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MORPHOLOGICAL ANALYSIS OF DIFFERENTIAL BONE SURVIVAL

ABSTRACT: The correlation between the preservation of entire skeletons and fragments from their ribs (N=63) and femurs (N=38) within a historic sample (1833–1861) from the Voegtly cemetery, Pennsylvania, USA was calculated using the Wilcoxon signed-rank test (WSRT), which considers information about both the sign and the magnitude of the differences between pairs. If the two variables are similarly distributed, the number of positive and negative differences does not differ significantly. Although no particular distributions are assumed for the two variables, the population distribution of the paired differences was assumed to be symmetric. Bone fractures and the presence of plant roots and root markings were also considered. The Z score for femurs (–2.579) and ribs (–2.391), according to positive ranks (fragment < skeleton) revealed that in both cases the fragments display better preservation than that of the whole skeleton, despite variation in such relevant features as bone density and morphology.

KEY WORDS: Taphonomy – Bone weathering – Voegtly, Pennsylvania (USA)

INTRODUCTION

The ability to generate data from skeletal remains has been the major focus in the fields of skeletal biology and forensic anthropology. But prior to any osteological analysis, experts usually determine the whole skeleton weathering stage based on the six-stage classification system proposed by Beherensmeyer (1978). The six progressive stages of bone weathering in this system range from stage 0 (excellent preservation) in which the bone surface lacks cracking and flaking to stage 5 (very poor preservation) in which bone is falling apart, usually with cancellous bone exposure.

Additionally, archaeological reports often make general observations concerning the differences in preservation among recovered skeletal remains, and some researchers have attempted to explain the differential preservation of skeletons within single sites (Gordon, Buikstra 1981, Badgely 1986, Boddington 1987, Henderson 1987, Micozzi 1991, Saunders 1992, Nawrocki 1995, Saunders *et al.* 1995, Galloway *et al.* 1997).

The present paper examines the differential survival of femoral and rib fragments of individual Voegtly cemetery skeletons in comparison with preservation of the entire skeleton and explores the possible influence of plant roots in this particular context. The Voegtly cemetery sample was excavated in 1987 following its detection in a survey preceding highway construction in Pittsburgh, Pennsylvania. The cemetery was associated with the Voegtly church and parsonage, dated to between 1833 and 1861. This Voegtly Evangelical Lutheran Church represented a population of Swiss-German ancestry living in Northside Pittsburgh.

MATERIALS AND METHODS

The Voegtly skeletal sample (1833–1861) from Pennsylvania (USA) is particularly interesting for its broad range of preservation, noticeable presence of plant roots in association with most parts of the skeletons, and the rich archaeological documentation (Ubelaker, Jones 2003). The anthropologically estimated age and sex distributions of both the rib (N=63) and femur (N=38) samples differred substantially (*Figures 1, 2*) with more immature individuals represented by ribs than by femora.

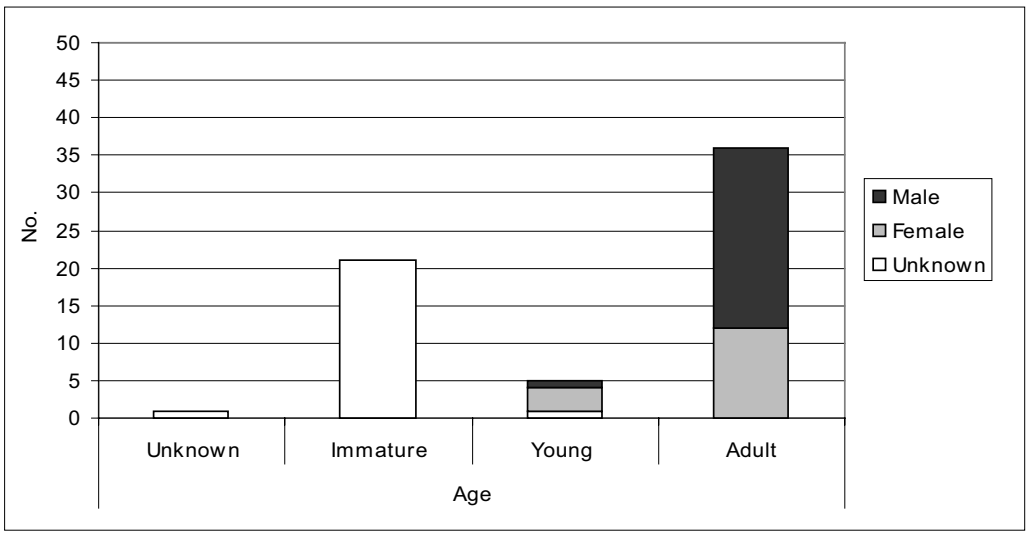

FIGURE 1. Distribution of the number of ribs used in the present study according to the estimated sex and age at death of the individual represented.

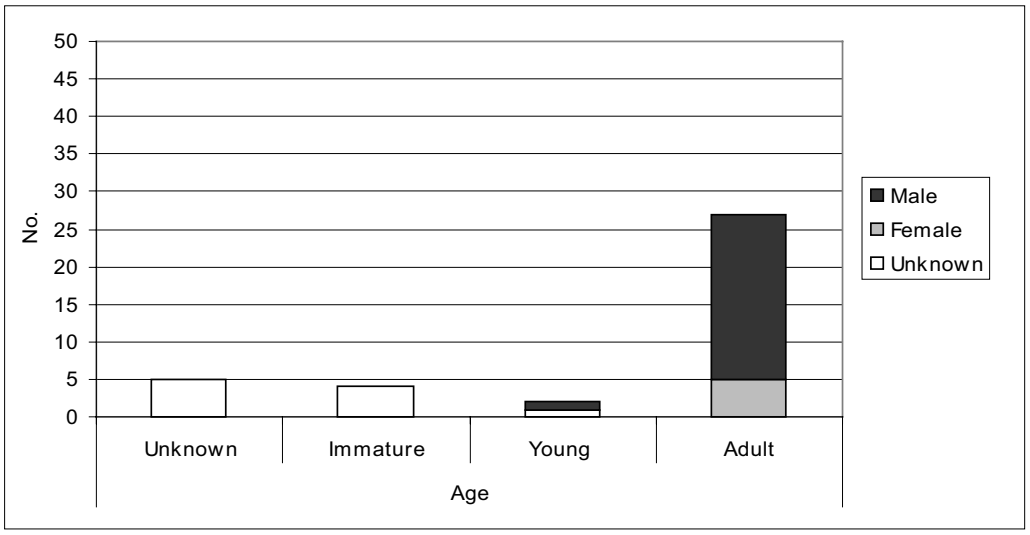

FIGURE 2. Distribution of the number of femora used in the present study according to the estimated sex and age at death of the individual represented.

TABLE 1. Statistical ranking of preservation comparisons between rib and femoral fragments and entire skeletons.

		N	Mean rank	Sum of ranks
Rib fragment versus Skeleton	Negative ranks	34(a)	25.01	850.50
	Positive ranks	15(b)	24.97	374.50
	Ties	14(c)		
	Total	63		
Femur fragment versus Skeleton	Negative ranks	21(d)	15.95	335.00
	Positive ranks	8(e)	12.50	100.00
	Ties	9(f)		
	Total	38		

a. Rib fragment < Skeleton
b. Rib fragment > Skeleton
c. Rib fragment = Skeleton
d. Femur fragment < Skeleton
e. Femur fragment > Skeleton
f. Femur fragment = Skeleton

TABLE 2. Wilcoxon signed ranks test results comparing preservation between rib and femoral fragments and entire skeletons.

	Femur fragment versus Skeleton	Rib fragment versus Skeleton
Z	–2.579*	–2.391*

* Based on positive ranks.

The overall weathering stage of the entire skeleton was classified by Ubelaker and Jones (2003) at the time of their general study of the skeletal sample. Subsequent classification of the weathering stage of the fragments was made independently by the first author using the same criteria.

Correlation between the preservation of the skeletons and their respective rib and femoral fragments was estimated using the non-parametric Wilcoxon signed-rank test (WSRT) for paired samples. The WSRT considers information about both the sign of the differences and the magnitude of the differences between pairs. If the two variables are similarly distributed, the number of positive and negative differences will not differ significantly. Although no particular distributions are assumed for the two variables, the population distribution of the paired differences was assumed to be symmetric. The WSRT, like the Sign test, is a test on pre-specified subsets, but it takes into account the magnitude of the performance differences on each subset rather than only which system had the better performance (Daniel 1978, Kanji 1994).

RESULTS AND DISCUSSION

The morphological and statistical analysis of entire skeletons and their respective fragments' degree of preservation

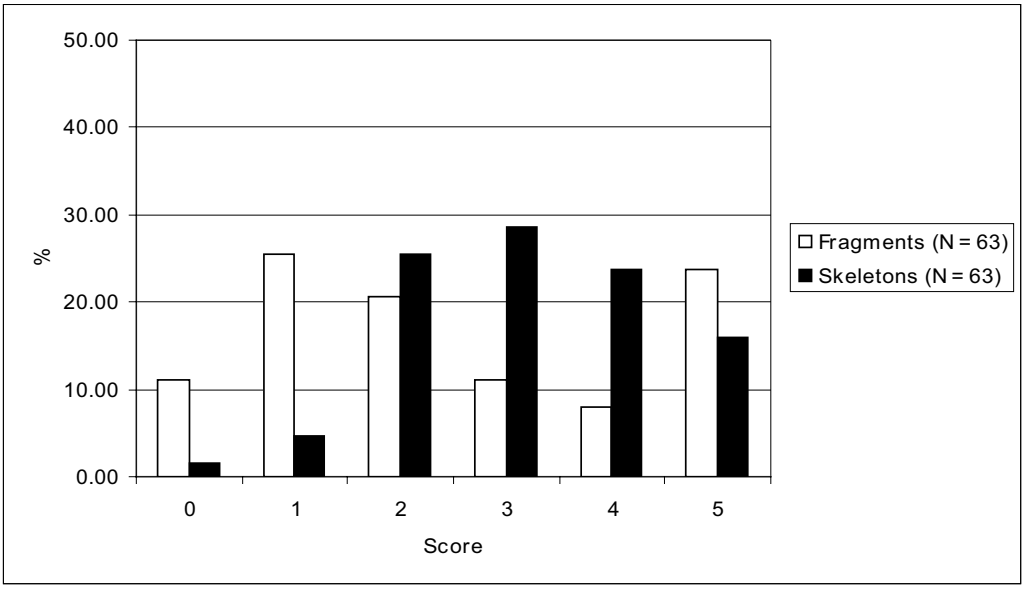

FIGURE 3. Comparison of the frequency distributions of the six weathering stages of rib samples with those of the entire skeletons.

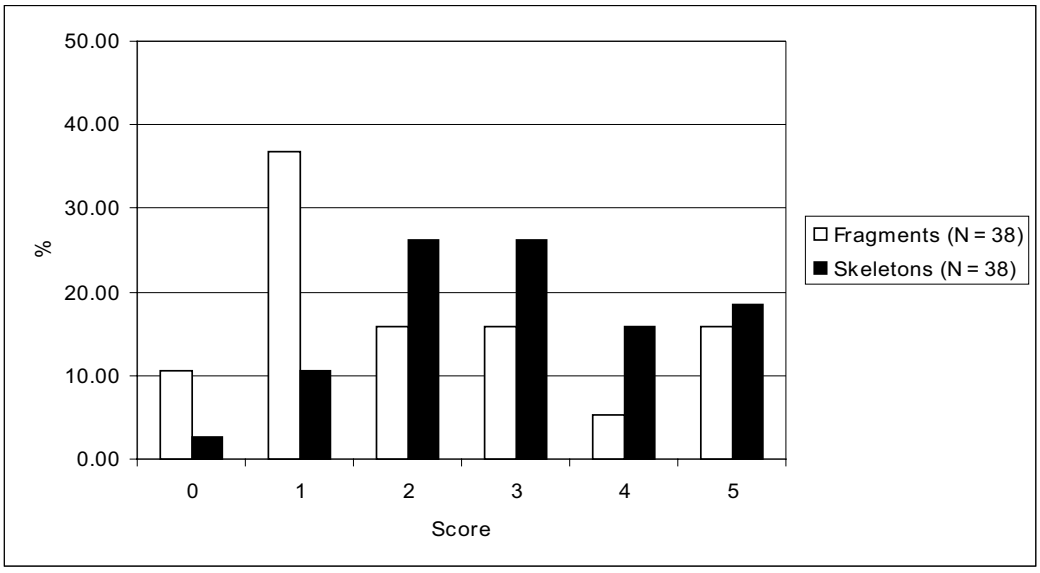

FIGURE 4. Comparison of the frequency distribution of the six weathering stages of femoral samples with those of the entire skeletons.

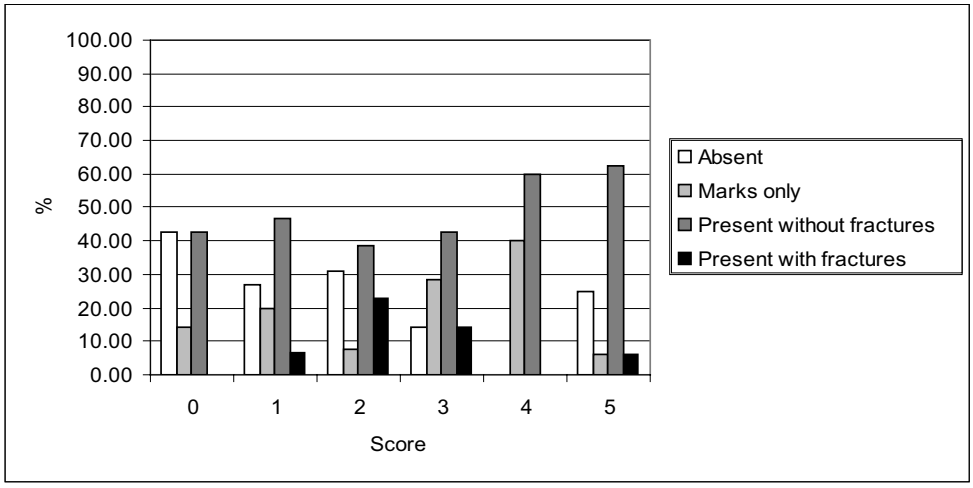

FIGURE 5. Frequency distributions of rib fragments showing roots, root marks and bone fractures within the six weathering stages.

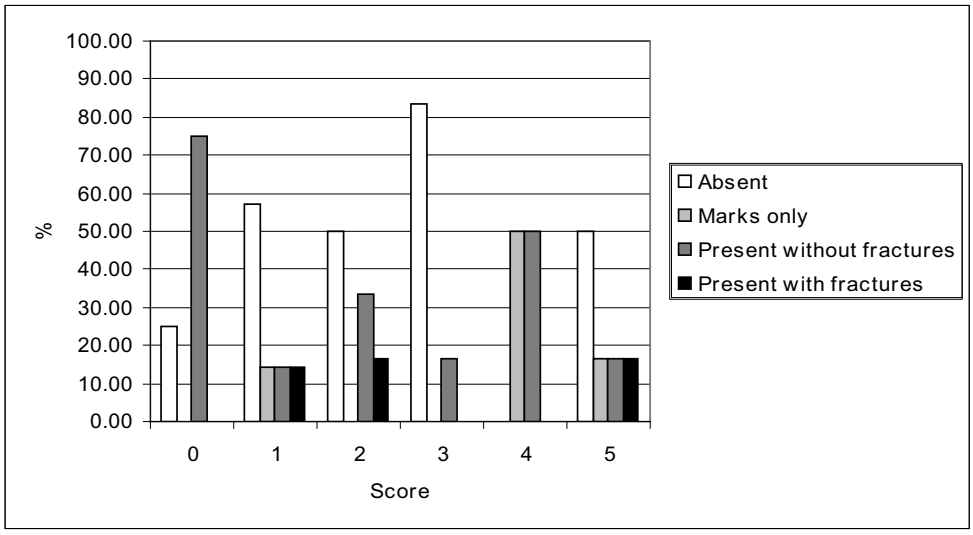

FIGURE 6. Frequency distributions of femoral fragments showing roots, root marks and bone fractures within the six weathering stages.

(*Table 1*) revealed poor correlation (*Figures 3, 4*). Both femur and rib fragments' scores are lower than whole correspondent skeletons in most of the cases. It should be noted that the rib sample is larger, but also represents a larger number of immature individuals. Juvenile bones tend to be less dense than mature bones and this contributes to a poorer resistance to diagenetic agents such as plant roots (Braz 2001). Plant roots were observed in both samples but they seemed not to play a central role in bone degradation (*Figures 5, 6*). Despite the possibility of soil acidification due to vegetation cover (Braz 2001), no direct relation was observed between bone survival and root presence in both samples. Many well-preserved fragments (approximately 50%), especially in the rib sample, displayed a considerable amount of root presence but statistical analysis revealed that root presence had no major correlation with bone preservation.

The Z score for femurs (–2.579) and ribs (–2.391), according to positive *ranks* (*Table 2*), revealed that in both cases the fragments have lower scores than the whole skeleton, despite such factors as density, morphology of studied bones and plant root presence.

This study corroborates that of Beherensmeyer (1978), which suggested different bones from the same skeleton weather at different rates. Lyman and Fox (1997) argued that the weathering velocity of each skeleton element is not yet known, making categorization more difficult. It is known that femurs are denser than ribs but this study suggests that preservation within individual areas of the skeleton may vary considerably. Environmental factors, such as vegetation, soil pH and composition, remain as important agents to be examined in future investigations.

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