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The Sacrum of the Poole-Rose Ossuary: Health Status, Variation, and Demography

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ABSTRACT

Excavated in 1990, the Poole-Rose ossuary represents a Late Woodland burial site in southern Ontario, Canada. The site is radiocarbon dated to A.D. 1550 \pm 50 years. The ossuary consists of commingled skeletal remains and likely corresponds to the “Feast of the Dead.”

The present study examines several aspects of the sacrum in the ossuary remains, including minimum number of individuals, measurements of several elements of the sacrum, prevalence of lumbar facets, frequency of osteophytic lipping along the margins of the first sacral vertebrae, incidence of variable numbers of sacral vertebrae less or greater than five, and finally presence of cultural modifications to the sacra. The minimum number of individuals is 172, including 155 adults and 17 subadults. The mean straight length and maximum breadth of the sacrum are 110.1 mm and 117.8 mm respectively. These measurements are in the upper range of variation when compared with other populations. Maximum sacral breadth also provides an estimate for width of the bony birth canal, although sexual differences regarding this relationship exist. Osteophytes along the rim of the first sacral vertebra are seen in 17.6% of adults. Osteophytes are an indicator of age and activity level in an individual. The prevalence of lumbar-sacral facets for this population is 5.2%. Twenty percent of the individuals have extra vertebrae fused to the sacrum; these anatomies may have important obstetrical implications for this population. Cut marks are seen on one of the sacral fragments, suggesting defleshing prior to the Feast of the Dead.

This study of the sacrum in the Poole-Rose ossuary provides information on the demography, health status, and cultural behavior of this population.

CHAPTER ONE

INTRODUCTION

Study of the sacrum is useful for addressing several demographic factors in a population. For example, measurements of the sacrum can be used to estimate stature (Pelin et al., 2005; Giroux and Westcott, 2008). Factors such as osteophytic lipping and sacral vertebral body fusion can give insight to the relative age of the individuals in a population. In addition, the study of sacral vertebral pathologies and anomalies is useful for determining a population's overall health. The sacrum participates in the pelvic complex; therefore, studying sacral pathologies and variation gives insights into the level of obstetric difficulty in a population as well. Variation in the sacrum, such as sacralization of the fifth lumbar vertebrae, can be obstetrically disadvantageous (Tague, 2009).

Research on the sacrum of Native American populations and First Nation People of Canadap has yielded results with implications for the health and demography of pre-contact and post-contact populations. Studies of the sacra of the Pecos Pueblo, Haida, Indian Knoll, and Libben sites, among others, have given information on the sacral dimensions of these populations, and studies suggest that measurements of the sacra can be used to estimate body size among individuals and populations (Pelin et al., 2005; Giroux and Westcott, 2008). Research on the dimensions and pathologies of the sacrum in Native American populations from different temporal intervals can help to understand changes in health and body size with regard to subsistence changes, differences in regional occupation, and differences between pre-contact and post-contact populations. Although inferences about individual health and body size are possible from analysis of the skeleton, this study will address health and demographic factors at the populational level.

The Poole-Rose ossuary represents a Late Prehistoric burial from southern Ontario, Canada. The ossuary was discovered in 1990 by building contractors during renovations to a 19th century farmhouse. Heather McKillop of Louisiana State University excavated the cemetery. Nora Bothwell, Chief of Alderville First Nation at the time of the ossuary's excavation, authorized the remains to be studied with respect to age, sex, and health status of the population and has only agreed to the remains for burial once research has been conducted on these factors (Personal communication, H. McKillop, 2011).

The Poole-Rose site covers an area 2.5m in diameter and extends about 1.5m underground. The ossuary was densely packed with disarticulated human remains; because the layers of bone were not separated by soil fill or soil layers, McKillop interpreted that the remains were probably deposited in a single burial event (Personal communication, H. McKillop, 2011). Due to the wide range of ages represented by the skeletal material, the ossuary remains are indicative of a natural population (McKillop and Jackson, 1991). The layout and makeup of the burial resemble the cultural practice of the "Feast of the Dead" which was described by early 17th century missionaries to Huronia (McKillop and Jackson, 1991). Therefore, the Huron are often used as an ethnographic analogy when studying the burial practices of this population and the layout of the site.

The material of the ossuary, which is radiocarbon dated to A.D. 1550 \pm 50, is well-preserved (McKillop and Jackson, 1991). Although there were three articulated human burials near the top of the burial pit, the majority of the remains were disarticulated and commingled. Due to the commingled nature of the bones, individual analysis of any single skeleton, aside from the few articulated burials, is impossible. However, studies of skeletal elements are possible

and can allow researchers to make inferences about the population as a whole; such studies may be vital to demographic and health analysis of the Poole-Rose population.

Ossuary burials are invaluable to researchers studying the demographics of historic and prehistoric populations. Ossuary burials are believed to contain individuals from a genetically related group of individuals from a single geographic area (Ubelaker, 1974), and this fact often makes assessment of the population's overall demographic makeup from the health and relative ages of individuals possible. In addition, one can make inferences about cultural practices from evidence of burial practices such as burning, defleshing, or other such postmortem treatment of bone. Although the material of the Poole-Rose collection is of a commingled nature, inferences about the health and demographic makeup of the population can still be made from analysis of individual bones. Therefore, study of the sacrum is helpful in understanding the overall health and demographics of the Poole-Rose site. Because the sacrum both is part of the spinal column and a component of the pelvic girdle, studying the sacrum allows one to make inferences about both body size and obstetric health in a population. In addition, relative age can be determined from the degree of vertebral body fusion, epiphyseal ring fusion, and level of osteophytic lipping and degeneration (Bass, 2005).

The goal of the present study of the Poole-Rose sacrum is to give insight into the demographic makeup of this Late Prehistoric site while shedding light on the overall health of the population. The following chapters will discuss the literature concerning burial practices of the Huron, used an ethnographic analogy for the Poole-Rose site to help understand the population's cultural practices, and the pathologies and variation in the human sacrum with health implications for this population. I will then report and explain the data collected from the Poole-Rose sacra. Finally, I will discuss the results of this study and draw comparison between

the Poole-Rose site and other Native American skeletal collections with regard to health and demographic factors.

CHAPTER TWO

LITERATURE REVIEW

2.1 Poole-Rose Ossuary

Attribution of the Poole-Rose ossuary to a specific cultural group is difficult. The excavation of the Poole-Rose ossuary yielded no associated artifacts (McKillop and Jackson, 1991). Although there is no definite association of the Poole-Rose ossuary with any specific Native Canadian group, inferences about the population can be made by the nature of the burial and remains.

The Poole-Rose ossuary, which is dated to A.D. 1550 \pm 50 years, corresponds to the Late Woodland period (McKillop and Jackson, 1991). The practice of ossuary burial was common in Ontario during the Iroquois Stage of the Late Woodland Period. Several ossuary burials dated to the Late Woodland Period have been located in south-central Ontario (Molto, 1983; McKillop and Jackson, 1991). Based on the age and location of the site, one can infer that the Poole-Rose population relied on an agricultural subsistence strategy (McKillop and Jackson, 1991).

Analysis of the hipbone in the ossuary has estimated the percent of juveniles to be 24%; among adults there are roughly equal numbers of males and females represented in the sample (Tague et al., 1998). Several studies of the ossuary remains have indicated that this population was generally in good health despite minor occurrence of degenerative joint disease, tuberculosis, and cribra orbitalia (Bordelon, 1997; Smith, 1997; Dunne, 1999; Lundin, 2000; Bodin, 2002). In addition, analysis of the nature of the Poole-Rose ossuary burial has given insights into the cultural practices of this population.

2.2 Huron and the Feast of the Dead: An Ethnographic analogy

An ethnographic account of the Huron by Jesuit missionaries in the 17th century described a ritual called the “Feast of the Dead” in which remains were taken from primary

burials and interred into a secondary communal burial (Thwaites, 1896-1901); the communal Poole-Rose ossuary burial is reminiscent of this Huron practice (McKillop and Jackson, 1991). Brébeuf described ritual defleshing of individuals prior to deposition in a secondary burial in his account of the Feast of the Dead (Thwaites, 1896-1901), and defleshing marks appear on bones in the Poole-Rose ossuary as well (Bodin, 2002; Scheiss, 2002; Penney, 2005; Smith, 2010).

Although the Poole-Rose ossuary shares some features associated with the Huron ritual of the Feast of the Dead, there are some key differences between these Huron ritual burials and the Poole-Rose burial. For example, the Poole-Rose ossuary is not located within Huronia. In addition, the remains of very young children appear in the Poole-Rose ossuary, but such individuals were apparently not disinterred from primary burials by the Huron during the Feast of the Dead rituals (McKillop and Jackson, 1991). While these dissimilarities exist between the Poole-Rose ossuary and burials associated with the Huron ritual of the “Feast of the Dead,” the similarities between the rituals indicate that there may have been some level of cultural resemblance between the Poole-Rose population and the Huron.

Because the states of the burial and remains of the Poole-Rose ossuary are in some ways congruent with the actions described in Brébeuf’s account of Huron ritual behavior, the Huron can be used as an ethnographic analogy to the Poole-Rose ossuary. The “Feast of the Dead” is a ritual practice that was observed and described by French missionary Jean de Brébeuf during his service as a missionary to the Huron from 1626 to 1649. While conducting his work in Huron villages, Brébeuf composed the only ethnographic record in existence concerning the Feast of the Dead (Thwaites, 1896-1901; Donnelly, 1975). During his stay in the Huron villages, Brébeuf noted the overall good health of the people he observed, although analysis of skeletal remains suggest the prevalence of pre-contact diseases and stress-markers such as dental caries,

hypoplasias, endemic syphilis, and tuberculosis (Warrick, 2008). In addition, osteoarthritis of the spine was prevalent among the Huron (Harris, 1949).

When Europeans first made contact in the early 17th century, the Huron, who referred to themselves as the Wendat or “people of the island,” represented a sedentary agriculturalist group of nearly 30,000 individuals with a tribal organization (Donnelly, 1975; Warrick, 2008). The Huron diet primarily consisted of the “three sisters” of corn, beans, and squash common among Native Canadian and American agriculturalists; the Huron also supplemented their diets with wild game, fish, and gathered seeds and fruit (Warrick, 2008).

The Feast of the Dead is described by Brébeuf as a ritual disinterment of the dead from cemeteries, occurring at an interval of about twelve years between each disinterment, and subsequent burial in a communal pit (Thwaites, 1896-1901). Between the years in which the Feast of the Dead occurred, individuals’ remains were placed in cemeteries near the village; these cemeteries consisted of enclosed scaffolding structures which served to keep scavenging animals away from the remains (Thwaites, 1896-1901; Tooker, 1964). After the remains were disinterred from the cemeteries, any remaining soft tissue on the bones was cut away and the bodies were covered with beaver skins (Thwaites, 1896-1901). A large grave pit was dug and lined with animal skins, and after this time the bodies were placed inside the pit. The remains of those individuals who had recently died and were still intact were placed at the bottom of the grave pit, while loose, commingled bones were cast in afterward (Thwaites, 1896-1901). Individuals whose remains were not included in the Feast of the Dead ritual were those who had committed suicide, those who had died a violent death, and infants (Tooker, 1964).

Ossuary burials such as those performed by the Huron are invaluable for study because the individuals buried in ossuaries are assumed to be the deceased relatives of those people who

were living in a specific area in a specific time period (Ubelaker, 1974; Pfeiffer, 1983). In this way, ossuary burials are thought to represent a temporally and genealogically related group of people. Because ossuaries often consist of commingled skeletal samples, only information about populations can be gleaned through studies of ossuaries that contain disarticulated remains.

2.3 Maturation of the Sacrum

Maturation of the sacrum occurs in a predictable fashion from the first trimester of life until mid-adulthood. Each sacral vertebra fuses from five primary ossification centers excluding at the level of the fifth sacral (S5), where the costal processes are absent. The primary ossification centers fully fuse by age 7 at the latest (Broome et al., 1998). After fusion of the primary ossification centers has occurred, the sacral bodies and costal elements begin to fuse. Fusion of the five sacral vertebrae, including both fusion of the costal elements and vertebral bodies, is completed by age 18 to 25 (Broome et al., 1998; Bass, 2005).

In addition to using ossification of the sacrum to determine relative age, one can also use epiphyseal rings, which fuse to the margins of vertebrae, to estimate age. Prior to the fusion of the ring, the centrum of the vertebral body has a billowed appearance. Epiphyseal rings appear during puberty and generally fuse to the vertebral bodies by age 25 (Bass, 2005). Although ossification of the sacrum and fusion of the ring epiphysis do not provide an exact age for an individual, these properties can be used to determine the relative age of an individual in a population.

Likewise, osteophytic growth in the vertebrae is another useful aid in determining skeletal age. Although lipping can appear on any margin of the vertebral body, osteophytic growth is most often found on the anterior margin of the vertebral body (Nathan, 1968). Research on osteophytic growth in the vertebral column suggests that not only does lipping appear with higher frequency in older individuals than younger ones, but the severity of lipping

is also positively correlated with age. Lipping can be seen developing in individuals of 20-30 years of age, and osteophytic growth is almost universally present to some extent on the vertebral body margins in individuals 40 or older (Nathan, 1968). Stewart (1958) observed that osteophytic growth tends to develop rather slowly in individuals 20-30 years of age, but the rate of growth dramatically increases between ages 30-50 (most markedly in the lumbar region). Although osteophytic lipping of the vertebrae may also be influenced by factors such as the frequency and types of activities one performs (Bridges, 1994), osteophytic growth can be a valuable aid in determining the relative skeletal ages of individuals in a population.

2.4 Lumbar Facets and High Assimilation of the Sacrum

Lumbar facets appear on the sacral alae when the costal processes of the caudal-most lumbar vertebra, most commonly the fifth lumbar vertebra (L5), contact the costal processes of the first sacral vertebra (S1). Lumbar facets appear laterally on the sacral alae as oval-shaped contact facets. Sacralization of L5, also referred to as “high assimilation of the sacrum,” occurs if the costal processes of L5 and S1 fuse with one another. Even if fusion of the costal processes of the lumbar vertebra with the sacral alae occurs, the vertebral bodies of L5 and S1 sometimes remain broadly separated from one another (Tague, 2009). Prevalence of high assimilation of the sacrum is significant for study because it is associated with reduced sagittal diameter of the pelvic outlet (Tague, 2009). The pelvic outlet is an area of possible constriction during childbirth; therefore, high assimilation of the sacrum may be obstetrically disadvantageous (Kirchoff and Kraübig, 1957; Berger and Stoll, 1965).

In addition to being obstetrically disadvantageous, sacralization of L5 is also associated with lower back pain and, in some cases, scoliosis (Gordon, 1923; Brailsford, 1929; Steinberg et al., 2003). Because high assimilation of the sacrum is often an indicator of other health complications, occurrence of sacralization of L5 in a group can give insights into the relative

health and quality of life for the population. Therefore, study of the prevalence of lumbar facets and incidence of fusion of the caudal-most lumbar vertebra with S1 is useful for making inferences about populational health.

2.5 Sacral Measurements

In addition to being valuable for inferring health status and relative age, the sacrum may also be used to determine an individual's body size. Estimation of body size from the sacrum is dependent on sacral measurements. Measurement of the straight length of the sacrum, also called sacral height, can be an indicator of an individual's overall stature. The sacrum is generally longer in males than in females but wider in females than in males; this fact is presumably related to obstetrics.

Straight length of the sacrum – measured from the most superior point along the anterior margin of the sacrum to the caudal-most point of the sacrum's anterior surface – has been effectively used to estimate living stature (Pelin et al., 2005; Giroux and Westcott, 2008), although the correlation between stature and sacral height is stronger when sacral measurements are taken radiographically than when dry bone is measured (Giroux and Westcott, 2008). This method for estimating stature from straight length of the sacrum is most effective when the sacrum to be measured has the modal number of five sacral vertebrae (Raxter and Ruff, 2010). Incorporation of fewer or greater numbers of vertebrae in the sacral complex is not uncommon; however, because in the majority of cases the sacrum is composed of only five vertebrae, using sacral height to determine stature may be helpful in determining the relative body size of individuals in a population.

2.6 Variable Numbers of Sacral Vertebrae

The sacrum is modally composed of five vertebrae (White and Folkens, 1991). Variable numbers of sacral vertebrae (i.e. greater or less than the modal number of five) occur when

lumbar or coccygeal vertebrae fuse to the sacral complex or when one or more sacral vertebrae remain unfused to the sacrum throughout adulthood. Besides being a concern when making estimations of stature, numbers of sacral vertebrae greater than the modal number of five may have obstetric implications. There is no difference between the incidence of females with assimilated sacra and incidence of males with assimilated sacra (Tague, 2009). In females with assimilated sacra, the posterior sagittal diameter of the outlet is significantly shorter than in females with only five sacral vertebrae (Tague, 2009). Because the posterior sagittal diameter of the outlet is an area of possible constriction during childbirth, having an assimilated sacrum may be hazardous for a female. Therefore, study of incidence of variable numbers of sacral vertebrae in a population may shed light on obstetrical difficulty encountered by women in the population.

CHAPTER THREE

MATERIALS AND METHODS

This study analyzed commingled sacra from the Poole-Rose ossuary; the ossuary remains were loaned to Heather McKillop by Alderville First Nation. Prior to the commencement of the present study, the remains had been cleaned, sorted, and catalogued.

The sacra of the collection included 18 whole bones and 595 fragments. I reconstructed as many of the sacra as possible from the fragments. Fifty fragments were matched, totaling 22 partially-reconstructed sacra. I then separated the sacra into adult and subadult specimens. Specimens were classified as adult or subadult based upon fusion of the epiphyseal ring to the first sacral vertebral body, as well as fusion of the sacral bodies to one another. Epiphyseal rings generally fuse to the vertebral bodies by age 25, and fusion of the five sacral vertebrae is completed by age 18 to 25 as well (Bass, 2005). After dividing the sacra by adult and subadult specimens, I collected data on minimum number of individuals (MNI), measurements of the maximum dimensions of the sacrum and first sacral vertebral body, prevalence of lumbar facets, frequency of sacra with fewer or greater than five sacral vertebrae, and prevalence of marginal lipping of the first sacral vertebrae. Finally, each specimen was examined for evidence of cultural modifications such as burning or cutmarks which could suggest post-mortem funerary rites or burial practices.

Using the right and left halves of the first sacral vertebral body, I counted the MNI for adults and subadults. I calculated MNI for both the right and left sides of the sacrum. At least half of the right or left side of the first sacral body was required to be present in order for the specimen to be included in the analysis for right or left MNI. The MNI for the right and left sides was then calculated.

I took measurements of several aspects of the adult sacra in the collection. I used a digital caliper to take all of the measurements. First, the maximum breadth of each sacrum was recorded for all those specimens which had undamaged costal processes at the level of S1. Maximum breadth was defined as the distance between the most lateral projections of the sacral alae. Then, I measured the straight length of all the sacra for which the measurement could be taken. Straight length of the sacrum is the distance between the most superior point along the middle of the first sacral body to the inferior edge of the caudal-most sacral vertebra.

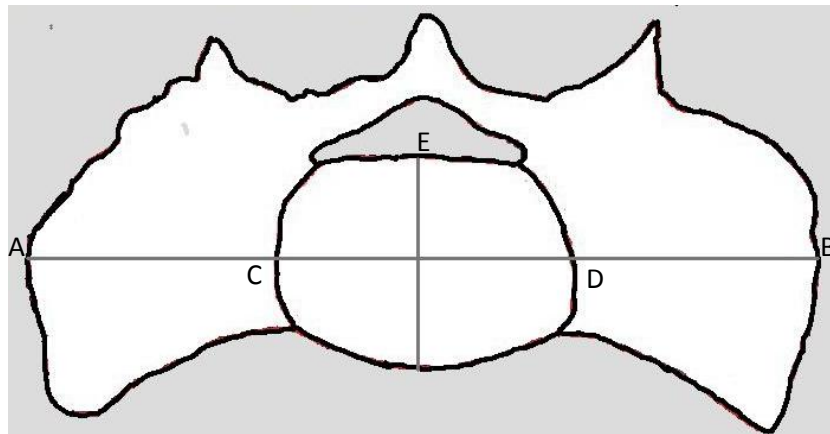


Figure 3.1: Measurements of the First Sacral Vertebra. Superior View. A-B: Maximum Breadth of the Sacrum; C-D Breadth of S1; E-F: Anteroposterior Length of S1; A-C and B-D: Alar Length. Drawing by E. Moffett.

The anteroposterior and transverse diameters of the first sacral body were also recorded. Anteroposterior diameter of the first sacral body is the distance from the midpoint along the anterior edge of the sacral body to the midpoint along the posterior edge. The transverse diameter of the sacral body is the maximum transverse distance of the vertebral body perpendicular to the anteroposterior diameter. Finally, I measured the lengths of the right and left alae of each of the sacra with undamaged right or left alae (Figures 3.1, 3.2).

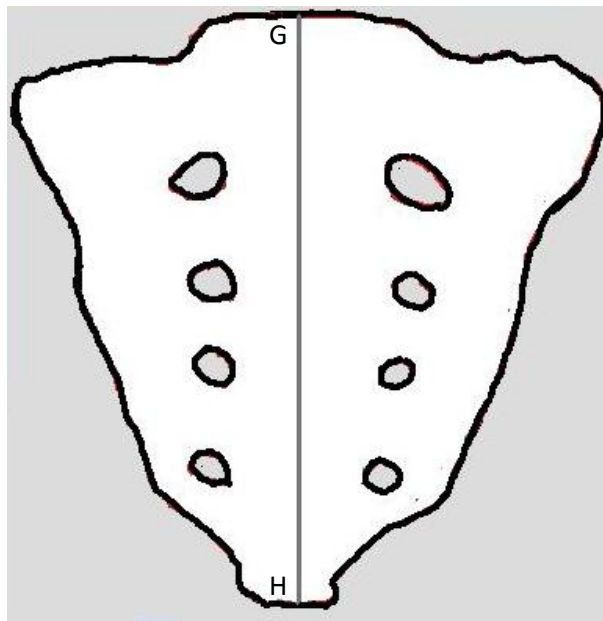


Figure 3.2: Measurement of Sacral Length. Anterior View. G-H: Straight Length of Sacrum. Drawing by E. Moffett

In order to ascertain the frequency of lumbar facets in the ossuary remains, I first recorded which specimens could be evaluated for the presence of facets. Those specimens which had damaged or broken costal processes at the level of S1 were not included in this portion of the study. I recorded whether or not analysis of the costal processes was possible for each specimen, and I then recorded which specimens had lumbar facets, noting if the presence was on the right side, left side, or on both alae of the sacrum.

While the sacrum is modally composed of five fused vertebrae, sacra with either four or six vertebrae are not uncommon (Tague, 2009; Tague, n.d.). In order to evaluate the prevalence of specimens with more or less than five sacral vertebrae, I chose all the specimens with at least four undamaged fused sacral vertebrae, although many of these had damage at the level of S5. For each specimen, I observed the number of sacral vertebrae. Special note was taken if the number of sacral vertebrae was the total number of fused sacral vertebrae (i.e., there was no damage to the caudal-most vertebra) or if the number of vertebrae was the minimum number of

fused sacral vertebrae (i.e., the caudal-most sacral vertebra was damaged, making knowledge of the total number of fused sacral vertebrae impossible). Each sacrum was placed in one of the following categories: “four total vertebrae,” “minimum of four vertebrae,” “five total vertebrae,” “minimum of five vertebrae,” “six total vertebrae,” and “minimum of six vertebrae.” I then calculated the percentage of individuals in the “four total vertebrae” category and then the percentage of individuals in the “six total vertebrae” and “minimum of six vertebrae” categories. Finally, I compared the results for the percentage of individuals in this population with a nonmodal number of sacral vertebrae with the frequency of variable numbers of sacral vertebrae in other populations for which this statistic is known.

Osteophytic lipping of the vertebrae is the presence of bony growths, or “osteophytes,” on the margins of the vertebral bodies. When present in the sacrum, osteophytic lipping can be observed along the superior rim of the first sacral vertebra; lipping is more often observed along the anterior margin of vertebrae (Nathan, 1962). In order to evaluate the prevalence of osteophytic lipping in the Poole-Rose ossuary sacra, I first chose those sacra and sacral fragments in which all or part of the anterior margin of the first sacral vertebral body was present. Those specimens with extensive damage to the anterior margin were not included. Of all the sacra, 210 of the bones and fragments had anterior margins well-preserved enough to make an observation about presence of lipping. I then counted the number of specimens which had lipping along the anterior border. The severity of the osteophytic growth was not noted; lipping was simply marked as “present” or “not present.”

Finally, I examined all the sacral bones and fragments for the presence of defleshing or cut marks as well as evidence of burning and other postmortem cultural modifications.

CHAPTER FOUR

RESULTS

4.1 Minimum Number of Individuals

The MNI for the Poole-Rose ossuary for the sacrum is 172 individuals based on the right half of the S1 vertebral body. This corresponds to the MNI for the left half of the S1 vertebral body, which is 168. Based on the MNI, 90.1% are adults and 9.9% are subadults (n= 155 and 17, respectively).

TABLE 4.1: MNI for Sacrum by Right and Left Halves of S1

Side	Adult	Subadult	MNI
Left	154	14	168
Right	155	17	172

4.2 Measurements of the Sacrum

For the antero-posterior and transverse diameters of the S1 vertebral body, the mean values for the measurements are 32.3 mm and 51.6 mm respectively. For maximum breadth, the mean is 117.8 mm, whereas for straight length the mean is 110.1 mm. I calculated straight length of the sacrum only on individuals with five sacral vertebrae; the mean length of the sacrum for all individuals in the sample is 113.1 mm. The mean value for the right ala is 41.3 mm, while the mean value for the left ala is 41.1 mm.

Table 4.2: Measurements of the Poole-Rose Sacra, in mm

Measurement	<i>n</i>	\bar{x}	σ	Range
Antero-Posterior Diameter S1	68	32.3	2.9	25.9 - 38.6
Transverse Diameter S1	74	51.6	5.6	30.6 - 61.4
Maximum Breadth	27	117.8	7.2	100.8 - 129.8
Straight Length	25	110.1	8.0	95.5 – 128.4
Right Ala	46	41.3	3.6	29.4 – 48.6
Left Ala	43	41.1	3.4	34.3 – 49.3

In order to ascertain the equality of the means between the measurements of the right and left alae, I conducted a Student's *t*-test (Table 4.3). Results show no significant difference in length between the right and left alae (level of significance set at $p \leq 0.05$).

Table 4.3: Results of Student's *t*-test for Right and Left Alae

	Right Ala	Left Ala
Mean	41.3	41.1
Standard Deviation	13.0	11.5
Observations	46	43
Degrees of Freedom	87	
<i>t</i> value	0.28	
Statistical Probability	0.78	

4.3 Lumbar Facets

To evaluate the prevalence of lumbar facets, I was able to observe 65 left and 50 right alae. Of these, three left and four right alae had lumbar facets. Only one of the observed sacra had lumbar facets on both the right and left alae (dual facets). Eight percent of the right alae and 4.6% of the left alae had lumbar facets present; for combined right and left alae the prevalence of lumbar facets was 6.1%; however, because one of the sacra had dual facets, the total prevalence of lumbar facets for the population is 5.2%.

Table 4.4: Prevalence of Lumbar Facets

Side	Number of Observed Alae	Number of Facets	Percent
Right	50	4	8.0%
Left	65	3	4.6%

In addition to finding lumbar facets on seven of the sacral alae, I also reconstructed from two fragments a single fifth lumbar vertebrae which articulated with the sacrum which had lumbar facets on both the right and left alae (Figures 4.1 and 4.2).

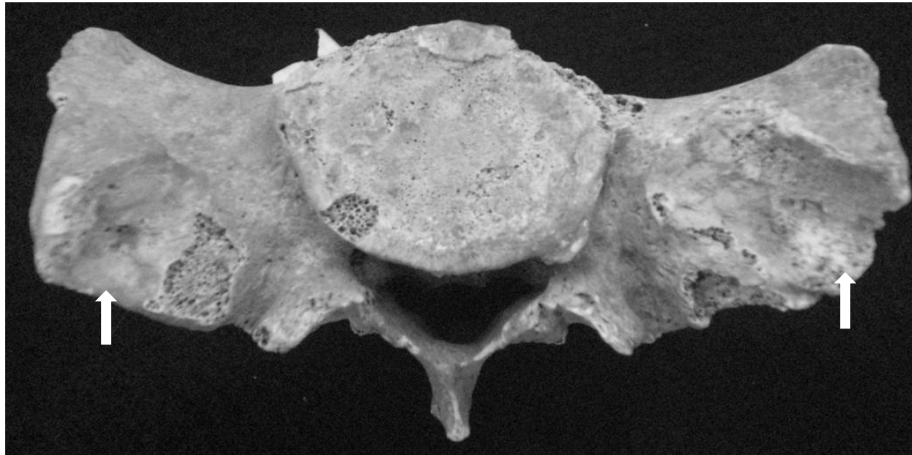


Figure 4.1: Presence of Lumbar Facets on the Right and Left Alae . Specimen: 3-24-481. Photograph by E. Moffett

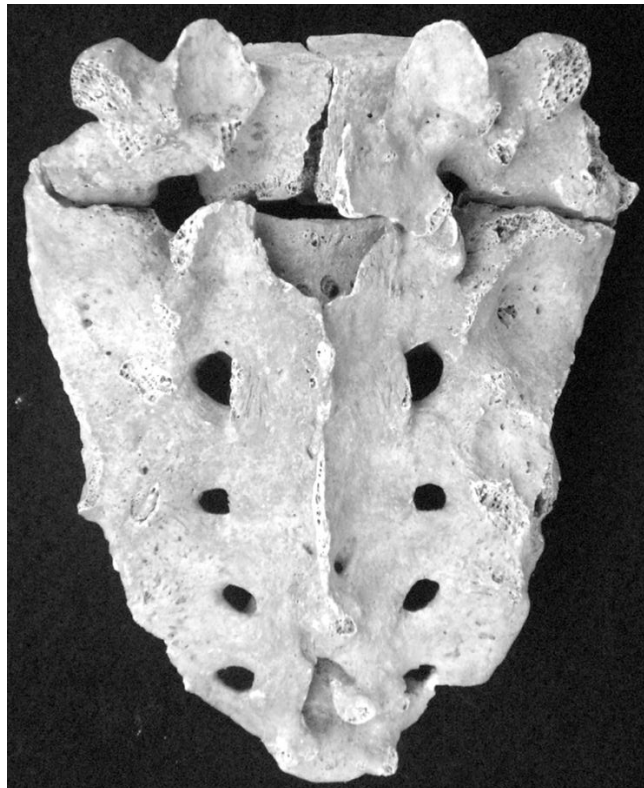


Figure 4.2: Articulation of Fifth Lumbar with the Sacral Alae. Specimen Numbers: 3-24-481; 3-24-1913; 3-24-2194. Photograph by E. Moffett

4.4 Variation in Number of Sacral Vertebrae

Of the 30 sacra that could be evaluated for variable numbers of vertebrae, four have at least six vertebrae, two have six total vertebrae, 10 have at least five vertebrae, and 14 have five

total vertebrae. None of the sacra has less than the modal number of five fused vertebrae.

Therefore, six of the sacra have greater than the modal number of five vertebrae. The frequency of sacra with six or greater vertebrae was six of the 30 sacra evaluated. Therefore, 20.0% of the specimens are in either the “At Least Six Vertebrae” or “Six Total Vertebrae” categories (Table 4.5).

Table 4.5: Variation in the Number of Sacral Vertebrae

Number of Sacral Vertebrae	Frequency	Percent	Cumulative Percent
Less than Five Total	0	0.0%	0.0%
Five Total	14	46.7%	46.7%
At Least Five	10	33.3%	80.0%
Six Total	4	13.3%	93.3%
At Least Six	2	6.7%	100.0%
Total	30	100.0%	100.0%

4.5 Osteophytic Lipping

Osteophytic growth was observable along the anterior rim of the first sacral vertebra on 14.5%, or 30 of the 207 whole and fragmented adult sacral bones available for observation (Table 4.6). Figure 4.3 shows one specimen with lipping along the right anterior margin of S1.

Table 4.6: Frequency of Osteophytic Lipping for the First Sacral Vertebra

Number of Sacral Specimens	Sacral Specimens with Lipping	Sacral Specimens without Lipping
207	30 (14.5%)	177 (85.5%)



Figure 4.3: Osteophytic Lipping along the Right Anterior Margin of S1. Specimen 3-24-771. Photograph by E. Moffett

4.6 Cultural Modifications

Of 613 sacra and sacral fragments, only one fragment had definite signs of postmortem cultural modification. This fragment had nine shallow parallel incisions along the median sacral crest. Each incision was 2-3 millimeters long and less than one millimeter deep (Figure 4.4). None of the sacra showed signs of charring.

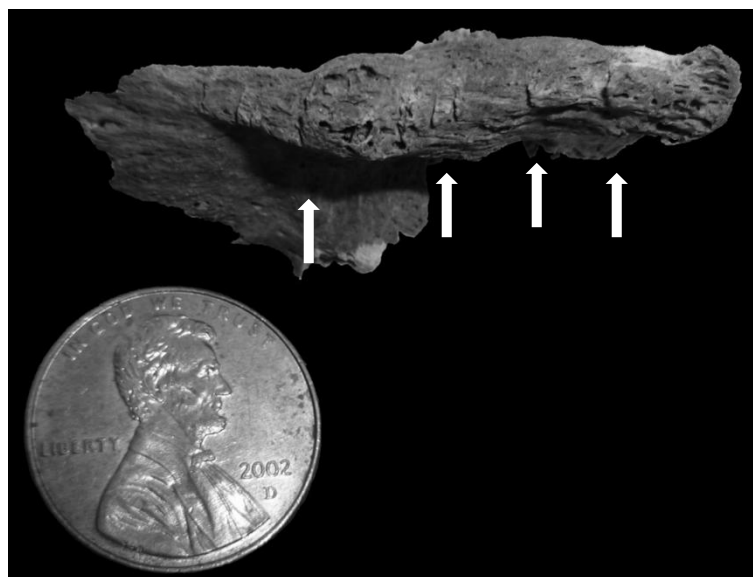


Figure 4.4: Cutmarks along the Median Sacral Crest. Specimen 7-21-128. Photograph by E. Moffett

CHAPTER FIVE

DISCUSSION AND CONCLUSION

This study of the Poole-Rose ossuary sacrum gives information on the demography, health, and cultural behavior of the ossuary population. The MNI for the sacrum is 172, including 155 adults and 17 subadults, based upon the right half of the first sacral body. The MNI for the sacrum is consistent with other studies performed on the Poole-Rose ossuary remains, which have reported MNIs of 178 based upon the second cervical vertebra (Dunne, 1999), 166 based upon the supraorbital notch (Smith, 1997), 193 based upon the right tibia (Bordelon, 1997), 196 based upon the right lateral epiphysis of the clavicle (Smith, 2010) and 242 based upon the ilium (Tague et al., 1998). The highest calculation of MNI in the ossuary is 337 based on the right petrous portion of the cranium (Seidemann, 1999). The MNI for the sacrum may be lower than MNIs for the tibia, petrous portion, and ilium because the sacrum is largely composed of trabecular bone and can be easily broken or damaged in archaeological contexts.

The percentage of subadults for the Poole-Rose ossuary population in this study is 9.9%. The percent subadults for the sacrum is lower than previous estimates for percent of subadults in the population. Tague et al. (1998) estimated the percent of subadults to be 24% of the total population. The low percent of subadults in the Poole-Rose ossuary population estimated using the first sacral body may be due to the fact that the costal elements of the sacrum begin to fuse later in childhood, usually after about age 7. Before fusion of the costal processes to the sacral body commences, determination as to whether the vertebral body in question is indeed a sacral vertebral body or if it is a lumbar vertebral body may be impossible. In addition, even after fusion of the costal processes to the sacral body is complete, fusion of the sacral vertebrae to one another does not commence until around age 7 and continues until early adulthood (Bass, 2005);

if an unfused sacral vertebra is found out of context, determination with certainty as to whether or not the vertebra is a first sacral vertebra may be impossible. Because the Poole-Rose ossuary material consisted of many juvenile vertebral bodies without fused costal processes and many other sacral vertebrae with costal processes that remained unfused to the sacral complex, accurate determination of whether or not many of the vertebrae were first sacral vertebrae was impossible in many cases. In addition, different skeletal elements complete ossification at different ages, so the percent of subadults in a population may be variable depending on the bone which is being studied.

Mean measurements of the sacrum for the Poole-Rose ossuary were 32.3 mm for anterior-posterior breadth of S1 and 51.6 mm for breadth of the S1 body. The Poole-Rose population is 7% larger for anterior-posterior breadth of S1 and 4% larger for transverse breadth of S1 compared to a combined sample of American whites and blacks, whose mean measurements for anterior-posterior breadth of S1 and transverse breadth of S1 are 30.3 mm and 49.6 mm respectively (Tague, 2007: 399, Table 1)

The measurements for the right and left alae were 41.3 mm and 41.1 mm respectively. Previous research has suggested that asymmetry in lengths of the sacral alae may be attributable to preferential hand use (Plochocki, 2002; Ackman et al., 2008). The values for mean lengths of the right and left alae in this study are nonsignificantly different, implying that preferential hand use cannot be determined using the sacrum. However, I used all available sacral alae in my analysis, not only the specimens for which both the right and left alae could be measured. Future analysis of the sacral alae only in those specimens for which both the right and left alae are present may show a significant directional asymmetry exists between the alae of the Poole-Rose population. Mean measurement of the alae for a combined sample of American whites and

blacks is 32.2 mm (Tague, 2007). The large difference (28%) between the Poole-Rose sample and the combined sample of American whites and blacks may be due to different measurement techniques between the two studies.

The mean value for maximum breadth of the sacrum is relatively large for the Poole-Rose ossuary population. The mean maximum breadth for the Poole-Rose ossuary population - 117.8 mm – is comparable to the pooled-sex mean for four samples of Native American skeletal collections, including Libben, Indian Knoll, Haida, and Pecos Pueblos, which is 117.2 mm (Personal communication, R. Tague, 2010). There is a high correlation between maximum breadth of the sacrum and both transverse diameter and circumference of the pelvic inlet (Tague, 2007). In addition, there is no difference in maximum breadth of the sacrum between males and females, although females have longer alae than males at the level of S1 (Tague, 2007). The large mean measurement of maximum sacral breadth in this study implies that the majority of females in the Poole-Rose population would have had an obstetrically spacious transverse diameter of the pelvic inlet.

Based on 19 studies reported in the literature, the mean for straight length of the sacrum among Native American groups is 99.6 mm and the median is 100.3 mm, and males are larger than females for this measurement in 16 of the 19 studies (Tague, 2010). Compared with other Native American populations for which straight length of the sacrum is known - including the Pecos Pueblos, Arkansas and Louisiana, Haida, Indian Knoll, Lenape, Libben, Southwestern Utah, Southwest Pueblos, and Southwest and Mexico samples – the straight length of the sacrum in the Poole-Rose ossuary (110.3 mm) is the largest. Sacral length in the Poole-Rose ossuary sample is 6.7% higher than the nine-sample mean for this measurement, 103.3 mm, among these Native American groups (Tague, 2010). The high mean value for the straight length of the

sacrum in the Poole-Rose sample may suggest that this was a relatively large-bodied population. However, because males are larger than females in straight length of the sacrum, the high value for straight length of the sacrum in the combined sample of the Poole-Rose ossuary sacra may be due to sampling bias, in which case more males may be represented in the sample than females.

The prevalence of lumbar sacral facets in the Poole-Rose ossuary is 5.2%. This is comparable to previous research which found the prevalence of lumbar sacral facets in American whites and blacks to be 5.8% (Tague, 2011). The ossuary population also had 20.0% of sacra with numbers of vertebrae greater than five. Among 13 samples reported in the literature, frequency of coccygeal fusion ranges from 0.0% to 71.1% with a mean frequency of 22.2% for the 13 samples, and prevalence of coccygeal fusion is shown to be associated with advanced age (Tague, n.d.). Lumbar facets and fusion of extra vertebrae to the sacrum can indicate both possible obstetric complications and lower back pain; therefore, the comparable occurrence of lumbar facets in the Poole-Rose sample with American whites and blacks and the relatively low prevalence of fusion of lumbar or coccygeal vertebrae to the sacrum imply that the majority of individuals in the Poole-Rose population did not experience obstetric difficulty associated with lumbar or coccygeal fusion. In addition, the lower incidence of extra vertebrae fused to the sacrum in the Poole-Rose ossuary may suggest a relatively young population.

The incidence of osteophytic lipping for S1 is 14.5% for the Poole-Rose population. This is slightly lower than a previous study on osteophytic lipping of the vertebral column in the Poole-Rose ossuary remains which found 17.48% of specimens to have osteophytic lipping at the level of S1 (Dunne, 1999); however, I used more sacral specimens in the present study, and this fact may explain the discrepancy. Bridges (1994) found high levels of osteophytic growth in a prehistoric sample of Native Americans of the southeast at the lumbar (50%) level, with lower

levels of lipping for the cervical (37%) and thoracic (16%) vertebrae. Jackes (1977) and Harris (1949) have noted the high prevalence of osteophytic lipping among Huron ossuaries despite the overall healthy appearance of the skeletal remains. The low prevalence of lipping among the Poole-Rose population at the level of S1 suggests either a population in which a minority of older individuals developed osteophytic lipping at the level of S1 or a population in which many individuals died at a young age. Dunne (1999) found high prevalence of lipping in the cervical, thoracic, and lumbar vertebrae, although her study also found lower occurrence of osteophytic degeneration at the level of S1. The low incidence of lipping at the level of S1 found in this study is in accordance with Dunne's (1999) research.

Clear evidence of defleshing was present on only one of the fragments. According to previous research, defleshing marks are present on other skeletal elements, including the femur, calcaneus, and ulna, of the Poole-Rose ossuary remains (Bodin, 2002; Scheiss, 2002; Penney, 2005; Smith, 2010). These defleshing marks are presumably related to the removal of soft tissues prior to the communal burial associated with the Feast of the Dead. Evidence of defleshing among the ossuary remains is in accordance with Jean de Brébeuf's ethnohistorical account (Thwaites, 1896-1901), although the presence of defleshing marks on only one sacral fragment implies that only one individual was defleshed based on the sacrum.

Previous studies of the Poole-Rose ossuary have suggested that this population was healthy (Listi, 1997; Dunne, 1999) but with minor incidence of degenerative joint disease (Bordelon, 1997; Lundin, 2000; Parks, 2002), cribra orbitalia (Smith, 1997), and possibly tuberculosis (Dunne, 1999). This study of the Poole-Rose ossuary sacrum reports low prevalence of osteophytic lipping, normal incidence of lumbar facets, and normal prevalence of fusion of extra vertebrae to the sacrum, and these findings indicate good health in the Poole-Rose ossuary

population. The measurements of the Poole-Rose sacrum, which are in the upper range of variation compared with other populations, suggest that the average height for this population may have been taller than the average heights for other populations.

This study of the sacra of the Poole-Rose ossuary collection is significant because it is the first study to make inferences about the stature and obstetrical adequacy of the pelvis in the Poole-Rose population. In addition, through examination of health and age indicators of the sacrum in the ossuary remains, this study complements the work of previous researchers who have investigated health and demography in the Poole-Rose population. Future research is needed in order to supplement information collected from the sacrum which allowed me to make inferences regarding the stature and obstetric health of the Poole-Rose population. In addition, further study of the health and demography of the Poole-Rose ossuary population may provide a clearer picture of the makeup and quality of life of the group.

WORKS CITED

- Ackman, S.D., Karakas, P., and Bozkir, M.G.
2008. Bilateral asymmetry in sacrum and handedness. *Neurosurgery Quarterly* 18: 66-68.
- Bass, W.M.
2005. *Human Osteology: A Laboratory and Field Manual*, (5th ed.). Columbia: Missouri Archaeological Society: Special Publication Number 2.
- Berger, M., and Stoll, E.
1965. Complications of labor in connection with assimilation pelves. *Bibliotheca Gynaecologia* 35: 1-57.
- Bodin, N.A.
2002. A study of the Poole-Rose Ossuary ulnae: demography, defleshing, and degenerative joint disease. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Bordelon, B.M.
1997. Incidence of degenerative joint disease in the tibia of the Poole-Rose Ossuary. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Brailsford, J.F.
1929. Deformities of the lumbosacral region of the spine. *British Journal of Surgery* 16: 562-627.
- Bridges, P.
1994. Vertebral arthritis and physical activities in the prehistoric southeastern United States. *American Journal of Physical Anthropology* 98: 83-93.
- Broome, D.R., Hayman, L.A., Herrick, R.C., Braverman, R.M., Glass, R.B.J., and Fahr, L.M.
1998. Postnatal maturation of the sacrum and coccyx: MR imaging, helical CT, and conventional radiography. *American Journal of Roentgenology* 170: 1061-1066.
- Donnelly, J.P.
1975. *Jean de Brébeuf: 1593-1649*. Chicago: Loyola University Press.
- Dunne, D.E.
1999. Health in the Poole-Rose Ossuary population: an analysis of vertebral body pathology. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Giroux, C.L., and Westcott, D.J.
2008. Technical note: stature estimation based on dimensions of the bony pelvis and proximal femur. *Journal of Forensic Sciences* 53: 65-68.

- Gordon, A.
1923. Lumbo-sacral pain and sacralization of the fifth lumbar vertebra complicated by involvement of the spinal cord. *Journal of Nervous and Mental Disease* 57: 364-370.
- Harris, R.I.
1949. Osteological evidence of disease amongst the Huron Indians. *University of Toronto Medical Journal* 27: 71-75.
- Jackes, M.K.
1977. The Huron spine: a study based on the Kleinberg Ossuary vertebrae. PhD dissertation, University of Toronto.
- Kirchoff, H., and Kraübig, H.
1957. The obstetric importance of the "long sacrum." *International College of Surgeons* 27: 607-612.
- Listi, G.A.
1997. Health among the Poole-Rose Ossuary population as inferred from transverse (Harris) lines in the left tibiae. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Lundin, D.
2000. Evidence of osteoarthritic alterations to the proximal and distal joints of the humerus: analysis of skeletal remains from the Poole-Rose Ossuary. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- McKillop, H., and Jackson, L.
1991. Discovery and excavations at the Poole-Rose Ossuary. *Arch Notes* 91: 9-13.
- Molto, J.E.
1983. Biological relationships of Southern Ontario Woodland peoples: the evidence of discontinuous cranial morphology. *Archaeological Survey of Canada Mercury Series Paper* 117: 1-396.
- Nathan, H.
1962. Osteophytes of the vertebral column: an anatomical study of their development according to age, race, and sex with considerations as to their etiology and significance. *Journal of Bone and Joint Surgery* 44A: 243-265.
- Parks, M.A.
2002. Occurrence of degenerative joint disease in the radius: an analysis of skeletal remains from the Poole-Rose Ossuary. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.

- Pelin, C., Duyar, I., Kayahan, E.M., Zağyapan, R., Ağildere, A.M., and Erar, A.
2005. Body height estimation based on dimensions of sacral and coccygeal vertebrae. *Journal of Forensic Sciences* 50: 294-297.
- Penney, A.E.
2005. Analysis of the talus and calcaneus bones from the Poole-Rose Ossuary: a Late Woodland burial site in Ontario, Canada. M.A. Thesis, Louisiana State University, Baton Rouge.
- Pfeiffer, S.
1983. Demographic parameters of the Uxbridge ossuary population. *Ontario Archaeology* 40: 9-14.
- Plochocki, J.H.
2002. Directional bilateral asymmetry in human sacral morphology. *International Journal of Osteoarchaeology* 12: 349-355.
- Raxter, M.H., and Ruff, C.B.
2010. The effect of vertebral numerical variation on anatomical stature estimates. *Journal of Forensic Sciences* 55: 464-466.
- Scheiss, L.K.
2002. Evidence of postmortem cultural modification of the femora and the Poole-Rose Ossuary as part of the Feast of the Dead Ceremony. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Seidemann, E. L.
1999. Analysis of the nonmetric traits of the skull in the Poole-Rose Ossuary, Ontario, Canada. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Smith, H.J.
1997. Health in the Poole-Rose Ossuary population: a look at cribra orbitalia and porotic hyperostosis. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Smith, N.E.
2010. Demography, health status, and mortuary rituals of the Late Woodland Poole-Rose Ossuary, Ontario, Canada: a study of the clavicles. M.A. Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.
- Steinberg, E.L., Luger, E., Arbel, R., Menachem, A., and Dekel, S.
2003. A comparative roentgenographic analysis of the lumbar spine in male army recruits with and without lower back pain. *Clinical Radiology* 58: 985-989.

- Stewart, T.D.
1958. The rate of development of vertebral osteoarthritis in American whites and its significance in skeletal age identification. *Leech* 28: 144-151.
- Tague, R.G.
2007. Costal process of the first sacral vertebra: sexual dimorphism and obstetrical adaptation. *American Journal of Physical Anthropology* 132: 395-405.
- Tague, R.G.
2009. High assimilation of the sacrum in a sample of American skeletons: prevalence, pelvic size, and obstetrical and evolutionary implications. *American Journal of Physical Anthropology* 128: 429-438.
- Tague, R.G.
2010. The obstetric pelvis of Pecos Pueblos. In *Pecos Pueblos Revisited: The Biological and Social Context*, Michele E. Morgan, ed. Papers of the Peabody Museum of Archaeology and Ethnology Harvard University, Cambridge, Massachusetts. Pp.109-128, 395-439.
- Tague, R.G.
2011. Sacralization is not associated with elongated cervical costal process and cervical rib. *Clinical Anatomy* 24: 209-217.
- Tague, R.G.
n.d. Fusion of coccyx to sacrum in humans: prevalence, correlates, and effect on pelvic size, with obstetrical and evolutionary implications. *American Journal of Physical Anthropology*.
- Tague, R.G., Manhein, M.H., and McKillop, H.
1998. Paleodemography of the Poole-Rose Ossuary. *American Journal of Physical Anthropology* Supplement 26: 214-215.
- Thwaites, R.G. (ed.).
1896-1901. *The Jesuit Relations and Allied Documents: Travels and Explorations of the Jesuit Missionaries in New France, 1610-1791*, Vol. 10. Cleveland: Burrows Brothers.
- Tooker, E.
1964. *An Ethnography of the Huron Indians, 1615-1649*. Washington, D.C.: U.S. Government Printing Office.
- Ubelaker, D.H.
1974. *Reconstruction of Demographic Samples from Ossuary Skeletal Samples: A Case Study from the Tidewater Potomac*. Smithsonian Contributions to Anthropology 18. Washington, D.C.: Smithsonian Institution Press.

Warrick, G.

2008. *A Population History of the Huron-Petun, A.D. 500-1650*. New York: Cambridge University Press.

White, T.D., and Folkens, P.A.

1991. *Human Osteology*. London: Elsevier Academic Press.