Oxygen Isotope Analysis of Human Bone Phosphate Evidences Weaning Age in Archaeological Populations

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ABSTRACT Here we report bone phosphate oxygen ($\delta^{18}O_p$) values from perinates/neonates and infants (<3.5 years; $n = 32$); children (4–12 years; $n = 12$); unsexed juveniles (16–18 years; $n = 2$); and adult bones ($n = 17$) from Wharram Percy, North Yorkshire, England, in order to explore the potential of this method to investigate patterns of past breastfeeding and weaning. In prior studies, $\delta^{15}N$ and $\delta^{13}C$ analyses of bone collagen have been utilized to explore weaning age in this large and well-studied assemblage, rendering this material highly appropriate for the testing and development of this alternative method targeting the inorganic phase of bone. Data produced reveal ^{18}O-enrichment in the youngest perinatal/neonatal and infant samples, and an association between age and bone $\delta^{18}O_p$ (and previously-published $\delta^{15}N$ values), with high values in both these isotope systems likely due to breastfeeding. After the age of 2–3 years, $\delta^{18}O_p$ values are lower, and all children between the ages of 4 and 12, along with the vast majority of sub-adults and adults sampled (aged 16 to >50 years), have $\delta^{18}O_p$ values consistent with the consumption of local modern drinking water. The implications of this study for the reconstruction of weaning practices in archaeological populations are discussed, including variations observed with bone $\delta^{15}N_{coll}$ and $\delta^{18}O_p$ co-analysis and the influence of culturally-modified drinking water and seasonality. The use of this method to explore human mobility and palaeoclimatic conditions are also discussed with reference to the data presented. Am J Phys Anthropol 000:000–000, 2015. © 2015 Wiley Periodicals, Inc.

Breastfeeding and weaning practices in past populations have become an increasingly important and studied area of archaeology and anthropology in recent years. It has been suggested that the natural age for the cessation of human breastfeeding lies between ~2.5 and 7 years (Dettwyler 1995; Dettwyler 2004), based on anthropological literature and various predictions concerning human physiology and reproduction (see review in Dettwyler 2004). However, incidences of breastfeeding beyond 4 years of age are unusual, with weaning most commonly occurring between 2 and 3 years among modern humans living in non-industrialized and traditional, natural fertility societies (Alvarez 2000; Sellen 2001, 2007; Kennedy 2005). Before the cessation of breastfeeding, most infant diets also include complementary liquid and solid foods, in many cases before the age of 6 months (Sellen 2001). However, practices are varied (Sellen 2001; Kennedy 2005), and cultural factors are known to strongly influence the duration and nature of breastfeeding (and complementary feeding) in past and present societies (Stuart-Macadam and Dettwyler 1995; Dettwyler 2004). Therefore, the investigation of breastfeeding (including the processes by which other foods are introduced to the infant and breastfeeding declines and ceases) can illuminate past cultural practices and lifeways in earlier societies, particularly aspects of life pertaining to children and women. These practices also have broader implications for our understanding of human ecology, health, population dynamics and demographics in the past. As well as providing total nutritional requirements in early life (Butte et al. 2002), breast milk provides immunological protection to infants, primarily against gut/diarrheal diseases but also against extra-intestinal diseases (e.g. Arifeen et al. 2001; Duijts et al. 2010; see review in Horta and Victora 2013a) and (possibly) even longer-term conditions (e.g. Rich-Edwards et al. 2004; see review in Horta and Victora 2013b), and may also have benefits for a child's cognitive development (e.g. Quinn et al. 2001). Lactation can also determine fertility in breastfeeding females

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