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Individual dietary patterns during childhood: an archaeological application of a stable isotope microsampling method for tooth dentin

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ABSTRACT

Diet from the late medieval Fishergate House cemetery site (York, UK) is reconstructed using nitrogen and carbon stable isotope ratio analysis from tooth dentin. Deciduous teeth from 42 subadult individuals (fetal to 5–6 years) were used to reconstruct weaning practices at a population and an individual level. This is the first archaeological use of this microsampling method (dentin ≥.3 mg). This method allows an individual's changing diet to be reconstructed from the fetal period through weaning. The fetal signals show a complicated relationship with adult female ratios, having higher $\delta^{15}N$ values than expected. At this site, there is an unusual decoupling between peak mortality (4–6 years) and weaning (2 years). The mean $\delta^{15}N$ ratios for weaned children were enriched when compared to the adult females (12.4‰ ± 1.29 and 11.4‰ ± 1.1; statistically significant to $p < .05$). Early childhood diet is surprisingly high in marine fish and/or pork given the low socioeconomic class of the sample. This is a departure in weaned diet from contemporary communities and may be responsible for the unusual disconnect between peak mortality and weaning. When the individual dietary reconstructions were combined with each individual's rib reconstruction the presence of a true child specific diet was clear starting at approximately 2 years of age. Some individuals diverge from the population norm and have an extended breastfeeding period linked to poor health. The increased resolution of microsampling allows bioarchaeologists to test detailed time depended questions about early childhood diet and health.

1. Introduction

Currently there are limited isotopic studies of breastfeeding and weaning practices in Medieval Britain; most focus on Wharram Percy (Mays et al., 2002; Richards et al., 2002; Fuller et al., 2003). The initial osteology report from Fishergate House indicated a high mortality rate at 4–6 years, which does not match the weaning period (2 years) found in contemporaneous British communities (Burt, 2013; Fuller et al., 2003, 2006b; Holst, 2005; Jay et al., 2008; Mays et al., 2002; Richards et al., 2002). The weaned child diet at Fishergate House reconstructed using a small sample of ribs is unusual as it is not the same as that of the adult females studied (Burt, 2013). At Fishergate House, weaned children appear to have a diet rich in marine protein and pig much like high socioeconomic individuals in a neighboring York suburb rather than a grain based diet as seen with their poor contemporaries (Burt, 2013; Fuller et al., 2003; Mays et al., 2002; Müldner and Richards, 2007a, 2007b; Richards et al., 2002).

The research presented here examines the breastfeeding and weaning pattern of 42 juvenile individuals from Fishergate House York, UK using carbon and nitrogen stable isotope ratio analysis of tooth dentin to reconstruct the population weaning practices and each individual's changing diet. A microsampling method for deciduous teeth formed by Burt and Garvie-Lok (2013) is used to expand the sample size at all age categories and to reconstruct the individual childhood diets at Fishergate House. This is the first archaeological test of this method, which tracks a child's diet from the fetal period through to early childhood. It is hypothesized that by analyzing fetal dentin it will be possible to reconstruct the diet of the mother during pregnancy. Maternal diet is currently unknowable for most archaeological populations and samples would be too small to examine statistically. By tracking an individual's changing diet it is also possible to gain a better understanding of the relationship between breastfeeding, weaning, and the diet at time of death (using rib analysis). This analysis will clarify the unusual weaning and mortality pattern at Fishergate House and provide a

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better understanding of the lives of children with low socioeconomic status.

2. Medieval Fishergate House

Fishergate House (Fig. 1) is an archaeological site from York excavated by the York Archaeological Trust between 2000 and 2002 (Spall and Toop, 2005). York was the second largest city in Britain during the medieval period and was a thriving trade hub for British goods and international products from Europe. The cemetery site runs from near the Fishergate in the city wall in a narrow band to the banks of the river Ouse. The cemetery was associated with St Helens Church. Peak cemetery usage was during the mid-14th to 15th centuries and was abandoned by the 16th century as determined by the pottery mixed into the sediments (Spall and Toop, 2005). No grave markers remained at the site, which was abandoned and largely forgotten until excavation for new construction. Historical records on the Fishergate community who utilized this cemetery indicate that all members of the sample are members of the working poor (Dyer, 1989; Wilson and Mee 1998). St Helens parish was taxed the least of any parish in the area, meaning these individuals were the poorest in their area of York. Individuals were buried in shrouds with minimal grave goods (Spall and Toop, 2005).

Fig. 1. Map showing the location of Fishergate House (black dot) in relationship to Wharram Percy (open square).

There is a large number of children at the site, all of whom appear to be buried in family groups. For a more detailed description of the site, see Burt (2013) or Spall and Toop (2005).

3. Food availability medieval Fishergate House

As a trade center, a large range of foods were available in medieval York. Fish and meat are generally associated with the higher socioeconomic status due to prohibitive costs (Adamson, 2004; Barrett et al., 2004; O'Connor, 2000; Rycraft, 2000; Serjeantson and Woolgar, 2006; Woolgar, 2001). Historical accounts and reconstructions state that the diets of poor individuals were grain based with limited dairy, meat, and poultry. By the late medieval period the fresh water fish sources available to city dwellers were primarily fished out (Barrett et al., 2004). Fish was in high demand in the medieval period due to increased piety and an urban middle class eager to emulate the rich. York was a major trading hub for marine fish from Scandinavia, particularly salted cod or pickled herring (Adamson, 2004; Barrett et al., 2004; O'Connor, 2000; Rycraft, 2000; Serjeantson and Woolgar, 2006; Woolgar, 2001). There is evidence that salt cod or pickled herring were available at prices that were more reasonable. The Fishergate House community was the poorest parish in York during this period and the community was thought to have little access to all but the most basic provisions.

Müldner and Richards (2007a, 2007b) recreated the food web in Late Medieval York using carbon and nitrogen stable isotope analysis of the faunal and human remains from the city. Fishergate House was not analyzed as part of this study. The fauna included herbivores (cattle), carnivores, freshwater fish, herring + salmonid, offshore marine, pig, and domestic fowl. This faunal reconstruction is used to interpret and reconstruct the Fishergate House adult and weaned diets. Stable isotope analysis of higher status individuals from York showed a higher than expected marine resource use in non-clergy and -nobility (Müldner and Richards, 2007a, 2007b). Grains were transported from the countryside where C_3 grains such as wheat, rye, oats, and barley dominated (Hall, 2000; Rycraft, 2000). Sugarcane would not be a regular component of most diets even for high status individuals.

4. Background on weaning and sampling strategies

The carbon and nitrogen that is incorporated into body collagen comes from the food a person eats, particularly dietary protein. It is possible to study breastfeeding and weaning in archaeological populations due to the large shifts in tissue $\delta^{13}C$ and $\delta^{15}N$ values that result from infants consuming their mother's secretion (breast milk) and then switching to a less enriched diet of non-maternally produced food. Trophic level effects in ^{13}C and ^{15}N have been demonstrated in human mothers and their nursing infants using fingernail, hair, and dentin samples (Eerkens and Bartelink, 2013; Fogel et al., 1989; Fuller et al., 2006a). At birth, an infant's $\delta^{15}N$ value is close to that of its mother, this led researchers to speculate that fetal and maternal stable isotope ratios would also be close. However, resent work on paired ratios from mother's and paired fetally formed tissue has indicated a possible fetal to maternal offset (Fuller et al., 2004, 2005, 2006b; de Luca et al., 2012; Burt and Garvie-Lok, 2013). This work is ongoing and the maternal/fetal relationship is not fully understood at this time. The newborn's tissues will maintain the low stable isotope ratio for a variable period that depends on growth rate and tissue turnover before being replaced by an elevated breastfeeding signal (Fuller et al., 2006a; Katzenberg and Pfeiffer, 1995; Katzenberg et al., 1996; Kinaston et al., 2009; Richards et al., 2002). In carbon, there is a 1‰ increase between the sampled value and the diet (Fuller et al.,