Growth Arrest Lines among Uxbridge Ossuary Juveniles

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Immature right tibial diaphyses from the Uxbridge Ossuary (N= 66) were radiographed in order to determine the proportion which showed growth arrest (Harris) lines. Ages were estimated from diaphyses length. Measurements of bone cortex development (percent cortical area) were compared between diaphyses which show such lines and those which do not. Thirty diaphyses show one or more lines of growth arrest. Growth arrest lines are very rare among infants (1/23), most common at ages 0.5 - 8.5 years, reaching 90% of all tibiae in the 4.5 - 8.5 year category. Lines are most numerous among the affected tibiae of ages 0.5 - 4.5 years (2.7 lines/diaphysis). At ages 0.5 - 8.5 years, diaphyses with growth arrest lines have significantly lower percent cortical area than those without lines. The childhood mortality profile constructed from diaphysis length age estimates is very similar to that previously constructed from dental emergence. Thirty five percent of juvenile mortality is represented by newborns.

Introduction

The Iroquoian ossuaries of Southern Ontario have attracted much research attention in past years as sources of information about the interplay of subsistence and health. Both skeletal and dental pathology have been studied in many ossuary samples with the goal of elucidating the relationship between subsistence changes and indicators of life expectancy and health. The Uxbridge Ossuary, a late prehistoric site, has been described demographically (Pfeiffer 1983) and has been shown to have a high incidence of pathological bone tissue changes comparable to those associated with tuberculosis (Pfeiffer 1984) as well as generally thin adult cortical bone development (Pfeiffer and King 1983).

However, neither Uxbridge nor any other ossuary sample has been studied systematically for indications of chronic health stress during childhood. Enamel hypoplasia and growth arrest lines have rarely been studied in an ossuary sample, despite their apparent value for quantifying nutritional and/or disease pressures in a population (Buikstra and Cook 1980). Patterson (1984) studied hypoplastic defects in three large samples: Le Vesconte, Bennett and Kleinburg. He concluded that the defects occurred most commonly at around age three (consistent with weaning stress), and that the defects are less common in the historic ossuary (Kleinburg) than in either of the prehistoric samples. No documentation of the frequency of growth arrest, or Harris, lines in any ossuary sample has been published. Despite the enamel hypoplasia evidence to the contrary, we would expect to see an increase toward historic times in the incidence of growth arrest lines, as the incidence of infectious diseases increases. While such a broad hypothesis cannot be tested through the analysis of one sample, the study described here may furnish a reference point against which other samples may be compared. Also, by analyzing the approximate age(s) of growth arrest and the cortical bone formation characteristics associated with growth arrest, we can determine whether the pattern followed at Uxbridge differs from expected due to its high incidence of tuberculosis-type disease.

Materials and Methods

The Uxbridge Ossuary (BbGt-1) is located approximately 100 km northeast of Toronto, Ontario. It was excavated from 1975-1977 by Patsy Cook and members of the Ontario Archaeological Society. It has a radiocarbon date of AD 1490 ± 80. Most bone elements are thoroughly mixed and there are few substantial articulations. The material represents a minimum of 457 individuals of whom 145 are immature (Pfeiffer 1983).

All immature right tibiae were selected from the sample and prepared for radiography. This included all whole tibia diaphyses up to the age of complete fusion of the proximal epiphysis and all partial diaphyses representing more than half the bone length. The right side was chosen arbitrarily. All whole diaphyses, proximal and distal fragments were radiographed at settings suitable to their various sizes. Diaphyseal length of whole bones was measured directly using an osteometric board. Cortical and medullary widths at midshaft were measured from the radiographs using a Helios needlepoint caliper. From these measurements, percent cortical area was calculated (Garn 1970).

To be counted, a line of radio-opacity had to extend at least half-way across the shaft (Mays 1985). All diaphyses were placed in broad age categories based on length (Bass 1971). The

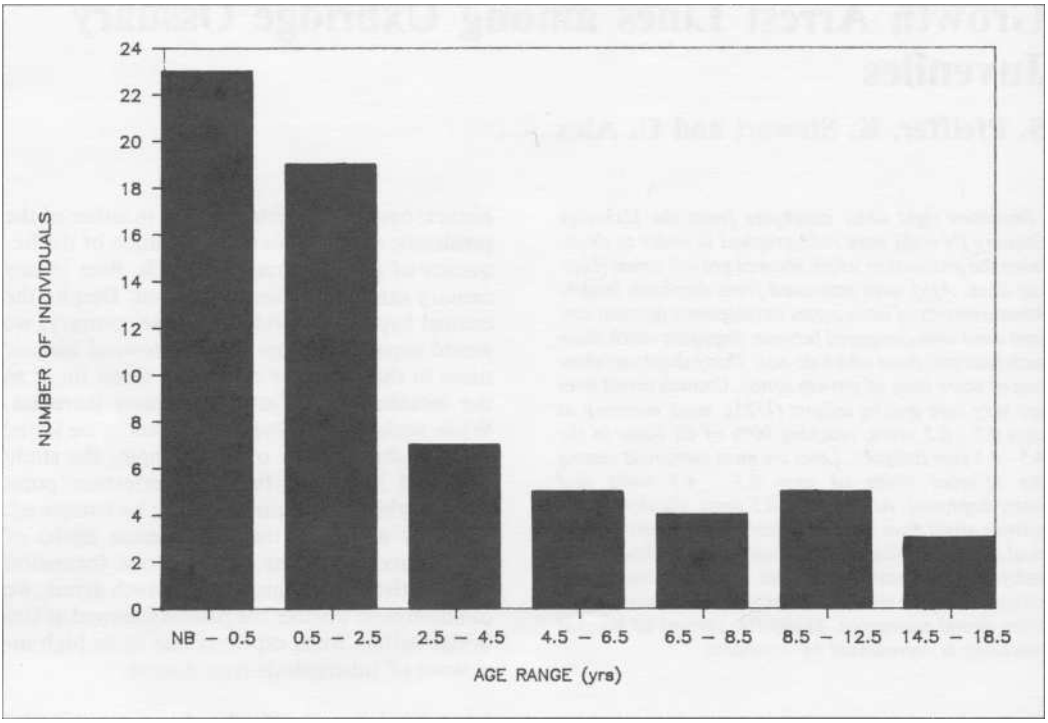

Fig. 1
Juvenile mortality profile from the Uxbridge Ossuary.

lengths of fragmentary diaphyses were estimated so that they could be assigned to an age category. These age categories are very clearly approximations.

Results

A minimum of 66 immature tibiae were identified, of which 40 are complete diaphyses. Twenty-three or 35% of the sample are of the size categorized as newborn to six months old. This proportion compares favourably to the 39% newborns seen in the earlier study of dental development. Juvenile mortality declines sharply after age 2.5 years and is lowest at ages 14.5 - 18.5 years, with only three diaphyses representing this age period (Fig. 1).

Of the 66 tibiae, 30 show one or more growth arrest lines. The lines are more common and more easily counted at the proximal end. Of those tibiae with growth arrest lines, ten have one line only and twenty have multiple lines, with the maximum being seven lines.

Growth arrest lines are not equally common among all age groups (Fig. 2). Only one infant shows a single line, while eight out of nine in the 4.5 - 8.5 year range show lines. Lines are most common, both absolutely and proportionally, from ages 0.5 - 8.5. Among tibiae showing lines, the lines are most numerous in the 0.5 - 4.5 year group (Fig. 3).

Our measurements of percent cortical area (PCA) show great variability in each age category(Table 1). The sample mean is 69.8%, with no clear trend associated with age. There is no statistical correlation between PCA and diaphysis length for tibiae with or without growth arrest lines. However, among those ages in which growth arrest lines are most common, 0.5 - 8.5 years, the PCA of those 10 tibiae without lines is significantly greater than that of the 25 tibiae with lines (66.5% vs. 61.5% $t = 4.03$, $p = 0.01$).

Discussion

It appears from our study of Uxbridge tibiae that growth arrest lines are quite common, that they are especially common among individuals who died in mid-childhood, and that they are associated with a reduced percent cortical area.

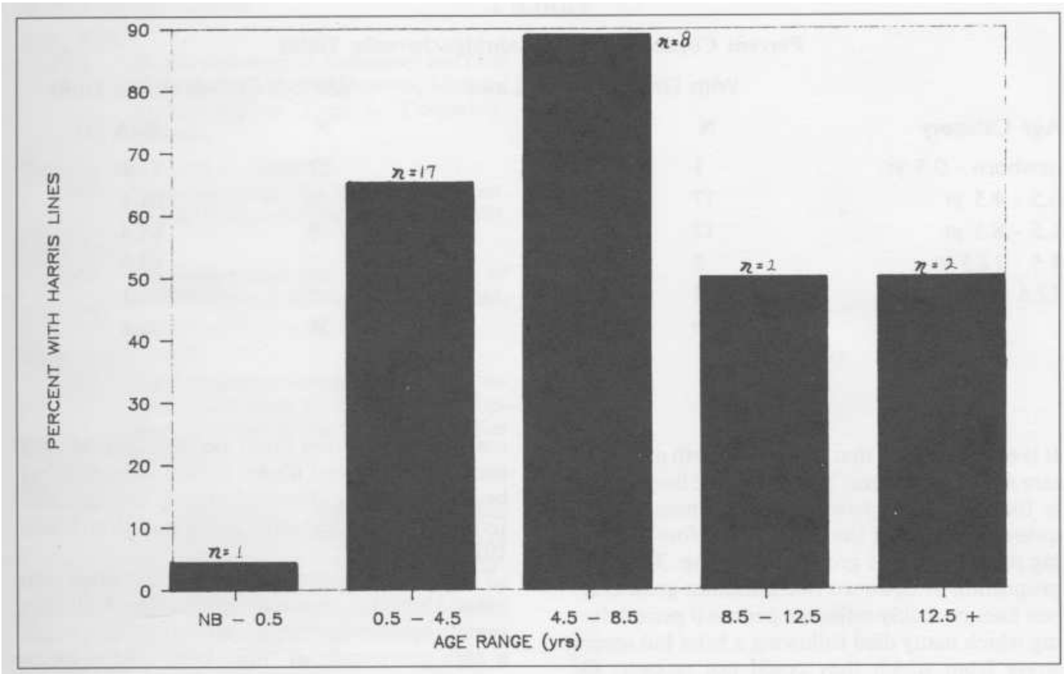

Fig. *2*
Population percentage showing Harris Lines.

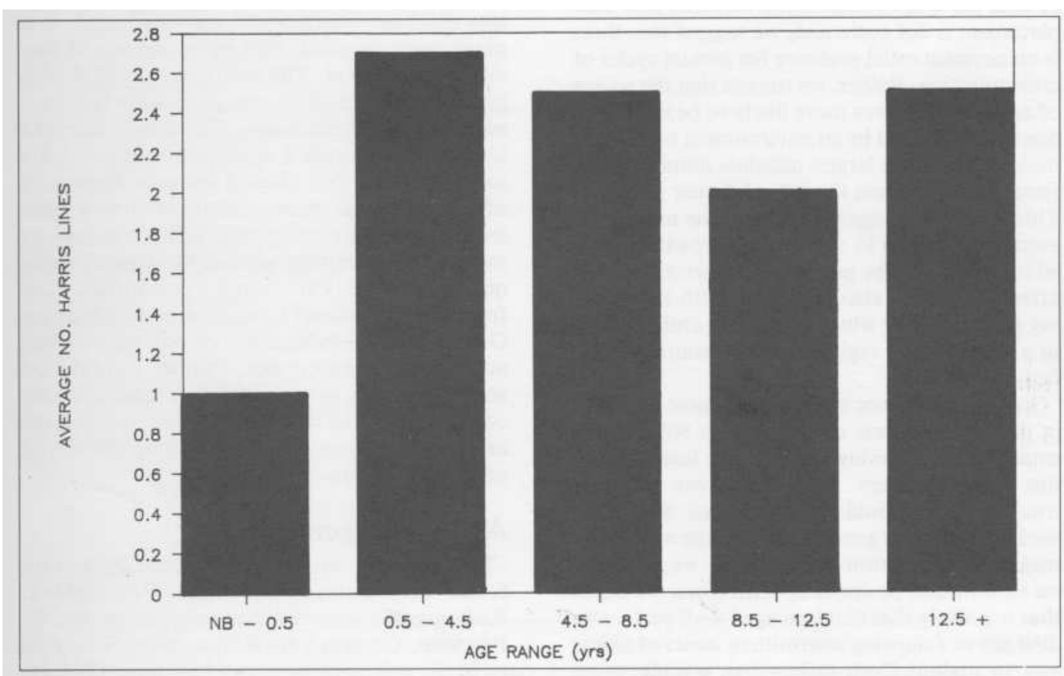

Fig. 3
Average frequency of Harris Lines when present.

TABLE 1

Percent Cortical Area of Uxbridge Juvenile Tibiae

	With Growth Arrest Lines		Without Growth Arrest Lines	
Age Category	N	**PCA (x)**	**N**	**PCA** (x)
newborn - 0.5 yr.	1	71.1	22	83.1
0.5 - 4.5 yr	17	58.6	9	65.4
4.5 - 8.5 yr	17	58.6	9	65.4
8.5 - 12.5 yr	2	67.0	2	67.3
12.5 yr +	2	72.3	2	46.1
	30	**63.0**	**36**	**76.6**

It is not surprising that signs of growth arrest are rare among newborns. The horizontal line of bone is formed when growth re-commences after a quiescent period. If the infant dies before recovering there will be no growth arrest line. The large proportion of newborn tibiae without growth arrest lines probably reflects a perinatal period during which many died following a brief but severe stress from which they could not recover. Of children who died after the first year of life, however, 67% (29/43) show growth arrest lines. This incidence indicates that some form of chronic stress was very common. Since the actual number of lines per diaphysis is highly variable, and their placement is not patterned, we suggest that there is no circumstantial evidence for annual cycles of undernutrition. Rather, we suggest that the source of growth arrest was more likely to be infectious disease contracted in an environment of chronic malnutrition. The largest absolute number of affected tibiae is from the 0.5 - 4.5 year category. This includes the age of weaning, the most common age at which to see arrested growth followed by recovery. The pattern of numerous lines in affected tibiae is also consistent with the weaning period during which the young child adjusts to a new nutrient regime and new sources of infectious disease.

Growth arrest lines are relatively most common in the 4.5 - 8.5 year category, with 90% of the small sample showing lines. If the lines seen in this category were remaining from weaning trauma, they would be positioned somewhat medially from the growth zone. While we did not measure the position of each line, we observed no such medial positioning. Therefore, we argue that it is likely that children aged 4 - 9 years who died did so following intermittent bouts of illness and/or malnutrition, rather than a single event of physical trauma/injury. This interpretation is corroborated by the lower percent cortical area seen in the affected tibiae. Such a reduction has been consistently observed among children suffering from protein-calorie malnutrition (Garn 1970).

The information presented here is consistent with other Uxbridge research results. The Uxbridge sample appears to represent a population in which a high proportion of those born died prior to adulthood (32%, Pfeiffer 1983). Of this group, over one third died during the perinatal period, probably following a brief bout of illness. Those who survived infancy commonly experienced brief stresses which temporarily arrested their growth. If a child survived beyond mid-childhood, it is much more probable that he or she would survive to adulthood. The bouts of growth disturbance during the adolescent years were less common. One might summarize that a population like Uxbridge supported a sizeable group of `sickly kids'. Uxbridge thus offers a dramatic illustration of how infectious disease can function as a selective agent. Only comparisons with other ossuary samples will determine whether this pattern is unique to Uxbridge. Patterson's observations of low frequencies of enamel hypoplasia in the Kleinburg Ossuary seem to indicate less chronic health stress at that later, historic site. Further information about variability in health through space and time could prove to be very useful in interpreting the archaeological record and in writing the record of Ontario's Native People.

Acknowledgements

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