Evaluation of Features of the Innominate for Sex Estimation

THESIS

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By
Ana Maria Casado
Graduate Program in Anthropology

The Ohio State University
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Master's Examination Committee:
Paul W. Sciulli, Advisor
Clark Spencer Larsen
Samuel D. Stout
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Abstract

The sex of an individual is a basic biological attribute as well as a source of variation that must be taken into consideration in human population studies. Skeletal samples from archaeological and forensic contexts present unique problems for the estimation of adult sex. The only biological features that consistently represent the individual are osseous elements, but these elements may be fragmentary or poorly preserved in many settings. Methods that yield accurate sex estimates for individuals from skeletal samples are thus crucial for more complete characterizations and studies of past human populations.

The present study evaluates characteristics of pelvic morphology (Bruzek, 2002) for discriminating adult males and females in Late Prehistoric Ohio Valley Native American skeletal samples. The skeletal samples are from the 17th century A.D. Grantham site (N = 41) located in northeastern Ohio and the 14th – 17th century A.D. Buffalo site (N = 77) in northern West Virginia. The pelvic characteristics used include morphology of the preauricular surface, greater sciatic notch, composite arch, inferior pelvis, and ischio-pubic proportions. Various aspects of each characteristic are also assessed. A logistic discrimination analysis evaluates the utility of each characteristic in sexing the individual. Results indicate that non-pubic bone features of the pelvis, as defined by Bruzek (2002), are not consistent with pubic bone estimators of sex in the samples from these Native American skeletal series.
This document is dedicated to Lucy G. Shepherd.
Acknowledgments

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Vita

May 2003 .......................................................Farragut High School

December 2007 ..............................................B.A. Anthropology, University of Tennessee

Sept. 2009 to present .....................................Graduate Teaching Associate, Department
of Anthropology, The Ohio State University

Field of Study

Major Field: Anthropology
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The accurate estimation of the sex of a skeletonized human is important to forensic anthropologists, bioarchaeologists, and anatomists (Bass 2005, White and Folkens, 2005). Forensic anthropology is the application of anatomical-osteological knowledge to medicolegal contexts to help recover and identify missing persons (Byers, 2005). Forensic anthropologists utilize sexing techniques to help in personal identification of human remains. Determination of sex is obviously crucial in establishing the identity of an individual, and forensic anthropologists rely on and require consistent and valid measures of estimating sex. Without reliable methods for sex estimation, missing persons would go unidentified, severely limiting the field of forensic anthropology.

Correct sex determinations can provide a wealth of information concerning many aspects of life history, especially as it relates to gender roles, the division of labor within societies, and sex-specific variability (White and Folkens, 2005). It can contribute to archeological and demographic studies as well (Novotný, 1986).

**Sexual dimorphism.** Though sexual dimorphism is slight in anatomically modern human populations, primary differences can be observed in osseous elements (White and Folkens, 2005). Most sexual dimorphism in the human skeleton is evident in the relatively smaller and more gracile morphology of female bones, but variations in shape
are also present (White and Folkens, 2005). Frequently, sex determination is not straightforward, as there is considerable overlap between the sexes. Normal human variation can produce small males and robust females, therefore anthropologists must rely on specific skeletal traits that are known to be sexually dimorphic (White and Folkens, 2005).

The pelvis is most sexually dimorphic and is the first bone assessed in sex determination because it is the skeletal element most affected by reproduction and parturition (Byers, 2005). If the pelvis is unavailable, anthropologists look to the skull, the femoral and tibial shafts (Lorenzo, et al., 1998), the humerus (Bass, 2005), and dentition (Bermúdez de Castro, et al., 1993; Frayer and Wolpoff, 1985). There are various theories attempting to explain sex-based differences in morphology. Some cite male-male competition for females (Van Gerven and Armelagos, 1980), while others suggest males overall larger size as an indicator that they serve as “protectors” (Brace 1973).

Some scholars point to the sexual division of labor as the reason for sex-based morphological differences. In many human societies, duties are often divided, most commonly into food acquisition and childcare roles. According to this notion, males would need to be larger and more robust to be successful hunters, and sexual dimorphism would thus increase as males and females exploit differing food procurement strategies (Holden and Mace 1999).

Frayer and Wolpoff (1985) propose two models, the proximate and the ultimate causation models, in an attempt to explain sexual dimorphism. The proximate causation
model attributes sex-based morphological differences to diet and nutrition. They assert culture can override genetics and refer to various studies in which males and females became more sexually dimorphic as their level of nutrition improved. This is probably because when nutritionally deprived, males are more affected than females, as “females…prove to be more stable under the same food deficits, presumably because of reproductive demands, storage of more subcutaneous fat, and overall smaller body size” (Frayer and Wolpoff, 1985:431). Gray and Wolfe (1980) substantiate this, stating males will achieve their growth potential in situations of high nutrition. Nutritional stress may have a disproportionate effect on males and females, causing male adult mean statures to decline. This in turn causes sexual dimorphism to increase in a population.

In contrast, the ultimate causation model for sexual dimorphism relies on genetics to account for a society’s level of sexual dimorphism. This model states that selection forces acting on underlying genetic adaptations control sexual dimorphism, and nutrition has very little impact (Frayer and Wolpoff, 1985).

Hormonal differences between the sexes, initiated in utero, can greatly affect sexual dimorphism in human groups. For example, all fetuses begin developing as females until the SRY protein assists in the development of testes in a male fetus (Sadler, 2006). Skeletal differences between the sexes are usually formed by androgen production that is stimulated by fetal development, the fetal environment, and genetic factors (Sadler, 2006).

Hormonal changes occurring in puberty also affect sex-based size differences. With the onset of puberty, increased secretion of gonadotropin-releasing hormone
(GnRH) and follicle stimulating hormone (FSH) begin to affect growth and development (Bogin, 1999). The cause of the rising levels of the above hormones is not known, though some have attributed the it to the involvement of the hormone melatonin (Bogin, 1999).

**Previous research and methodology.** Novotný (1986) stresses the importance of correct sexing methods in sex determination, and asserts that accurate sex determination cannot occur with substandard methodology. Methods may vary greatly and can significantly alter the outcome of sex determination therefore anthropologists often disagree on sexing methodology. Nonetheless, decades of research on this topic indicate that accuracy of sex estimation is an important goal in bioarchaeological and forensic research.

Various authors have stated that sex can be determined from subadult remains. For example, Bruzek (2002) states that sexual dimorphism can be observed in sacroiliac complex in a human fetus. Krogman (1986) also contends sexual dimorphism is present in a human fetus, with the most significant differences being manifest in the subpubic angle. In contrast, LaVelle (1995) cites various published comparisons, claiming significant sex differences among the ischial and acetabular regions of eight year-olds, but also asserts great ontological pelvic changes take place in puberty and adolescence, resulting in most dimorphism clearly present at around age 18 (1995: 98). Byers (2005) asserts that the female pelvis does not completely fuse until after the age of 12, therefore attempts to determine sex from the remains of children are futile. Similarly, both White and Folkens (2005) and Bass (2005) maintain that sex cannot be determined from the
ischiopubic area until after puberty. Based on the general consensus in the literature, the author also takes the view that sex cannot be accurately determined from subadult remains.

Some authors contend that sex can be determined by examining the preauricular surface or the dorsal surface of the pubic symphysis for scars of parturition (Krogman and İşcan, 1986; Schemmer, et al., 1995). These scars of parturition are depressions, grooves, or pits that can occur in either of the above regions due to pregnancy and childbirth stressing muscle and tendon attachments in the area. Spring, et al. (1989) found no correlation between a deep preauricular groove with parity pits and pregnancy events, while others (Schemmer, et al., 1995; Kelley, 1979) showed statistically significant findings suggestive of a relationship between parturition and pelvic scars. While some researchers contend that number of offspring can be estimated from parity pits (Angel, 1969), the prevailing view is that number of actual children is not able to be determined (Kelley, 1979; Krogman and İşcan 1986).

Pits in the preauricular area may arise from causes other than parturition. Andersen states “pelvic flexibility” is the primary cause of pelvic scarring; she describes pelvic flexibility as a “…significantly greater range of motion, rotation of the sacrum, and expansion of the pelvic articulations…” (1986:iv). On average, women exhibit and experience greater pelvic flexibility, presumably due to the morphological sex differences that childbirth necessitates. Andersen refers to female pelves as “loosely articulated,” and male pelves as “tightly articulated,” and states excessive movement can occur to
“…pelvic articulations not maintained by bone” (1986:iv). Female os coxae thus exhibit more scarring in the preauricular area.

Traditionally, anthropologists refer to various pelvic characteristics in estimating the sex of an individual. Since its 1969 publication, the Phenice method has become the most well-known and most widely used method for visual determination of sex. It has been tested various times (see Kelley 1978, Lovell 1989, Sutherland and Suchey 1991). In addition, many anthropologists refer to Krogman (1962) or Krogman and İşcan (1986, Table 1).
<table>
<thead>
<tr>
<th>Trait</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis as a whole</td>
<td>Massive, rugged, marked muscle sites</td>
<td>Less massive, gracile, smoother</td>
</tr>
<tr>
<td>Symphysis</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Subpubic angle</td>
<td>V-shaped</td>
<td>U-shaped, rounded, broader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>divergent obtuse angle</td>
</tr>
<tr>
<td>Obturator foramen</td>
<td>Large, often ovoid</td>
<td>Small, triangular</td>
</tr>
<tr>
<td>Acetabulum</td>
<td>Large, tends to be directed laterally</td>
<td>Small, tends to be directed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>antero-laterally</td>
</tr>
<tr>
<td>Greater sciatic notch</td>
<td>Smaller, close, deep</td>
<td>Larger, wider, shallower</td>
</tr>
<tr>
<td>Ischiopubic rami</td>
<td>Slightly everted</td>
<td>Strongly everted</td>
</tr>
<tr>
<td>Sacroiliac joint</td>
<td>Large</td>
<td>Small, oblique</td>
</tr>
<tr>
<td>Postauricular space</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>Preauricular sulcus</td>
<td>Not frequent</td>
<td>More frequent, better developed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postauricular sulcus</td>
<td>Not frequent</td>
<td>More frequent, sharper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>auricular surface edge</td>
</tr>
<tr>
<td>Ilium</td>
<td>High, tends to be vertical</td>
<td>Lower, laterally divergent</td>
</tr>
<tr>
<td>Iliac tuberosity</td>
<td>Large, not pointed</td>
<td>Small or absent, pointed or varied</td>
</tr>
<tr>
<td>Sacrum</td>
<td>Longer, narrower, with more evenly</td>
<td>Shorter, broader, with</td>
</tr>
<tr>
<td></td>
<td>distributed curvature, often 5 or more</td>
<td>tendency to marked</td>
</tr>
<tr>
<td></td>
<td>segments</td>
<td>curvature at S1-2 and S2-5;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 segments the rule</td>
</tr>
<tr>
<td>Pelvic brim, or inlet</td>
<td>Heart-shaped</td>
<td>Circular, elliptical</td>
</tr>
<tr>
<td>True pelvis, or cavity</td>
<td>Relatively smaller</td>
<td>Oblique, shallow, spacious</td>
</tr>
</tbody>
</table>

Table 1: Sex Differences in Pelvic Morphology. Adapted from Krogman and İşcan, 1986. Traits based on stereotypical male and female pelvic characteristics.

The Phenice (1969) method includes the ventral arc, subpubic concavity, and the medial aspect of the ischiopubic ramus (Table 2).
<table>
<thead>
<tr>
<th>Trait</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventral arc</td>
<td>Ridge is small or nonexistent</td>
<td>Ridge is present</td>
</tr>
<tr>
<td>Subpubic concavity</td>
<td>V-shaped, angle is &lt;90 degrees</td>
<td>U-shaped, angle is &gt;90 degrees</td>
</tr>
<tr>
<td>Medial aspect of ischiopubic ramus</td>
<td>Ischiopubic ramus is straight or slightly convex</td>
<td>Ischiopubic ramus is concave</td>
</tr>
</tbody>
</table>

Table 2: Phenice sexing methods. Adapted from Phenice, 1969.

Rogers and Saunders (1994) tested various methods for sex determination of the innominate on 49 pelves of known sex from a 19th century cemetery in Canada. In their systematic assessment of 17 standard sexing methods “reported in the literature,” Rogers and Saunders (1994) found the single best indicator for sex was sacrum shape (94.1% accuracy), but combinations of traits yielded even higher accuracies. The authors also found that the three morphological indicators of sex estimation outlined in Phenice (1969) – ventral arc, subpubic concavity, and ischiopubic ramus – were excellent indicators of sex, albeit with lower accuracy than reported by Phenice. In this regard, they found that use of these three indicators provided an accuracy of 88%, whereas Phenice reported 96% accuracy (Rogers and Saunders, 1994). Regardless, both studies reveal a relatively high accuracy in those pubic indicators of sex and are further substantiation of the Phenice (1969) method.

Bruzek (2002) claims sexual dimorphism is most visible in the posterior aspect (chord) of the greater sciatic notch, asserting that the size and shape of the pelvis, which are directly correlated to sex, affect sciatic notch morphology. Walker (2005) asserts that while sexual dimorphism in certainly present in the sciatic notch, one must take age at
death into account, as sciatic notch morphology can be affected with increasing age. Walker found that sciatic notch dimorphism increases with age in twentieth century European-Americans, African-Americans, and English skeletons, as males experience a “…shift in a masculine direction” (2005:388), but the trend decreases after age 50. It is therefore imperative to take age at death into account when assessing sex using sciatic notch morphology, especially when analyzing the above populations from Walker’s (2005) study.

While Bruzek (2002) suggests sexual dimorphism can be seen in the greater sciatic notch, Correia et al. (2004) have suggested otherwise. They argue that the aspects of the pelvis exhibiting the most sexual dimorphism are within the pelvic inlet, citing childbirth as the primary reason, and Rogers and Saunders (1994) assert that sexual dimorphism is greatest in anterior features of the pelvic girdle than in the posterior aspect. Arsuaga and Carretero (1994) found sex-based morphological differences to be most marked in auricular and preauricular surfaces and sciatic notch morphology.

Bruzek asserts that sexual dimorphism of the entire innominate bone should be assessed whenever possible. Reliance on standard pelvic aspects, (e.g., Phenice, 1969) provides “inconsistent” results and reduced accuracy levels (59%) (Bruzek, 2002). Bruzek concludes that his method is an accurate visual assessment of sex, especially as it pertains to isolated and fragmentary pelvic remains.

Motivation for present study. This study is crucial to forensic anthropology, especially since the landmark 1993 case of Daubert vs. Merrill Dow Pharmaceuticals. The Daubert ruling ended the precedent set by the Frye vs. the United States ruling,
which stated that expert testimony is admissible in court if the methodology and the
witness are both “generally accepted” as reliable by the scientific community (Grivas and
Komar, 2008). In contrast, the Daubert ruling made it so that evidence presented in court
must have been gathered using strictly empirical, objective methodology that has been
repeatedly tested, peer-reviewed, and has withstood expert scrutiny (Grivas and Komar,
2008). Since the standardization of forensic methods in the 1990s, there has been a need
for additional testing of both old and new methods. It is thus necessary to test methods as
they are proposed to ascertain their accuracy and/or comparability with methods
considered standard.

Within a bioarchaeological context, a common problem facing investigators is the
incompleteness often found in archaeological skeletal samples. Pelvic bones are fragile
and often poorly preserved, rendering standard sexing techniques (Phenice, 1969;
pubic region is damaged or destroyed, the widely used visual sexing technique of Phenice
(1969) for the pubic bone becomes largely ineffective.” It is thus crucial to have sexing
methods that can be applied to other areas of the os coxae. The method proposed by
Bruzek (2002) encompasses multiple areas of the pelvis, and allegedly ameliorates the
above problem.

The purpose of this paper is to test Bruzek’s (2002) method for visual sex
determination of the hip. This study specifically addresses the utility and accuracy of
Bruzek’s method and draws wider conclusions about sex estimation based on pelvic
indicators and how these indicators apply to Native American skeletal series. My
hypothesis is that Bruzek’s (2002) method will not accurately reproduce Phenice’s (1969) estimation in Native American skeletons. The null hypothesis states that the method tested in this study will indeed duplicate Phenice’s results in these Native American populations.
Chapter 2: Materials

The Grantham Site

Two collections of Late Prehistoric Native American skeletal remains, Grantham and Buffalo, were used in this study. The Grantham site (33LA139) is located in Lake County, Northeastern Ohio on the banks of Lake Erie (Figure 1).

Figure 1: Map indicating ranges of various Late Prehistoric Ohio cultures. The red circle delineates the range of the Whittlesey tradition. Adapted from Brose, 2000.
The burials belong to pre-contact Native Americans, and date to the 17th century A.D. (Blatt, 2006). The artifacts recovered suggest the individuals associated with the Grantham burials were of the Late Whittlesey archaeological tradition, which dates from approximately A.D. 1550 to A.D. 1650 (Brose, 2000).

The Whittlesey culture, named after the nineteenth century Ohio antiquarian, Charles Whittlesey, is known as the first Early Woodland (Bense, 1994) culture to incorporate ceramics. Pottery includes shell and grit tempering (Brose, 2000). The Whittlesey people are also credited with being the first fully agricultural society in Northeastern Ohio. Although the Whittlesey people depended somewhat on the agricultural “three sisters” - corn, beans, and squash - their reliance on agricultural foods did not prevail; archaeologists have found evidence of the continued use of traditional wild foods such as birds, fish, and freshwater clam shells. Faunal remains in association with stone tools indicate the Whittlesey people regularly exploited bear, deer, and elk as protein sources (Blatt, 2006).

The Grantham site was first partially excavated in 1937 by Morgan and Ellis. Another partial excavation took place in 1967 (Bush, 1984). Only a preliminary report exists of the excavation, currently housed at Case Western Reserve University in Cleveland, Ohio, and the author could not gain access to it. Thus, no photographs or diagrams of the site or associated burials/artifacts are available.

**Burials.** During excavations, 72 graves consisting of 177 individuals were uncovered. Many of the graves contained multiple burials (as many as eight individuals could be found in one grave). Burial types were differentiated by sex (Figure 2), and age and sex correlations were also made.
Individuals were sexed using Phenice (1969) (see Table 2). The individuals were interred in four positions: extended, semi-flexed, flexed, and bundled (Blatt, 2006).

**Artifacts.** Material culture discovered consists of various grave goods including copper ornaments, ceramic pottery, stone and ceramic pipes, flint tools, bone ornaments and awls, and tooth beads. The collection of artifacts is currently housed at the Cleveland Museum of Natural History and the human skeletal remains are stored at The Ohio State University in Columbus, Ohio. The Grantham site has been radiocarbon dated in three differing locations; dates range from A.D. 1600 +/- 60 years to 2,200 B.C. +/- 50 years (Bush, 1984). These dates include both Late Prehistoric and Archaic components, though only Late Prehistoric skeletons were used for this study.
The Buffalo Site

The Buffalo site (46 Pu 31), located in Putnam County, West Virginia, is a Late Prehistoric site with dates ranging from the 15th – 17th centuries A.D. (Hanson, 1975). The site occupies a terrace on the banks of the Kanawha River, 15 miles from its juncture with the Ohio River (Hanson, 1975).

Excavated in the 1960s by Edward McMichael, the site spans approximately 500,000 square feet, though only 67,000 square feet were excavated (Hanson, 1975). The site spans three temporal/cultural periods, namely, Archaic, Woodland, and Fort Ancient, while the village component is only associated with the Fort Ancient time period. The Woodland occupation is represented by a few spear points and pottery fragments, however, excavations of the two overlapping Fort Ancient Indian villages revealed a rich record of material culture, including ceramics, ornaments, different types of tools (cutting, boring, flaking, abrading, hammering, and digging tools), ‘leisure’ artifacts, middens, fire basins and hearths, housing structures, and graves. Three charcoal samples from differing areas of the Buffalo site were radiocarbon dated, and yielded dates of 1490 B.P. ± 70 years, 780 B.P. ± 70 years, and 270 B.P. ± 120 years. It is important to note that the charcoal dates are from the Buffalo site, and not the associated village.

Burials. Excavators discovered at least 562 burials at the Buffalo Site. Hanson (1975) divided the site’s burials into four quadrants (Figures 3-6).
Figure 3: Northeast quadrant of burials at the Buffalo site. After Hanson, 1975.
Figure 4: Northwest quadrant of burials at the Buffalo site. After Hanson, 1975.
Figure 5: Southeast quadrant of burials at the Buffalo site. After Hanson, 1975.
Metress (1971) provides age groupings for the individuals recovered: infant, 0-2 years; child, 2-12 years; young adult, 12-18 years; and adult, 18+ years. The age and sex of each individual was recorded, as well as body position, orientation of interment, and presence of grave goods found in association with the burials. Burials were both flexed (Figure 7) and unflexed (Figure 8).
Figure 7: Flexed burial at the Buffalo site. After Hanson, 1975.
Individuals were sexed using Phenice (1969) (see Table 2). Seventy-seven of these individuals were selected for this study based on relative completeness of skeletal remains. Metress provides an analysis of age and sex composition of the population: adult, 61.5 percent; young adult, 6.7 percent; child, 12.0 percent; infant, 19.8 percent; male, 41.0 percent; and female, 59.0 percent.
Chapter 3: Methods

The visual assessment of the pelvic material was conducted over a period of four months; Bruzek’s specific methodology was strictly adhered to. First, Bruzek describes five characteristics with various associated conditions, totaling 11 different sex indicators (Table 3).

<table>
<thead>
<tr>
<th>Pre-auricular Surface</th>
<th>Greater Sciatic Notch</th>
<th>Composite Arch</th>
<th>Inferior Pelvis</th>
<th>Ischio-pubic Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. development of negative relief</td>
<td>1. proportion of length of notch cords</td>
<td>1. relation between sciatic notch outline and auricular surface outline</td>
<td>1. inferior margin of the os coxae</td>
<td>1. relation between pubis and ischium lengths</td>
</tr>
<tr>
<td>2. development of outline border</td>
<td>2. form of notch cords</td>
<td></td>
<td>2. phallic ridge</td>
<td></td>
</tr>
<tr>
<td>3. development of positive relief</td>
<td>3. contour of notch cords</td>
<td></td>
<td>3. ischiopubic ramus aspect</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Bruzek’s method for visual determination of sex. The five in bold represent the five primary pelvic aspects utilized; the pelvic characteristics listed below these are the eleven specific determinants of sex used by Bruzek.
For example, the preauricular surface is one of the five major characteristics specified, but it consists of three conditions: development of negative relief (depth of preauricular sulcus), aspect of grooves or pitting (pitting in the preauricular sulcus), and development of positive relief on the preauricular surface (piriform tubercle).

Forty-one individuals from the Grantham collection and 77 individuals from Buffalo were selected for this study, based on relative completeness. Adequate completeness for this study was evaluated by number of pelvic aspects present and intact. If a pelvis did not include at least three of Bruzek’s 11 indicators of sex, it was deemed too fragmentary and eliminated from the study. Only adult individuals were chosen, as sexual dimorphism is not discernible until after puberty (Bass, 2005, Bruzek, 2002).

Visible characteristics of sex were assessed and recorded using paper and pencil. A compass and a protractor were employed in quantitative measurements (i.e., of the greater sciatic notch and the ischiopubic proportions). SAS 9.2 was used in statistical analyses.

**Qualitative Assessment of Sex.** Of the five characteristics, three are considered qualitative measurements and require only visual inspection. These include the preauricular surface, the composite arch, and the inferior pelvis (Figure 9).
The first condition, or the development of the negative relief, refers to the depth of the preauricular sulcus. If the depression is deep, an assignment of “F” is given. If the relief is smooth or slight, “M” is assigned. The second condition assesses the presence of grooves or pitting in the preauricular sulcus, which some argue is indicative of parturition (citation). If grooves or pits are slightly present with an open circumference or completely absent, it is deemed male.

If pits are present and exhibit a closed circumference, it is deemed female (Figure 10).
Third, the positive relief, or the piriform tubercle, is examined. If the tubercle is present or there is clear protuberance, it is male, and if the tubercle is absent, it is female.

The composite arch is also visually assessed by determining the relation between the outline of the sciatic notch and the outline of the auricular surface. In males, the contour will form a part of one circle, and the composite arch is deemed absent. In females, the contour should form two distinct circles with different radii; this means the composite arch is present. Therefore, the contour of the outlined areas will either form a single curve (“M”) or a double curve (“F”) (see Figure 9).

The inferior pelvis is the third visually assessed characteristic. Three conditions are evaluated. First, external eversion of the ischiopubic ramus is evaluated. If external
eversion is present, an “F” is assigned. If the medial ramus has a direct course, an “M” is assigned. Second, the presence or absence of the phallic ridge, or a lateral swelling in the middle part of the ischiopubic ramus, is assessed. If the phallic ridge is clearly present, it is male; if the pelvis is lacking a phallic ridge it is female. Third, the robusticity of the medial aspect of the ischiopubic ramus is taken into account. Very robust specimens are considered male, while more gracile specimens are female.

Quantitative Assessment of Sex. Two of the five characteristics, the greater sciatic notch and the ischiopubic proportions, require quantitative measurements (Figure 11).

Figure 11: Right pelvis from the Grantham site. The red curved line and corresponding D depict the greater sciatic notch while the turquoise lines and E refer to the ischiopubic proportions.
The greater sciatic notch (and its three conditions) is measured using a “shadow image” of the contour of the notch. The pelvis is placed on a flat surface, laterodorsal iliac side down, and a contour is drawn from the base of the ischial spine (labeled “Point B”) to the top of the piriform tubercle (labeled “Point A”). This forms line AB. A perpendicular line is then drawn from the deepest point of the sciatic notch contour until it intersects line AB. This divides the notch width into two chords, posterior (chord AC) and anterior (chord CB). The notch chords are then measured. If chord AC is longer than or equal to chord CB, an assignment of “F” is given. If chord CB is longer than AC, an assignment of “M” is given. The second condition is measured by determining the symmetry or asymmetry of chords AC and CB. If the chords are symmetrical, an assignment of “F” is given, and “M” is assigned to pelves exhibiting asymmetrical notch chords. The third condition is measured by drawing a line parallel with the depth line through point A of the notch width. If the contour of the posterior chord crosses the perpendicular line drawn (line PA’), it is deemed “M,” and “F” is given to the lines that do not cross the perpendicular line.

The second quantitative measurement relates to the ischiopubic proportion, and measures ischium and pubis lengths. The pelvis is placed on a flat surface, laterodorsal iliac side down. The lengths are measured using a ruler (mm). If the pubis is longer than the ischium, an assignment of “F” is given, and “M” is assigned to pelves in which the ischium is longer than the pubis. If the two are equal in length, an Intermediate (“O”) assignment is given.
Statistical analyses. Multivariate statistics were required in order to analyze the data. A logistic regression was performed using SAS 9.2 in order to evaluate the hypothesis that Bruzek’s method does not correspond with the Phenice (1969) method for sex determination. Various groupings of traits used in the logistic regression are recorded (see Results, Table 5). Walker (2008) also uses logistic regression to determine accuracy of sex estimation on the human skull. In his study, Walker claims logistic regression yields the best results for “…Americans of recent African and European ancestry” (Walker, 2008:40), but may prove problematic in sexing ancient Native American remains. This is due to the fact that traits vary in their level of sexual dimorphism between and among populations. Walker also compared his results to what he refers to as “…reliable sex determination…based on os coxae morphology using standard sex determination procedures” (Walker 2008:41).

Discriminant function analyses were also conducted using SAS 9.2. A discriminant function analysis serves to separate two groups of individuals on the basis of multiple variables (Manly, 1986). Notch chords AC and CB were the traits used in the discriminant function.

The inferior pelvis and ischiopubic proportion (and the associated conditions) were omitted from all statistical analyses as the pelves were too fragmentary to yield an adequate sample size for these traits. A significance level of $p < 0.05$ was used and pelvic characteristics were assessed according to significance and percent correct (or percent in agreement with the Phenice [1969] method). In this paper, when the word
“correct” is used, it is in reference to agreement with the Phenice (1969) method, as actual sex of the individuals is not known.
Chapter 4: Results

In the Grantham collection of 41 individuals, 26 are scored as male. That is, 28 individuals have a majority of “M” assignments of sex; 10 are scored as female, with the majority of assignments being “F,” and 4 are scored “O” for intermediate. In the Buffalo sample of 75 individuals, 42 are scored as male (M), 30 are assessed as female (F), and 5 are scored as intermediate (O) (Table 4).

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of Individuals</th>
<th>Number of Males</th>
<th>Number of Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grantham</td>
<td>41</td>
<td>26</td>
<td>10</td>
</tr>
<tr>
<td>Buffalo</td>
<td>77</td>
<td>42</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 4: Number of males and females from the Grantham and Buffalo sites determined using Bruzek (2002). Intermediate not shown.

A possible male bias inherent in Bruzek’s (2002) method and will be addressed in greater detail later in this paper.

In the first trial, the two sciatic notch chords, AC and CB, were grouped with the preauricular sulcus, the preauricular pitting, and the piriform tubercle, all from right pelves. These five traits in combination yielded an accuracy rate of 62.5%, as it correctly sexed 40 of the 64 pelves. The error rate of 37.5% is much higher than Bruzek’s (2002) reported 4% (or less in some cases).
In the second trial, it was noted that sciatic notch chord AC had greater statistical significance, and CB was thus omitted. Notch chord AC was used along with the preauricular sulcus, the preauricular pitting, and the piriform tubercle, all from right pelves. These traits yielded a slightly higher accuracy rate of 67.2%. Sciatic notch chord AC was used along with the preauricular pitting and the composite arch to yield similar results (67.1% agreement with Phenice).

In the discriminant function, only the sciatic notch chord lengths (AC and CB) were assessed. Of the right os coxae, 69.44% were sexed correctly and only 59.8% were scored correctly from the left os coxae. The mean AC length in males was 1.5 cm while the mean CB length in males was 3.2 cm. In females, the mean AC length was 1.9 cm and 3.2 cm in females.

Most of the trait combinations produced accuracies in the high sixities, ranging from 62.5% to 69.9% correct (Table 5).
<table>
<thead>
<tr>
<th>Traits Used</th>
<th>R/L Pelvis</th>
<th>Percent Concordant with Phenice (1969)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC, CB, preauricular sulcus, preauricular pitting, piriform tubercle</td>
<td>Right</td>
<td>62.5%</td>
</tr>
<tr>
<td>AC, preauricular sulcus, preauricular pitting, piriform tubercle</td>
<td>Right</td>
<td>67.2%</td>
</tr>
<tr>
<td>AC, preauricular pitting, composite arch</td>
<td>Right</td>
<td>67.1%</td>
</tr>
<tr>
<td>AC, preauricular sulcus, preauricular pitting, composite arch</td>
<td>Right</td>
<td>68.5%</td>
</tr>
<tr>
<td>Ratio of AC and CB, preauricular pitting</td>
<td>Right</td>
<td>71.2%</td>
</tr>
</tbody>
</table>

Table 5: Traits used and percent concordant with Phenice (1969), continued
<table>
<thead>
<tr>
<th>Ratio of AC and CB, preauricular pitting, contour of sciatic notch chords</th>
<th>Right</th>
<th>69.9%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of AC and CB, preauricular pitting, contour of sciatic notch chords</td>
<td>Left</td>
<td>68.2%</td>
</tr>
<tr>
<td>AC and preauricular pitting</td>
<td>Left</td>
<td>63.6%</td>
</tr>
<tr>
<td>Preauricular sulcus, preauricular pitting</td>
<td>Left</td>
<td>66.3%</td>
</tr>
<tr>
<td>AC, preauricular sulcus, preauricular pitting</td>
<td>Left</td>
<td>66.7%</td>
</tr>
<tr>
<td>AC, preauricular sulcus, preauricular pitting, contour of sciatic notch chords</td>
<td>Left</td>
<td>66.7%</td>
</tr>
<tr>
<td>Preauricular pitting, piriform tubercle</td>
<td>Right</td>
<td>64.9%</td>
</tr>
<tr>
<td>AC, preauricular pitting</td>
<td>Right</td>
<td>75.3%</td>
</tr>
</tbody>
</table>
The highest achieved accuracy, however, came from combining only two traits, sciatic notch chord AC and the preauricular pitting. These characters produced an accuracy of 75.3%, as 55 pelves were correctly sexed and 18 were incorrectly sexed. Though this is somewhat higher than the above percentages correct, it does not match or come close to Bruzek’s (2002) accuracy levels.

It may be inferred from the above statistics that the sciatic notch chord AC and the presence or absence of preauricular pitting are the most sexually dimorphic characteristics in these Native American skeletal series.

The sexes of individuals were compared to site reports and records in which the researchers utilized more standard methods for sexing pelvic material (Phenice, 1969). Based on statistical analyses, the author proposes that Bruzek’s methods are in fact inaccurate measures of sex determination for Native American remains, as they do not correspond with the Phenice (1969) method.
Chapter 5: Discussion and Conclusion

Bruzek (2002) argues that while more standard and better accepted sexing methods can serve to accurately sex the entire human pelvis, methods must be put forward that can positively and effectively sex fragmentary remains. Methods such as the widely accepted Phenice (1969) method, Bruzek maintains, are only useful when handling complete, most often modern, human remains. Bruzek (2002) claims that his method will alleviate problems generated by incomplete archaeological skeletal remains.

This assessment of 11 indicators for sex identification using aspects of the ilium, ischium, and pubis confirms the author’s hypothesis that Bruzek’s methods are not accurate indicators of sex in the two Native American Indian populations selected for this study. First, Bruzek mentions the lack of completeness encountered in archaeological human remains, and argues most sexing methods rely heavily on the entire pelvis for accurate assessment of sex. Moreover, Bruzek proposes his methods are ideal for sex determination of fragmentary skeletal remains. Claiming that more popular sexing methods such as Phenice (1969) have proved inconsistent and unreliable, Bruzek states that his method is an effort to better sex an incomplete human pelvis. The irony present in Bruzek’s statement is that in order to diagnose a pelvis using his methods, one must have most pelvic aspects present. Bruzek states, “…sexual dimorphism of the whole hip bone should be considered, and observations should not be restricted to the pubis” (158). Though this statement is not without merit, it directly contradicts what Bruzek set out to
accomplish. In the present study, the author often found skeletal remains too incomplete to assess entirely; these samples were removed from the study. The author was also required to discard the last two characteristics Bruzek describes from statistical analyses – the inferior pelvis and the ischiopubic proportion – due to the fragmentary nature of the remains. The total number of the above two traits did not equal a sufficient quantity to be included in statistical analyses.

*An issue of bias.* Some consider a male bias to be inherent in sexing methodologies. Weiss (1972) asserts that many intermediate features on “doubtful” specimens are often declared male due to the general appearance of bony sex characteristics. Weiss (1972) terms these characteristics “larger-smaller,” in reference to traits that are subjectively assessed using “larger” or “smaller” criteria (e.g., muscle markings on the skull, femoral head size, etc.). When a specimen is of an intermediate nature, Weiss asserts, these “larger-smaller” traits may cause the observer to call the skeleton a male (1972).

Bruzek states that problems lie more often in sexing males than females. He maintains that female pelves are often smaller and more gracile, and are thus more obviously suggestive of female sex. Moreover, Bruzek states that when one sex is more frequently diagnosed, an inherent bias in the methodology is present. The irony of this statement is obvious when faced with the results of this study: more males than females were discerned in both Grantham and Buffalo skeletal collections using the very same methods Bruzek claims to dispel (see Results). This may be due to the fact that this study examines Late Prehistoric Native American remains and Bruzek’s study analyzes modern European individuals, specifically from France and Portugal. The French sample dates to
the first half of the twentieth century, while the Portuguese series includes individuals born between 1820 and 1920.

Another reason for the apparent male bias in the results of this study may be due to an inherent bias in the skeletal series themselves. Weiss points out that differential burial practices or poor preservation of female skeletal remains can produce a perceived male bias in methodology, and further obscure the process (1972).

The differing time periods and geographic variation between these populations may certainly be the cause of mine and Bruzek’s varying results. It is well-known that the same methods are often not applicable across geographic regions (Novotný, 1986), and that sexual dimorphism is also contingent on biological relatedness. As Sciulli, et al. (1991) point out, skeletal elements within populations are usually morphologically similar, therefore it can be expected that geographically different populations may exhibit rather distinct skeletal markers. Similarly, Krogman and İşcan (1986) state that standards of morphological sex differences will differ from one population to another, and standards should only be used on populations for which they were created. Moreover, Walker (2008) corroborates this, adding that discriminant function analysis should be used with caution on different populations, as groups can vary greatly interpopulationally. Debono and Mafart (2006) tested the Bruzek (2002) method on 963 French pelves dating from the 4th to the 17th centuries A.D. and found 92.7% accuracy using all 11 traits combined. Since the remains in Debono and Mafart’s (2006) study belong to the same geographic population that Bruzek examined, it can be concluded that similar results are due to geographic and intrapopulational similarities.
Not only do separate populations vary in their skeletal morphology as a rule, they oftentimes exhibit differing socio-cultural variables that may affect the manifestation of skeletal characters. For example, if a society engages in higher activity levels, their bones might display differing characteristics. This is due to the fact that the sexual division of labor or differing gender roles can play a role in how sexually dimorphic a group is; when gender roles converge, size and morphological differences between the sexes generally decrease (Frayer and Wolpoff, 1985).

It is important to note that Bruzek’s method is most appropriate in sexing archaeological skeletal samples, rather than modern human remains. Bruzek states that the piriform tubercle is “…likely associated with high levels of muscular activity,” but this assumption does not correspond to modern populations’ behavior and activity patterns. Modern Western societies exhibit non-traditional locomotor patterns, such as excessive sedentism; the skeletal manifestations of this phenomenon are not often viewed in prehistoric populations. Moreover, extreme athleticism must also be taken into account when assessing the piriform tubercle for sex.

The results demonstrate that Bruzek’s (2002) methods are inaccurate indicators of sex, insofar as Late Prehistoric Native American skeletons are concerned. These methods are inaccurate not only for sex diagnosis of pelvic fragments, but for sexing the entire hip bone as well.

This study is a valuable addition to the anthropological literature in that it informs researchers to be wary of interpopulational differences when analyzing skeletal remains. Since geographic regions can vary so greatly, anthropologists must be cautious to use methods derived for and tested on the samples and populations in question.
**Future directions.** In the future, the author plans to undertake evaluation of sex on the same Native American skeletal samples using the Phenice (1969) method, as well as Krogman (1962). As the first assessment of sex was performed decades ago by anthropologists other than the author, a re-evaluation of the skeletons using Phenice (1969) is necessary. A second standard sexing technique (Krogman, 1962) will be employed to improve the reliability of the study. Further, it has been stated above that standards for sex identification should only be applied to the population for which they were designed; the author wishes to investigate whether proper satisfactory methodology exists for sexing American Indian skeletal remains from the Ohio Valley.
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