Early Onset Osteoporosis in Early Bronze Age Burials from Bab edh-Dhra, Jordan

Ashley Andrada & Donald J. Ortner. Department of Anthropology, NMNH, Smithsonian Institution, Washington D.C.

INTRODUCTION

Bâb edh-Dhrâ is an important Early Bronze Age site located near the Dead Sea in the southeastern Ghor region of Jordan. Three field seasons of excavation at the site between 1977 and 1981 resulted in the discovery of 579 total secondary burials from the EB 1a period (3300-3200 BCE). In this poster we will examine the high prevalence of early onset osteoporosis in the population, as was determined by obtaining the mass of the bones and confirming that data with radiographs which displayed the degree of bone loss in a particular specimen.

The sample size is limited to 36 individuals, the number of burials present at the Smithsonian Museum of Natural History for which complete skeletal elements remain of at least one of the limb bones, the L3 vertebrae, or the sacrum. In healthy individuals, the trabeculae in these bones is dense, and can provide us rare insight into the degree of bone loss in an ancient population, allowing us to assess and understand the relative health of individuals at their time of death and better comprehend the prevalence and patterns of osteopenia in modern populations.

Osteoporosis is defined as a reduction in bone mass that exceeds 30% of the average bone mass for a given age and sex category (Ortner, 2003). Increased bone porosity and fragility are generally linked to age, but severe bone density loss can also occur in younger populations that are malnourished or starving. It is clear that some of the young women in the sample bore signs of bone loss sufficient to show that malnutrition likely lead to both morbidity and mortality in the population and played a role in the health of the Bâb edh-Dhrâ people. It has been noted in a review of studies on bone mass in other historical populations (Agarwal and Grynpas, 1996), that generally female bone density loss began to occur at an earlier age in ancestral populations than in modern day ones. This is likely due to the fact that these women were intaking fewer calories than was necessary for their skeleton to maintain a balance between bone resorption and formation.

Insufficient protein-caloric intake has been shown in modern-day populations of young female anorexics to correlate with low bone mass density and lead to the development of early onset osteoporosis. However, the resorption of cancellous and cortical bone stops when anorexics begin to develop a healthy diet again. The fact that many of the female remains from the Bâb edh-Dhrâ tombs exhibited markers of bone loss at death suggests that there was never a significant period of recovery prior to death. This scenario is likely when one considers the lack of dietary variety and the food shortages that early agricultural societies probably experienced.

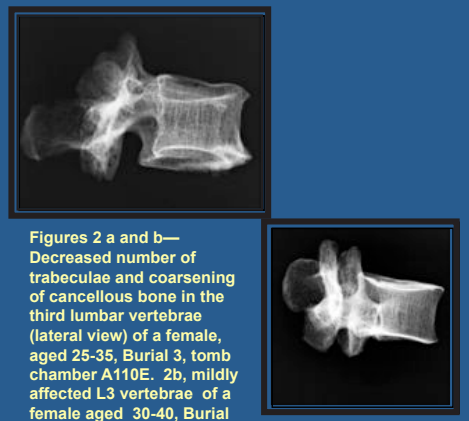
MATERIALS & METHODS

The skeletal elements present for each burial were assessed to determine sex and estimates of age. For each individual bone, the data listed below was collected:

Length, for the long bones, and width for the vertebrae and sacra, were determined as a control for the measurements of bone weight. Weight was measured on a top-loading scale. These measurements were then analyzed using the statistical program Systat.

In order to confirm the data obtained from weighing the bones, radiographs of the femora (Figure 1) and vertebrae (Figure 2) were taken for each individual. These radiographs were compared to those of contemporary osteoporotic individuals and to normal bones in the sample in order to assess the relative degree of bone loss. The amount of cortical bone loss in a radiograph of people with osteoporosis is 25-30%, which is why cortical bone thickness relative to overall thickness of the midshaft of the femur was measured using calipers.

Figure 1—Trabecular bone loss and cortical thinning in the femur of an osteoporotic female, aged 25-35, Burial 3, tomb chamber A110E. Healthy adult male femur, Burial 1, tomb chamber A 110NW.



Figures 2 a and b—Decreased number of trabeculae and coarsening of cancellous bone in the third lumbar vertebrae (lateral view) of a female, aged 25-35, Burial 3, tomb chamber A110E. 2b, mildly affected L3 vertebrae of a female aged 30-40, Burial 3, tomb chamber A 111W3.

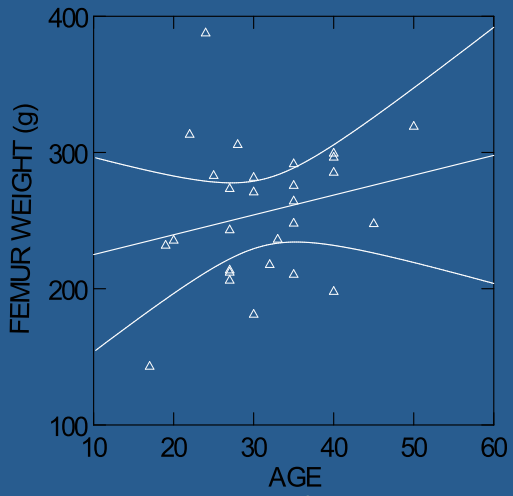


Figure 3—Femur weight vs. age for the EB 1A burials. The bones that constitute the outliers belong to relatively younger females for whom radiograph analysis and low weights revealed clear indicators of osteoporosis. The degree of bone density loss points to the likelihood that these individuals suffered severe malnutrition right before death.

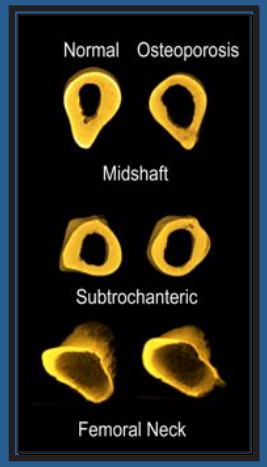


Figure 4—3-D CT images of a healthy femur from a female 25-30 yrs. (Burial 1, tomb chamber A 114N) compared with the femur of a female 25-35 yrs. with osteoporosis (Burial 3, tomb chamber A 110NE). Note the reduced cortical thickness, increased marrow space and loss of trabecular bone in Burial 3. Density measurements of the cortical bone at the femoral midshaft and the mean density of trabeculae located in the femoral neck consistently show a much lower density in Burial 3.

RESULTS

Figure 3 shows the association between weight and age for the EB 1A femora. Eight females in the study were clear outliers, lying well below the regression line. Radiographic analysis of those same eight femora showed there to be significant trabecular bone loss and, in most cases, at least a mild degree of cortical bone loss. Weight and age comparisons of the humeri, tibiae, sacra, and vertebrae yielded similar results, in which the clear outliers remained, for the most part, the same few females.

The average age of these eight women was about 30 years old, much younger than the age expected of someone typically suffering osteoporosis. A CT scan comparing cross sections of two different EB 1A femora (Figure 4) showed the degree of bone loss and increased marrow space in an osteoporotic 25-35 year old.

Radiographs of the bones of affected individuals showed exemplary biological evidence of osteoporosis. Figure 1 shows trabecular bone loss, particularly in the femoral neck, and the coarsening of the remaining trabeculae as a result of destructive remodeling. Figure 2a shows the same phenomenon in the third lumbar vertebra, where the laterally placed vertebra becomes nearly transparent in places due to the amount of bone loss. Some of these remains from young women presented nearly textbook cases of osteoporosis, that would be seen in modern populations of osteoporotic women who are decades older. This prevalence of severe osteoporosis in young people is most likely the result of prolonged malnutrition.

CONCLUSIONS

Previous study of the paleopathology of the Bâb edh-Dhrâ remains resulted in the conclusion that there was clear evidence of malnutrition (Ortner et al. 2008). The prevalence of metabolic disorders observed in that study in combination with the high occurrence of pre-menopausal osteoporosis in the female population makes it very likely that malnutrition was a problem in the EB 1A period. Data on modern third world populations (UN-SCN Report, 2004) shows a strong correlation between malnutrition and chronic disease. Most of these chronic metabolic disorders are also found in the EB 1A remains, which makes it likely that there were at least episodes of famine similar to what occurs today in some contemporary Third World nations.

Malnutrition was a significant factor affecting the health of the Early Bronze Age inhabitants of Bâb edh-Dhrâ, leaving many of the females severely undernourished. These affected individuals' remains show the biological markers of bone resorption, which occurred at a rate much more rapid than in healthy populations. This imbalance between bone formation and bone destruction resulted in a high prevalence of young women with osteoporosis.

REFERENCES

Agarwal, Sabrina C. & Grynpas, Marc D. (1996). Bone Quantity and Quality in Past Populations. The Anatomical Record: 246: 423-432.

Gonzalez-Reimers E., et al. (2004). Noninvasive Esitmation of Bone Mass in Ancient Vertebrae. American Journal of Physical Anthropology: 125: 121-131.

Ortner, Donald J, et al. (2008). The Paleopathology of the EBIA and EB IB People. *The Early Bronze Age Tombs and Burials of Bab edh-Dhra, Jordan*, Altamira Press, Plymouth, UK.

Ortner, Donald J. (2003). *Identification of Pathological Conditions in Human Skeletal Remains*, Elsevier, Oxford, UK.

UN Standing Committee on Nutrition. (2004). 5th Report on the World Nutrition Situation. United Nations, NY.

ACKNOWLEDGMENTS

I would like to thank Dr. Ortner for advising me over the course of the summer and imparting on me invaluable knowledge necessary to navigating this research project and any osteological research I do in the future. I would also like to thank Dr. Cristian Samper and the Smithsonian Museum of Natural History for funding the NHRE program, and Virginia Power, Elizabeth Cottrell, and Gene Hunt for coordinating the program. Dr Frohlich also helped a great deal with using the statistical software and interpreting the results yielded in the experiment.