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Nursing mothers and feeding bottles: reconstructing breastfeeding and weaning patterns in Greek Byzantine populations (6th–15th centuries AD) using carbon and nitrogen stable isotope ratios

Chryssi Bourbou [a,*], Benjamin T. Fuller [b,c,d], Sandra J. Garvie-Lok [e], Michael P. Richards [b,f]

[a] Hellenic Ministry of Culture, 28th Ephorate of Byzantine Antiquities, Sourmeli 24, 73110 Chania, Crete, Greece
[b] Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, 6 Deutscher Platz, D-04103 Leipzig, Germany
[c] Laboratory of Biodiversity and Evolutionary Genomics, Centre for Archaeological Sciences, University of Leuven, Ch. Debériotstraat 32, B-3000 Leuven, Belgium
[d] Department of Earth System Science, University of California, Irvine, Keck CCAMS Group, B321 Croul Hall, Irvine, CA 92697, USA
[e] Department of Anthropology, University of Alberta, Edmonton, Alberta T6G 2H4, Canada
[f] Department of Anthropology, University of British Columbia, Vancouver, British Columbia V6T 1Z1, Canada

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ABSTRACT

Traditionally, documentary evidence (mainly medical works and the vitae and miracles of saints) served as the primary source of information for perinatal nutrition in the Byzantine era. In the last decade, however, stable carbon and nitrogen isotope ratio analysis has also been applied for the reconstruction of Byzantine breastfeeding and weaning practices. This paper reviews the documentary evidence for Byzantine weaning and compares it to isotopic data for eight Greek Byzantine skeletal samples from the sites of Eleutherna, Kastella, Messene, Sourtara, Stylos, Nemea, Petras and Servia (6th–15th centuries AD). The documentary evidence suggests that Byzantine children were weaned at a relatively late age. The age patterning of the stable isotope data is not as clear as normally seen at single sites. However, the presence of a higher proportion of elevated values in juveniles aged three years or less suggests that weaning was completed by the fourth year—a pattern consistent with the written sources. The data available from this study allow us to make some tentative suggestions about cultural and temporal differences in weaning, and to recommend directions for further research. A comparison of the Byzantine data presented here to data published for Roman-era sites from the Mediterranean and Western Europe suggests that the Byzantines maintained a Roman-era practice of relatively late weaning. In contrast, medieval data for Western Europe and the few measurements made on post-Byzantine Greek material suggest more variation, with some groups weaning late and others weaning earlier, by two years of age.

1. Introduction

Stable isotope ratio analysis of bone collagen has been widely applied to Greek skeletal populations to reconstruct adult diets from prehistoric times through to the Byzantine period (for reviews see Bourbou, 2010; Bourbou et al., 2011; Papathanasiou et al., in press). However, this method has been used less frequently to address questions pertaining to juvenile diets. Previous work has been conducted on Greek populations of the Byzantine era (Bourbou and Garvie-Lok, 2009, in press; Bourbou, 2010) and Bronze Age (Triantaphyllou et al., 2008), as well as on the Greek colonists of Apollonia on the Black Sea (Kwok, 2007; Holt, 2009). One reason for the relative paucity of stable isotope studies of weaning in Greek archaeological populations is the problem of sample size: for many eras the typical cemetery size is small and the preservation is often poor, with the result that sites often contain insufficient juvenile remains for a confident reconstruction to be done.

This study undertakes a large-scale survey of juvenile human remains from the early (4th–9th centuries AD) and middle Byzantine (10th–15th centuries AD) periods by integrating the isotopic results of 61 non-adult individuals from eight sites, from various geographical locations in Greece. This work is an expansion of a smaller pilot study that used the same approach (Bourbou and Garvie-Lok, 2009), and acts as a follow up to a previous discussion

* Corresponding author. Almyridos 10, 73133 Chania, Crete, Greece. Tel.: +30 69735 54028; fax: +30 28210 44114.
E-mail address: chryssab@gmail.com (C. Bourbou).

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of the Byzantine adult diet based on stable isotope values from the same eight sites (Bourbou et al., 2011).

In the context of these juvenile isotopic values, the possible effects of weaning stress on non-adult mortality in Byzantine populations as well as the development of specific pathological conditions (i.e., metabolic disorders) at the onset of weaning are discussed. In addition, the infant feeding habits of the Byzantine Empire are compared and contrasted to the practices of Western Europe. Breastfeeding and weaning patterns of Roman and medieval populations from the Mediterranean region and Western Europe have been investigated in a number of relevant isotopic studies (Dittman and Grupe, 2000; Dupras et al., 2001; Mays et al., 2002; Richards et al., 2002; Herrscher, 2003; Prowse et al., 2004; Turner et al., 2007). However, no attempt has been made to compare isotopic results between Greek and Western Mediterranean populations and it is believed that such a comparison can provide useful information on differing attitudes toward infant feeding practices in the two regions.

2. Reconstructing breastfeeding and weaning patterns by stable isotope ratio analysis

Stable isotope studies of breastfeeding and weaning patterns are based on the shifts in infant tissue $\delta^{15}N$ and $\delta^{13}C$ values that typically occur at the onset and termination of breastfeeding. Observations made on fingernail clippings of modern human mother–infant pairs (Fogel et al., 1989; Fuller et al., 2006a) show that infant $\delta^{15}N$ values rise rapidly with the onset of breastfeeding, reaching a plateau roughly one trophic level (2–3‰) above the mother's tissue value. As supplementation with other foods begins the values start to drop, falling to a level similar to the mother's after nursing has halted completely. A similar, though subtler, effect (~1‰) is present for $\delta^{13}C$ and this can be used to better understand the timing of the introduction of solid foods (Fuller et al., 2006a).

Since the initial documentation of the effects of nursing and weaning on human $\delta^{15}N$ values, nitrogen isotope ratio analysis has been used to study nursing and weaning in many archaeological human populations (e.g., Katzenberg and Pfeiffer, 1995; Katzenberg et al., 1996; Schurr, 1997; Herring et al., 1998; Dupras et al., 2001; Richards et al., 2002, 2006; Prowse et al., 2004; Schurr and Powell, 2005; Clayton et al., 2006; Fuller et al., 2006b; Dupras and Tocheri, 2007; Turner et al., 2007; Jay et al., 2008; Nitsch et al., 2011; Redfern et al., 2012; Howcroft et al., 2012). This application is possible because bone collagen, like other body proteins, reflects the changes in the $\delta^{15}N$ value of an infant's diet that occur during the initiation and termination of breastfeeding. The most common approach to studying weaning through archaeological remains is the study of bone samples from a number of infants and children in a burial group. These samples are analyzed and the $\delta^{15}N$ values are plotted by age at death and compared to the mean value for adult females in the population. Typically, such studies show $\delta^{15}N$ values for neonates that are similar to those of adult females. The values then rise fairly rapidly to roughly one trophic level above the mean adult female value as nursing incorporates ^{15}N-enriched collagen into the bones. After a given age, the $\delta^{15}N$ values start to drop again; the point at which this drop begins is taken to be the age by which significant consumption of protein-rich foods other than breast milk typically began. Because bone is slower to turnover than most tissues, this age will lag behind the 'true' age at which weaning actually began in the population. However, although the bones of adults may retain the isotopic signal of an earlier diet for decades (Stenhouse and Baxter, 1979; Hedges et al., 2007), bone turnover in a rapidly growing infant is considerably faster, especially in small and porous bones such as the ribs (Richards et al., 2002). Observations on large samples of infants from archaeological skeletal populations have led researchers such as Katzenberg et al. (1996) and Richards et al. (2002) to suggest that the lag time between weaning and a shift in infant rib $\delta^{15}N$ value is quite brief, on the order of a few months or less.

Although powerful, this application of nitrogen isotopes has its limitations and requires caution. Because of the delay caused by turnover, the onset of a drop in $\delta^{15}N$ values must be taken as the time by which weaning had typically begun for a population rather than a precise estimate of weaning age. Problems may also arise from any differences between a culture's approach to weaning healthy and sick infants, as the weaning pattern reflected in the deceased infants from a burial population is likely to be biased toward the approach preferred for an unhealthy child (Katzenberg et al., 1996; Fuller et al., 2003). The delay in the weaning signal caused by bone turnover can be circumvented to a degree by sampling the growing edge of bones and teeth in order to access collagen that was being formed at the time of death (Waters-Rist and Katzenberg, 2010; Waters-Rist et al., 2011). To compensate in part for the bias resulting from the study of non-survivors the teeth of older individuals can be analyzed, using the $\delta^{15}N$ and $\delta^{13}C$ values of dentine that formed at given ages to provide a record of shifting dietary $\delta^{15}N$ and $\delta^{13}C$ during the childhood years of those who survived the weaning process (Fuller et al., 2003; Dupras and Tocheri, 2007; Eerkens et al., 2011). However, these approaches represent only partial solutions to the biases and inaccuracies inherent to the method.

As a result of the bias introduced by studying non-survivors, and because of a certain normal variation in weaning age expected for any population, studies that reconstruct weaning behavior using bone collagen values should ideally sample the remains of a large number of infants, and where large burial groups are available, this is commonly done (e.g., Herring et al., 1998; Dupras et al., 2001; Richards et al., 2002; Prowse et al., 2004; Schurr and Powell, 2005). However, this is a problem for researchers studying cultures for which large infant burial groups are unavailable for reasons such as a preference for smaller, less centralized burial sites, a tendency to bury infants and adults separately, or small social group size. In such cases researchers have chosen to tentatively reconstruct weaning patterns based on a small series of juvenile remains, cautioning that the resulting weaning estimates are very general (e.g., Richards et al., 2003). Here we take a different approach, combining juvenile remains from several sites of the same culture to produce an aggregate sample. The juvenile values from each site are converted to $\delta^{15}N$ and $\delta^{13}C$ departures from that site's adult female mean, allowing them to be directly compared to one another. At least one other study has successfully used pooled stable isotope data from different sites to study weaning behavior (Williams et al., 2005). In doing so here, we hope to contribute to the understanding of weaning practices from the Greek Byzantine period and also to illustrate the value of this approach for reconstructing weaning in past human cultures for which large series of infant remains are unavailable.

2.1. Feeding the infant in Byzantine Greece: documentary evidence

The Byzantine Empire was the predominantly Greek-speaking continuation of the eastern Roman Empire. Although the western portion of the Roman Empire fell in the 5th century AD its eastern portion, including the area known today as Greece, remained under imperial control. As the Byzantine Empire it would persist through periods of expansion and decline until its fall to the Ottoman Empire in the 15th century AD. The documentary and zooarchaeological evidence for adult diets in Byzantine Greece has been presented elsewhere (Bourbou, 2010; Bourbou et al., 2011; Bourbou and Garvie-Lok, in press). To summarize, the adult diet was based