David R. Hunt,[1] *Ph.D.*

Sex Determination in the Subadult Ilia: An Indirect Test of Weaver's Nonmetric Sexing Method

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ABSTRACT: The sexing of subadult remains has been an ongoing problem in physical anthropology for many years. This is due in part to the scarcity of subadult collections of known age and sex which are large enough to be used to develop and test analytical methods. Several methods have been devised but few have produced reliable results. In 1980, Weaver presented a method for sexing subadult ilia using a nonmetric trait (the raised versus nonraised auricular surface), which has an accuracy of 75% in fetal females and 92% in fetal males. His method has not been tested for reliability on a different subadult sample. An indirect test of Weaver's method was made on a sample of subadult South Dakota Arikara Indian ilia by comparing the ratio of raised to nonraised auricular surfaces with an expected 1:1 sex distribution.

Bimodal sex distributions in the Arikara formed unrealistic sex ratios, following an age-related shift from a 6:1 raised/nonraised ratio in newborns to a 1:4 ratio in young adolescence. Significant age correlations were found both in the present study and in Weaver's published results. The age-to-sex correlations indicated no confounding in the present study. The results of this test suggest that auricular surface morphology is not sex specific in subadult ilia, but may be related to aspects of shape and morphology in pelvic growth.

KEYWORDS: physical anthropology, human identification, musculoskeletal system, sex determination, subadult sexing, auricular surface, nonmetric sexing techniques, skeletal growth

Since the adult pelvis is considered one of the most highly sex diagnostic skeletal regions in the human body [*1–3*], it is logical to investigate the subadult pelvic bones for a reliable method for sexing infants and adolescents. Several studies have taken this approach to sex determination in children [*4–8*], with generally low degrees of success. More recently, Weaver [*9*] studied 154 ilia from the Hrdlicka known age and sex fetal collection, using Thomson's and Boucher's metric methods as well as investigating a raised versus nonraised auricular surface nonmetric trait. This trait is similar to the auricular surface elevation used as a sex discrimination trait in adults, [*3,10,11*].

Weaver found no significant sex differences in the metrical data, but the nonmetric trait sexed his fetal test sample at a 75% (female) and 92% (male) accuracy (Table 1). The sample size was small, but large enough to yield statistically significant results. The females in the sample did not separate well because, as Weaver [*9*] explains,

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[1]Research associate, Department of Anthropology, University of Tennessee, Knoxville, TN.

> it was required that the auricular surface be elevated along the entire length of both the anterior and posterior edges, if the surface were to be scored elevated. Complete elevation of this sort is not very common even in adult females.

He concluded that, with further study using larger sample sizes, this nonmetric trait and the metric indices might be more fully interpreted.

It is possible that the features he designated as sex related may be an artifact of that particular sample set. To test the reliability of this method for sexing subadults fully, a nonrelated sample of ilia of known sex and age should be analyzed using Weaver's criteria. Unfortunately, there are few known subadult skeletal samples large enough to be used to make these evaluations. This study proposes to use Weaver's method as a demographic tool to "sex" a series of unknown subadult ilia and evaluate the effectiveness of the method by the resulting sex distribution patterns of the sample.

Materials and Methods

A sample of 275 subadult ilia from an American Indian skeletal population were scored using Weaver's [*9*] raised and nonraised auricular surface criteria. Three South Dakota Arikara sites (Leavenworth, No. 39C09, Mobridge, No. 39WW1, and Larson, No. 39WW2) were chosen from the skeletal collections housed at the Department of Anthropology, University of Tennessee, Knoxville, Tennessee. These populations were chosen because of their geographic proximity to one another, their excellent state of preservation, and the large size of the collection. These three sites comprise the northern extension of the Arikara from their earlier occupations of the Central Plains and Middle Missouri basin [*12*]. Interaction with Mandan groups during their movements has also been suggested [*13*].

Complete or nearly complete ilia from individuals before the age of fusion of the tripartite acetabular junction (usually before the age of 11 or 12 [*1*]) were chosen for analysis. The left ilium was preferred but, when it was absent, the right was used. The nonmetric trait was scored for the ilium following the method of Weaver [*9*]:

> If the sacro-iliac surface was elevated from the ilium along its entire length and along both the anterior and posterior edges of the sacro-iliac surface, the auricular surface was considered elevated and was so scored. If the surface was not elevated, it was so scored.

TABLE 1—*Distribution of Weaver's nonmetric trait tested on the Hrdlicka fetal collections.*[a]

Sample	Total, *n*	Elevated, *n*	Nonelevated, *n*	Percent Correct
Fetal[b]				
Females	(24)	18	6	75.0
Males	(24)	2	22	91.7
Newborn[c]				
Females	(24)	13	11	54.2
Males	(24)	7	19	73.1
Six months[d]				
Females	(23)	10	13	43.5
Males	(32)	3	29	90.6

[a]From Weaver [*9*] (p. 195).
[b]$P < 0.005 x^2_{(1)} = 19.29$, Yate's correction applied.
[c]$0.05 < P < 0.1 x^2_{(1)} = 2.81$, Yate's correction applied.
[d]$0.005 < P < 0.01 x^2_{(1)} = 6.84$, Yate's correction applied.

TABLE 2—*Distribution of the nonmetric trait tested on the Arikara collection.*

Femur Length, mm	Approximate Age[a]	Raised, n[b]	Nonraised, n[c]	Total, n
60	7.5	7	0	7
80	11.5	117	21	138
100	18	14	4	18
120	24	12	5	17
140	30	10	15	25
160	36	4	14	18
180	45	4	10	14
200	55.5	2	12	14
220	66	0	10	10
240	78	3	6	9

[a]The ages are postconception, in months. The femur is 78 mm at birth.
[b]$P < 0.001$, $\chi^2 = 34.4$.
[c]$P < 0.001$, $\chi^2 = 61.3$.

The maximum diaphyseal femur length associated with each ilium was obtained from previous postcranial analyses done by D. W. Owsley. Age equivalents to femur lengths were assigned by adjusted dental ages for Arikara using the data of Jantz and Owsley [*14*]. As with the ilium, the left femur was preferred but, when it was absent, the right was used.

Statistical analysis was accomplished using the SAS statistical package, which was part of the facilities of the University of Tennessee Computing Center, Knoxville, Tennessee.

Results

Table 2 and Fig. 1 illustrate the vast numerical imbalance produced by the nonmetric criterion. The raised trait is 5.6 times more prevalent than the nonraised trait in newborns.

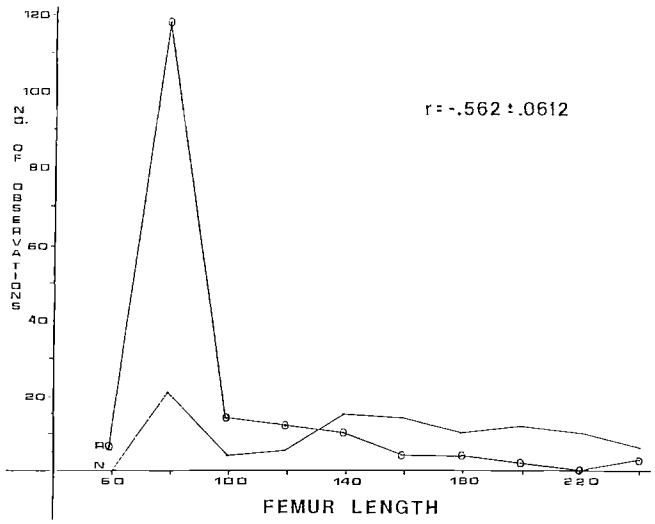

FIG. 1—*Graphic results of the bimodal distribution in the present study using Weaver's nonmetric trait: R = raised auricular surface; N = nonraised auricular surface.*

This biasing decreases with increasing age and inverts at a femur length of 135 mm (approximately 2½ years of age) in favor of the nonraised trait on the order of 3.5 to 4 times greater in the older children.

The distribution of raised versus nonraised auricular surfaces was so unbalanced that it almost certainly cannot reflect sex variation. Rather, a strong tendency for the raised frequency to decrease with age is evident. The correlation between the auricular surface, scored as 0 for nonraised and 1 for raised, and the femur length is -0.562 ± 0.061. Thus, in the Arikara sample the nonmetric trait is unmistakably correlated with age. A similar test of correlation performed using Weaver's published data (Table 1) resulted in an $r = -0.162 \pm 0.082$, which is significant above 2 standard deviations. The lower correlation found in these results is due to the more restricted age distribution. Both data sets were tested for a combined age/sex correlation. The result of this test indicated that there was no significant confounding of the two factors ($r = -0.06$) in either data set.

A goodness-of-fit chi-square test was performed on the Arikara "age" categories to evaluate the differences between the observed and expected distribution curves. Both nonmetric traits indicated significant deviations (nonraised = 61.3; raised = 34.4; degrees of freedom = 9) from the expected values at $P < 0.001$. The two distribution curves are distinctly separate from one another and from a 1:1 ratio.

Discussion

It was the intent of this paper to evaluate the level of sex separation produced by Weaver's nonmetric trait in an unknown archaeological population. Since the sex ratios of the Arikara sample are unknown, no direct check of sexing accuracy could be performed. However, vast numerical discrepancies in the raised versus nonraised ratio and its correlation with age suggest a weak relationship to sex. The Arikara Indians were not known to have selective burying practices, and no indications of this practice were found in either the protohistoric or the historic cemeteries excavated. It is also not documented that the Arikara practiced infanticide. Even if they did, the sex ratios probably would not reach the proportions found in the present samples (6:1 for raised/nonraised at birth), and the later reversal of the ratios in the results would also be impossible to explain. Therefore, it does not appear that the results of this study are an artifact of cultural, preservational, or methodological influences.

The departure of the raised versus nonraised ratio of auricular surfaces from a 1:1 distribution, the correlation of the auricular surface form with age, and the similar significant correlation found in Weaver's data all suggest that the morphology of the auricular surface is not primarily a feature of sex but one of growth variation during prepubescence. What can be concluded from this study is that the feature which Weaver categorizes as sex specific may have some real correlations to sex in the fetal group, but the major factor governing the formation and modeling of the auricular surface and its size and shape variation in subadults is age related. If gender has any influence on the design of the auricular surface in the subadult, it is deeply hidden by the overriding influences of growth on the morphology of the ilium.

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References

[*1*] Bass, W. M., *Human Osteology: A Laboratory Manual of the Human Skeleton,* Missouri Archaeological Society Special Publications, Columbia, MO, 1979.

[*2*] Krogman, W. M., *The Human Skeleton in Forensic Medicine,* Charles C Thomas, Springfield, IL, 1978.

[*3*] Phenice, T. W., " A Newly Developed Visual Method of Sexing the Os Pubis," *American Journal of Physical Anthropology,* Vol. 30, No. 4, 1969, pp. 297–302.

[*4*] Thomson, A., "The Sexual Differences of the Foetal Pelvis," *Journal of Anatomy and Physiology* (London), Vol. 33, April 1899, pp. 359–380.

[*5*] Reynolds, E. L., "The Bony Pelvic Girdle in Early Infancy: A Roentgenometric Study," *American Journal of Physical Anthropology,* Vol. 3, No. 4, 1945, pp. 321–354.

[*6*] Reynolds, E. L., "The Bony Pelvis in Prepuberal Childhood," *American Journal of Physical Anthropology,* Vol. 5, No. 2, 1947, pp. 165–200.

[*7*] Boucher, B. J., "Sex differences in the Foetal Sciatic Notch," *Journal of Forensic Medicine,* Vol. 2, No. 1, 1955, pp. 51–54.

[*8*] Boucher, B. J., "Sex Differences in the Foetal Pelvis," *American Journal of Physical Anthropology,* Vol. 15, No. 4, 1957, pp. 581–600.

[*9*] Weaver, D. S., "Sex Differences in the Ilia of a Known Sex and Age Sample of Fetal and Infant Skeletons," *American Journal of Physical Anthropology,* Vol. 52, No. 2, 1980, pp. 191–195.

[*10*] Stewart, T. D., *Essentials of Forensic Anthropology,* Charles C Thomas, Springfield, IL, 1979.

[*11*] Ubelaker, D. W., *Human Skeletal Remains: Excavations, Analysis, Identification,* Aldine, Chicago, IL, 1978.

[*12*] Jantz, R. L., "Craniometric Relationships of Plains Populations: Historical and Evolutionary Implications," *Plains Anthropologist,* Memoir 13, No. 22–78, 1977, pp. 162–176.

[*13*] Jantz, R. L., "Microevolutionary Change in Arikara Crania: A Multivariate Analysis," *American Journal of Physical Anthropology,* Vol. 18, No. 1, 1973, pp. 15–26.

[*14*] Jantz, R. L. and Owsley, D. W., "Long Bone Growth Variation Among Arikara Skeletal Populations," *American Journal of Physical Anthropology,* Vol. 63, No. 1, 1984, pp. 13–20.

Address requests for reprints or additional information to
David R. Hunt, Ph.D.
Collections Manager/Physical Anthropology
National Museum of Natural History
Smithsonian Institution
Washington, DC 20560