The co-occurrence of congenital anomalies and osteoarthritis in the foot and ankle

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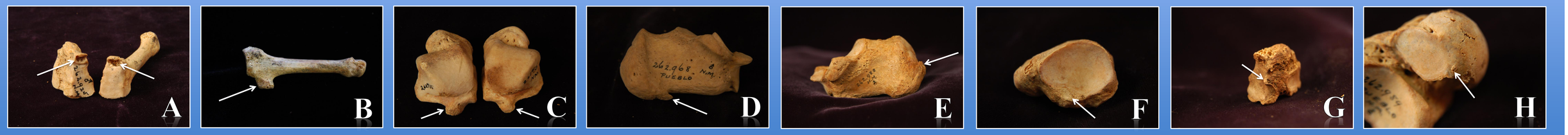
Introduction

Skeletal defects present in the foot at birth, or congenital anomalies, are pervasive but often overlooked conditions in prehistoric populations (Case et al., 1998; Regan et al., 1999; Burnett and Case, 2005). Similarly, osteoarthritis and related inflammation of the joints are ubiquitous in human populations, especially in older adults (Weiss and Jurmain, 2007). Although both conditions have been studied, previous research has not explored the possible interrelationship of these conditions. Weiss and Jurmain (2007) list anatomical variation as an influence on the presence and severity of osteoarthritis, arguing that anatomical variation affects the torque and movement of joints, increasing the stress on a joint, and promoting arthritic change. It would follow that congenital anomalies, which are anatomical variants, would have some impact on the occurrence and degree of osteoarthritis. To evaluate the relationship between anomalies and arthritic change, a survey of anomalies in the foot was conducted on a series of 230 pre-Columbian Tewa Indians from the Puye site in northern New Mexico (tree-ring dated to 1507-1561 AD) (Barnes, 1991). Four congenital anomalies were assessed and levels of arthritic change were recorded for each element of the foot.

Understanding the relationship between congenital skeletal anomalies and osteoarthritis not only contributes to the understanding of both conditions, but also has larger implications in understanding the relationship between congenital and pathological conditions. Additionally, this research provides a better understanding in the quality of life and living conditions of the individuals who inhabited Puye and other related prehistoric populations.

Congenital Anomalies

Arthritic Change

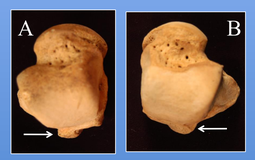


A. Non-osseous coalition: Abnormal fusion of the cartilaginous tissue between two or more tarsal bones B. Os Intermetatarseum : Accessory bone on the 1st or 2nd metatarsals and/or 1st of 2nd cuneiforms C. Os Trigonum: Accessory ossicle on the posterior end of the talus D. Plantar enthesophyte: Excess bone growth on the plantar side of the calcaneus E. Achilles enthesophyte: Excess bone growth on the posterior end of the calcaneus F. Porosity: Amount and severity of pores on the articular surfaces of a joint G. Lipping: Amount and severity of excess bone growth on the marginal edges of the articular surface of a joint H. Surface Osteophyte: Bony adhesions on the articular surface of a joint

Materials and Methods

Due to time constraints, only the first ninety-one adults within the target age ranges were examined for this initial study, with total of eighty-nine individuals used in this analysis. Each individual's age and sex were obtained from data provided by the Repatriation Osteology Laboratory at the National Museum of Natural History. These data were used to determine whether the observed characteristics varied by age or sex. Scoring for each anomaly and level of arthritic change was derived from Wilczak and Jones, 2011; Silva, 2010; Regan et al., 1999; Case et al., 1998; and Buikstra and Ubelaker, 1994. The scoring systems ascribe a numeric code to an observable characteristic, providing a standardized expectation for observation. Of the anomalies scored, Os Intermetatarseum was not present in this sample.

Scoring Os Trigonum



A. Score 1: Present
B. Score 2: Absent

Score	Meaning	Look For
0	Absent	---
1	Present	Accessory ossicle on the posterior end of the talus
2	Unobservable	Unable to view area where anomaly would be present

The poor preservation of some of the remains, because of their archeological context, resulted in a number of fragmented or missing bones, making some features unobservable; this affected the coding process. Historical archaeological excavation protocol also resulted in a number of comingled remains. Remains determined to be comingled were separated and coded as different individuals, and attempts were made throughout the project to re-associate these elements.

Results

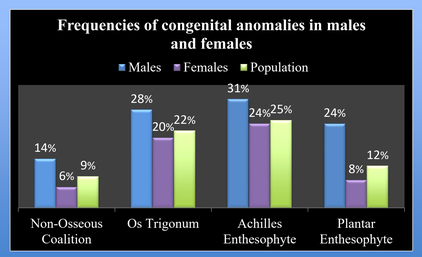


Figure 1. Note higher rates of anomalies among males.

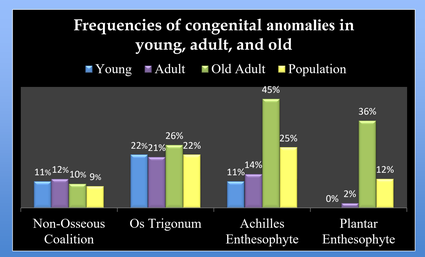


Figure 2. High rates of achilles and plantar enthesophytes in old group most likely related to increase in arthritic change with age.

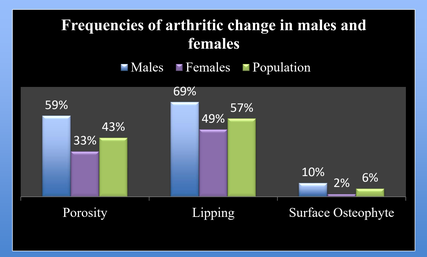


Figure 4. Note higher rates of arthritic change in males.

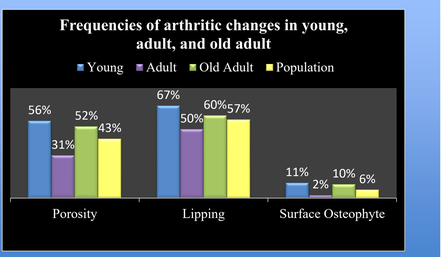


Figure 3. Note unexpected high rates of arthritic changes in young group.

Conclusions

No strong trends were observed in the co-occurrence of congenital anomalies and osteoarthritis in the foot and ankle. Chi-square tests confirmed these observations with a nominal p-value that did not strongly support an interrelationship between conditions (Figure 5). A strong relationship may not exist because congenital anomalies of the foot are largely subclinical, meaning they are without symptoms and may not have greatly affected movement or stress placed on joints. Exploring congenital anomalies and osteoarthritis in other joints may provide greater insight into their relationship. Frequency data showed higher rates of congenital anomalies and osteoarthritic change among males (Figures 1, 4). These rates may reveal relatedness between males and suggest a patrilocal residence pattern in which adult females were more likely to be integrated into Puye from other communities. However, more data are required to confirm this hypothesis. The observed higher rates of osteoarthritic change among males were unexpected, since females in other studies tended to have higher rates of this condition (Weiss and Jurmain, 2010). This sex difference may be related to cultural practices, with the possibility of males participating in activities that could have increased osteoarthritic change, such as traveling more by foot. Finally, there were unexpectedly high frequencies of arthritic change among individuals in the young age category (12-20 years old). In modern populations, osteoarthritis usually increases with age, and is therefore not commonly found in younger people. Greater frequencies in younger individuals are likely a result of harsher living conditions, labor-intensive means of subsistence, and less advanced technology characteristic of pre-Columbian populations. To further explore the interrelationship between congenital anomalies and osteoarthritis, future research could be conducted on the entire collection from the Puye site to increase sample size. Additionally, these data could be compared to other collections to determine if these results were significant across pre-Columbian populations. Though results in this study were not strong, additional research may provide greater insight into both conditions.

	Arthritic Change	No Arthritic Change	Total
Anomaly	31	8	39
No Anomaly	29	21	50
Total	60	29	89
P-value: 0.031877958			

Figure 5: Distribution of congenital anomalies and arthritis in the population, P-value is nominal.

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References

Barnes E. (1991) Developmental defects of the axial skeleton in paleopathology, with focus on a Southwest prehistoric Anasazi population: Puye, New Mexico. PhD Dissertation, Department of Anthropology: Arizona State University.

Buikstra JE, and Ubelaer DH, eds. (1994). Standards: for data collecting from human skeletal remains. Fayetteville: Arkansas Archaeological Survey.

Burnett SE, and Case DT (2005) Naviculo-cuneiform I coalition: evidence of significant differences in tarsal coalition frequency. The Foot 15:80-85.

Case DT, Ossenberg, NS, and Burnett SE (1998) Os intermetatarseum: a heritable accessory bone of the human foot. American Journal of Physical Anthropology 107:199-209.

Regan MH, Case DT, and Brundige, JC. (1999) Articular surface defects in the third metatarsal and third cuneiform: nonosseous tarsal coalitions. American Journal of Physical Anthropology. 109:53-65.

Silva AM. (2010) Foot anomalies in the late Neolithic/Chalcolithic population exhumed from the rock cut cave of Sao Paulo 2 (Almada, Portugal) Online Issue, International Journal of Osteoarchaeology.

Weiss E, and Jurmain R. (2007) Osteoarthritis revisited: a contemporary review of aetiology. International Journal of Osteoarchaeology. 17: 437-450.

Wilczak, CA, and Jones EB, eds. (2011) Osteoware software manual volume II pathology module. Washington, D.C.: Smithsonian Institution.