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Karin L. Sandness

Karl J. Reinhard

University of Nebraska at Lincoln, kreinhard1@mac.com

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Vertebral Pathology in Prehistoric and Historic Skeletons From Northeastern Nebraska

by

Karin L. Sandness and Karl J. Reinhard

ABSTRACT

Vertebral pathology has long been a useful criterion for anthropologists in the assessment of activity patterns, stress, and general health of extinct peoples. This method of analysis, however, has never been applied to the peoples of the Nebraska Great Plains. This study is the first to concentrate on the indigenous Native Americans of this region, examining the spinal pathology present in the prehistoric and historic skeletal remains. Pathology present in the form of spondylolysis, Schmorl's nodes, osteophytosis (degenerative disc disease), and osteoarthritis (degenerative joint disease), provides evidence to suggest differing activity patterns and levels of stress in Plains groups before and after European contact. Higher levels of acute stress and trauma in the historic individuals are documented. Gender-specific vertebral pathology, expressed through differential patterns of degenerative disease between the historic females and males, is also noted.

INTRODUCTION

Bones undergo remodeling in response to a number of events: disease, trauma, nutritional stress, and physical changes in life-style. Bone modifications, specifically pathological alterations, can in turn be indicative of certain cultural practices or particular behavioral patterns of a population (Mann and Murphy 1990). Vertebral pathology is a method of interpreting the activity patterns and levels of stress within past populations as demonstrated by Merbs' (1983) analysis of vertebral pathology in arctic peoples. Differential activity patterns between populations and genders are documented. Similarly, Loveland (1989) is able to document patterns of group behavior by relating gender-specific activities to the various pathological conditions evidenced on the spinal columns of Caddoan males and females from the southern plains of Texas.

This study summarizes the degenerative and trauma-related vertebral pathology of northeastern Nebraska prehistoric and historic Native American groups. Comparisons of vertebral pathology are made to assess transitions in activity patterns from prehistory to post-contact periods. Two classes of degenerative dis-

ease, osteoarthritis and osteophytosis, are examined. Osteoarthritis involves degeneration of the apophyseal joints due to "pressure which is too great or sustained for too long a time for a particular joint to bear" (Merbs and Wilson 1960). Osteophytosis is characterized by degeneration of the amphiarthrodial joint surfaces, or discs, of the vertebrae. Both chronic and acute stress stimulate onset of the condition (Merbs 1983; Merbs and Wilson 1960). In general, both degenerative diseases develop in response to habitual stresses placed upon the spine of an individual during his or her lifetime (Jurmain 1977). Spondylolysis and Schmorl's nodes are used to evaluate incidences of acute stress and trauma. Spondylolysis occurs as a vertebral fracture, typically in the region of the pars interarticularis. Although genetic predisposition to the fracture has been suggested by the presence of certain anatomical variations common to individuals affected by the condition (Cyron et al. 1976; Roche and Rowe 1952; Stewart 1956), a force, or "triggering mechanism," in the form of sustained stress or trauma is required for fracturing to occur (Merbs 1983, 1989). Schmorl's nodes appear as depressions, or cavitations, on the intervertebral

disc surface due to herniation of the nucleus pulposus into the vertebral body. Schmorl's depressions result from trauma or prolonged stress involving axial loading of the spine (Resnick and Niwayama 1978).

MATERIALS AND METHODS

Vertebral pathology was assessed from the skeletal remains of five sites located within close proximity to one another in Knox and Dakota counties of northeastern Nebraska. Two sites, 25DK9 and 25DK13, are prehistoric, St. Helena Phase cemeteries dating from approximately A.D. 1200 to A.D. 1400. The remaining three sites, 25DK2, 25DK10, and 25KX1, are historic Omaha (25DK2 and 25DK10) and Ponca (25KX1) cemeteries dating from approximately A.D. 1750 to A.D. 1840. All sites are dated on the basis of artifact association. Similar site location and a marked temporal division allow a comparative population study between the prehistoric and historic groups.

All adult vertebral columns from both historic and prehistoric contexts that could be entirely or partially reconstructed are included in the analysis. Eighteen prehistoric and 21 historic vertebral columns were examined.

Analysis initially focused on assigning age and gender. Ectocranial suture closure (McKern and Stewart 1957; Meindl and Lovejoy 1985), long bone epiphyseal closure (McKern 1970), and dental attrition are used to determine general ages for both sample sets. Classifications of early and late adulthood are assigned. Gender is determined by cranial characteristics (Krogmen 1962), long bone length, robusticity, and pelvic structure (Bass 1971; Steele and Bramblett 1988). Due to prehistoric Plains burial practices that commingled several elements from several individuals, vertebral columns from sites 25DK9 and 25DK13 are not associated with specific individuals even though the columns themselves can be reconstructed. Consequently, gender is not assigned to prehistoric remains and age is determined as a mean for the total adult population. In contrast, the historic vertebrae are readily associated with specific individuals and age and gender can be determined for every spine.

Examination for postmortem breakage and erosion was undertaken prior to scoring pathological alterations. Radiographs were employed to further evaluate alterations evident in some vertebrae. Osteoarthritis and osteophytosis are scored for several variables: severity, side, and vertical placement. Severity is based on three levels of occurrence: 1) slight, 2) moderate, and 3) severe degeneration of the affected joint. Slight degeneration caused by the onset of osteoarthritis is determined by minor bony lipping of the superior or inferior articular facet joint. Moderate osteoarthritic levels involve further remodeling through lipping and a porosity, or pitting, of the joint surface. Severe involvement is based on fusion or extensive remodeling of the articular facet due to pronounced lipping, pitting, and in some cases eburnation. Eburnation is characterized by the erosion of cartilage from the joint surface resulting in a polishing effect of the bone. Osteophytosis is scored as minor on the basis of slight osteophyte growth on either the inferior or superior rim of the vertebral body. An increase in the level of bony growth at the vertebral margin indicates moderate degeneration. Fusion along the borders of associated vertebral bodies is recorded as severe osteophytosis. Distribution patterns of osteoarthritis and osteophytosis are determined by the absence or presence of the condition, regardless of the level of severity.

Spondylolysis and Schmorl's nodes are determined as either present or absent. Following Merbs' (1989) definition of the condition, recognizable lines of fracture or complete separation bilaterally or unilaterally in the areas of the pars interarticularis, the lamina, or the pedicle are recorded as spondylolysis. Schmorl's nodes are scored as present if circular or linear depressions characteristic of the condition are present on the inferior or superior end-plates.

RESULTS

Estimations of age indicate a ten to 15 year difference in the means of the prehistoric and historic skeletal series. Prehistoric adults are determined to have a mean age at death of 40 years. The majority of historic individuals fall within the 25 to 30 year age category, with a mean

Fig. 1. Frequencies of vertebral osteoarthritis (a) and osteophytosis (b) by degree of involvement for both prehistoric (1200-1400 A.D. black bar, n = 18) and historic (1750-1840 A.D. hatched bar, n = 21) skeletal series.

age at death of 29.3. Mean ages determined by gender in the historic series document a difference of approximately three years between males and females, females generally dying at a younger age.

Prehistoric spines show greater overall occurrence of osteoarthritis (Fig. 1a). Seventeen of the 18 prehistoric vertebral columns (94.5%) exhibit osteoarthritis to some degree, ranging from minor involvement (44.4%) to severe (22.2%). Approximately 71% of historic spines exhibit osteoarthritis. Of these, a majority display only minor involvement (38.1%). A difference in the prevalence of osteoarthritis between the prehistoric and historic spines is statistically significant at P.1 (Kruskal-Wallis $Z = 1.795$, $P = 0.080$).

Degeneration of the vertebral body is present in 72.2% of the prehistoric spines. Minor osteophytosis was most common (Fig. 1b). Osteophytosis is found in over one half of the historic vertebral columns, most displaying moderate involvement. No significant difference in the prevalence of the condition is present between the prehistoric and historic spines (Kruskal-Wallis $Z = 0.382$, $P = 0.7044$).

Distributions of osteoarthritis in prehistoric vertebral columns (Fig. 2) display maximum in-

volvement in regions of the mid-cervical vertebrae (C-3 and C-5), upper thoracic vertebrae (T-3, T-4 and T-6) and mid- to lower lumbar vertebrae (L-3, L-4, L-5). Historic spines exhibit lower frequencies in the distribution of osteoarthritis. Differences between historic and prehistoric spines are also evident in elevated osteoarthritic occurrence in historic lower thoracic vertebrae, particularly in the tenth thoracic, a region minimally affected in prehistoric spines.

Distribution patterns of osteophytosis reveal relatively equal frequencies in the cervical, thoracic and lumbar regions of prehistoric and historic columns (Fig. 3). Historic spines differ slightly from the prehistoric columns in the thoracic region. While the mid-thoracic vertebrae exhibit the highest frequency of occurrence in the prehistoric mid-column, this pattern is shifted downward in the historic spine, with a greater frequency of occurrence in the lower thoracic region (T-10 and T-11). Although no significant difference could be statistically determined, there is evidence for intersexual differences in the historic skeletal series. Females exhibit osteoarthritic vertebral degeneration at a greater frequency (75%) than

Figure 2. Distributions of osteoarthritis in prehistoric (1200-1400 A.D. black bar) and historic (1750-1840 A.D. hatched bar) vertebrae.

males (66.6%) (Fig. 4a). Females exhibit a higher prevalence of osteoarthritis in both moderate (33.3%) and severe (8.3%) stages of the disease. In contrast, males were more commonly affected with osteophytosis (66.6%), most showing minor (22.2%) or severe (22.2%) involvement (Fig. 4b). Half of the female spines (50%) show degeneration of the vertebral body, with moderately and severely affected columns.

Distributions of osteoarthritis by gender (Fig. 5) show males are primarily affected in the lower thoracic and lumbar regions of the spine,

with highest frequency in the tenth thoracic vertebra. In contrast, historic females exhibit higher frequencies of osteoarthritis throughout the column, particularly in the upper thoracic and lower lumbar vertebrae.

Distributions of osteophytosis in the female and male historic spines are appreciably different (Fig. 6). Female columns exhibit frequencies of 40% or greater in the upper and mid cervical (C-3 and C-5), mid and lower thoracic (T-8, T-11 and T-12) and lower lumbar vertebrae (L-3 to L-5). In contrast, male spines dis-

Figure 3. Distributions of osteoarthritis in prehistoric (1200-1400 A.D. black bar) and historic (1750-1840 A.D. hatchedbar) vertebrae.

play frequencies of 40% or greater in the upper and mid thoracic vertebrae (T-2, T-4, T-5, and T-10).

Schmorl's nodes are found in 16.7% of the prehistoric spines. In each case, degenerative conditions are present on the spine. Two cases involve depressions on single lumbar vertebra. The third case involves depressions on two consecutive thoracic vertebrae (T-6 and T-7).

Schmorl's nodes appear with greater frequency in historic spines (42.8%). A statistically significant difference in the number of in-

dividuals with Schmorl's nodes is present between the prehistoric and historic skeletal series at P.1 (Chi-square = 3.121, $P = 0.077$, $DF = 1$, $n = 39$). Characteristics of the condition in historic cases suggest a relationship to trauma. Seven of the nine historic cases involve Schmorl's nodes on two or more vertebrae. Degenerative conditions are present only in five of the nine cases. One spine with a Schmorl's depression also displays spondylolysis of the fifth lumbar, but lacks any evidence of degeneration of the vertebral joints. The three remaining

Fig re 4. Frequencies of osteoarthritis (a) and osteophytosis (b) by degree of involvement for both females (black bar, n = 12) and males (hatched bar, n = 9) of the historic skeletal series.

cases are present in spines with no indication of degeneration or pathology. Six males and three females have vertebrae with Schmorl's nodes.

Spondylolysis is present in 19% of the historic spines. No evidence of the condition is found in the prehistoric series of the study. Statistical significance between historic and prehistoric distributions is present at P.1 (Chi-square = 3.82, $P = 0.051$, $DF = 1$, $n = 39$). All four historic cases involve complete, bilateral separation in the pars interarticularis region, with the fifth lumbar vertebra being most commonly affected. Three cases are present in females, all less than 25 years old at death. A frequency of 25% is calculated for the female historic series. The remaining case is present in a male, age 40 years or older at death. A frequency of 11.1% is calculated for the historic male series.

DISCUSSION

Two factors are primary agents in the onset and severity of degenerative disease: age and the degree of stress placed on the spine. The normal processes of aging are often associated with degenerative alterations of the vertebral column (Jurmain 1977; Ubelaker 1989). Increases in the

number of vertebrae affected and in the severity of the degeneration have been correlated with an increase in age (Stewart 1958).

In this small series, historic adults were generally not surviving as long as the prehistoric individuals. The influx of epidemic diseases documented for the period (Lowie 1954), increased conflict, and the recently discovered high levels of lead in the skeletal remains (Reinhard and Ghazi 1991), all suggest probable ill-health of Nebraska tribes during contact. The resulting disparity of ten to fifteen years estimated for the mean ages at death between the two skeletal series is, therefore, a likely explanation for the higher levels of osteoarthritis in prehistoric individuals. Trauma and repeated mechanical stress triggers the onset of degeneration in particular joints regardless of age. Failure to determine a significant difference in the presence of osteophytosis between prehistoric and historic spines can be attributed to higher stress levels for the younger, historic individuals relative to the older, prehistoric adults. This trend is particularly evident in the high incidence of spondylolysis and Schmorl's nodes in the historic skeletal series. The high frequency of spondylolysis seen in the

Figure 5. Distributions of osteoarthritis in historic female (black bar) and male (hatched bar vertebrae).

younger historic Omaha and Ponca spines is similar to the high frequencies found in protohistoric Arikara spines from the Sully and Larson sites of South Dakota (Bradt Miller 1984). Bradt Miller's study of Arikara spines noted associations of spondylolysis with increased age and osteophytosis. The prehistoric individuals of this study however, show no evidence of spondylolysis despite their older age at death and the slightly higher frequency of degenerative disc disease. The absence of the condition in the prehistoric remains and its high

frequency in the younger individuals lends support to a mechanical argument for separate neural arches. In addition, continued survey of the pathology of prehistoric remains by Reinhard, Barnum and Miller has revealed no cases of spondylolysis from prehistoric sites 25CD7 and 25DX4 (Reinhard pers. comm., 1992). This indicates that spondylolysis was not a problem of prehistoric peoples in Nebraska. At this point, it is evident that spondylolysis is a pathology of the historic period for this region. Also, as noted previously in the text, Schmorl's nodes develop

Figure 6. Distributions of osteophytosis in historic female (black bar) and male (hatched bar) vertebrae.

in direct response to repeated episodes of stress, or an intense traumatism, such as a fall (Campillo 1989). Given the higher frequency of both spondylolysis and Schmorl's nodes in the younger historic series, it seems likely that individuals of this period were victims of activities predisposing them either to greater habitual stress, or incidences of trauma.

Differences in the distribution of degenerative diseases have been associated with differences in activity patterns between groups and individuals (Merbs 1983). Variations between

the prehistoric and historic distribution patterns of osteoarthritis and osteophytosis were primarily limited to the thoracic regions of the spine. The historic vertebrae displayed proportionately higher occurrences of degeneration in the lower thoracic region than did the prehistoric vertebrae. These results suggest that activities primarily affecting the thoracic vertebrae were altered, or perhaps introduced, during the historic period. Other activities involving the upper portions of the spine may have continued to be practiced as they were in the past, but with

increased intensity, thus maintaining similar distribution patterns in these regions of the spine.

Explanations for the differential distribution of degenerative disease and the evidence of increased stress and trauma exhibited in the historic individuals can be found in the ethnohistoric documentation of transitions in life-style for Native American groups during the period of European contact. These explanations include cultural transformations as well as demographic change. The introduction of the horse, the gun, European trade along the Missouri River, and the resultant spread of infectious disease are cited as major contributors to the changes in the culture and health of Great Plains tribes during the period of initial contact (Lowie 1954).

The region of northeastern Nebraska was a central location for many trade routes on the Plains due to its location along the Missouri River (O'Shea and Ludwickson in press). Prior to contact the subsistence strategies of the indigenous groups involved a mixed economy of horticulture and hunting (Fletcher and LaFlesche 1972; Lowie 1953; O'Shea and Ludwickson in press). Contact with the eastern fur trade during the historic period promoted hunting for economic gain, not merely for survival. As a result, hunting and trapping practices of various Great Plains groups increased. Ethnohistoric documentation (Fletcher and LaFlesche 1972) and large amounts of trade goods found in association with the historic Omaha remains included in this study suggest high levels of involvement for northeastern Nebraska tribes in trade during the late eighteenth and early nineteenth centuries.

The result of increased participation in trade is reflected in the vertebrae of both sexes. Close examination of the levels of degenerative disease and incidences of spondylolysis and Schmorl's nodes in the females of the historic sample suggest that they were participating in strenuous activities slightly different from the males with respect to intensity of labor and trauma. In their ethnographic study of the Omaha, Fletcher and LaFlesche (1972) place the preparation of pelts among the primary duties of the woman. The arduous task of tan-

ning and dressing the skins required hours of scraping in a bent posture. This posture is similar to the 90° stance cited by Merbs (1983) as a factor in the development of spondylolysis in Arctic peoples. With the increase in trade and the resultant increase in hunting, the labors of the women would have been doubled in the preparation of the skins for the market. As Fletcher and LaFlesche (1972) note, "In the old time one woman could scarcely give proper attention to all the skins secured by a good hunter; still less could she do the additional work occasioned by the pressure of trade." Because the Omaha had no custom of hired labor or slavery, the woman, alone, was also responsible for her household. All duties related to the maintenance of the household, preparation of meals, setting up and taking down the tepee, and fashioning clothing were hers. Training in these tasks began at a young age for girls (Fletcher and LaFlesche 1972), a factor that would have promoted early onset of degenerative disease in women. In addition to the above duties, horticultural practices, with the exception of preparing the fields for planting, were carried out by females (Fletcher and LaFlesche 1972). Females within groups participating in intense maize horticulture have been noted as having high levels of vertebral pathology (Rose 1984). Pregnancy and childbirth are additional aspects of female life that contribute to vertebral stress (Merbs 1983). The young females in the historic sample reflect this heavy workload in the high occurrence of degenerative disease and trauma seen in their skeletal remains, particularly spondylolysis, which occurred in three females below the age of 25 and possibly as young as 15 years.

Ethnohistoric records of the Nebraska Great Plains groups document that males performed very different tasks from females. The preparation of the fields for planting, hunting, trapping, and trade were male duties. They were the primary protectors of the tribe and providers of meat for their families (Fletcher and LaFlesche 1972). Horseback riding would have figured prominently in both the increased hunting and intensified warfare of the early nineteenth century. Hyperextension and hyperflexion of the spine, which occur during horse-

back riding, and specifically horse-breaking, would result in the trauma seen in the historic individuals. Axial pressure and jarring during horseback riding would also contribute to the increased levels of degenerative disease in thoracic regions of the spine and might be responsible for the unique patterns of osteophytosis and high numbers of Schmorl's nodes present in the male vertebrae. Similar trauma can occur as the result of packing large weights and lifting large bundles. When done repeatedly, these activities would encourage the processes of fracture, Schmorl's nodes, and certain patterns of degenerative disease.

CONCLUSIONS

The vertebral pathology exhibited in the prehistoric series and in both the females and males of the historic series indicates that contact and the resultant increase in trade produced a number of circumstances leading to an increase in labor and physical stress for the Native Americans of northeastern Nebraska during the late eighteenth and early nineteenth centuries. Intensification of previous activity patterns for both males and females, such as hunting and the preparation of skins, in addition to the introduction of new activities, such as horseback riding, placed greater physical demands on individuals already stressed by disease and outside forces. The stress created by the increased labor, particularly for the female, could have adversely affected health and likelihood of survival.

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Department of Anthropology

126 Bessey Hall

University of Nebraska-Lincoln

Lincoln, Nebraska 68588-0368

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