04	0.04	0.08	0.05	0.82	0.05	0.07	0.16	0.09	0.24	0.15	0.81
SCT	0.10	0.04	0.23	0.09	0.10	-0.02	-0.04	0.06	-0.02	0.14	0.02	0.81	-0.08	0.76
SCF	0.05	0.01	-0.04	0.02	-0.11	-0.07	0.18	0.14	0.10	0.81	0.04	0.11	-0.08	0.76
ABB	0.02	0.87	0.03	-0.03	0.03	-0.05	-0.02	-0.11	0.04	0.13	0.03	-0.04	0.01	0.81
AST	0.08	0.22	0.03	0.05	-0.01	0.94	0.04	0.06	0.05	-0.01	0.03	-0.01	-0.01	0.95
AFC	0.09	0.59	-0.00	0.04	0.01	-0.02	-0.10	-0.13	0.03	0.63	0.01	0.01	0.05	0.78
IPA	0.01	-0.03	-0.10	0.01	0.87	-0.02	0.06	-0.02	0.05	-0.08	-0.01	0.14	0.05	0.81
PAA	0.26	-0.02	-0.10	-0.02	-0.85	-0.01	-0.02	-0.08	-0.06	0.02	-0.06	0.07	0.02	0.82
SIA	-0.00	-0.30	0.01	-0.22	0.04	-0.09	0.07	-0.01	0.09	0.05	0.01	-0.09	0.86	0.92
IFA	0.01	-0.33	0.13	0.71	0.07	0.02	-0.10	-0.15	-0.09	0.07	-0.15	-0.05	-0.46	0.92
AIA	0.19	-0.53	-0.01	0.08	0.13	-0.01	0.02	-0.23	0.21	0.06	-0.11	-0.04	0.64	0.87
AFA	-0.15	-0.33	-0.11	0.81	0.09	0.01	-0.02	0.04	0.13	0.15	0.06	0.04	0.08	0.86
ABA	-0.06	0.25	-0.03	-0.08	0.01	-0.93	-0.04	-0.11	-0.03	0.07	-0.00	0.01	0.03	0.96
SNA	-0.04	0.02	-0.13	0.01	0.04	0.06	0.80	-0.01	0.04	0.01	0.07	-0.42	0.14	0.87

Table D-3. Sacra: VARIMAX Rotated Principal Components Matrix

Variable	Factor I	Factor II	Factor III	Communality
MVS	0.09	0.19	0.76	0.62
SBT	-0.78	0.15	-0.09	0.64
ASB	-0.07	0.63	0.07	0.41
TRS	0.14	0.55	0.19	0.36
APS	-0.28	0.59	-0.02	0.43
BWD	0.51	0.40	-0.49	0.66
SFC	0.19	0.09	0.64	0.45
SCA	0.72	-0.05	0.27	0.60

VITA

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