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Infant feeding practices in a pre-Roman/Celtic population from Verona (Italy)

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ABSTRACT

We studied an osteological sample from the pre-Roman/Celtic necropolis of Seminario Vescovile of Verona (Italy), dated to the 3rd to 1st century BCE and attributed to the *Cenomani* Gauls population. The sample is mostly composed of well-preserved infants in their first months and years of life. In this study we combined isotopic ($\delta^{15}N$ and $\delta^{13}C$) and anthropological evidence with the aim of investigating infant feeding practices in non-adult samples. 36 non-adults were selected and divided into seven age phases. The isotopic composition of their rib bone collagen was determined and related to the mean values of adults (n = 54) and animals (n = 7). $\delta^{15}N$ values ranged between 7.1‰ and 12.9‰ (AIR), with a mean of 10.2‰ (± 1.5‰), while $\delta^{13}C$ values ranged between − 20.2‰ and − 9.7‰ (V-PDB), with a mean of − 15.3‰ (± 2.5‰). These results indicate the initiation of transitional feeding around six months. Significantly high $\delta^{15}N$ values in some infants up to two years old suggests prolonged breast-milk consumption. In comparison with the $\delta^{15}N$ and $\delta^{13}C$ data from the adult females (n = 21), considered as potential mothers, these infants clearly show the effect of breastfeeding on trophic level ($\delta^{15}N$ enriched between 1.8 and 3.3‰).

1. Introduction

Quite a lot of studies have been published on the human diet during different phases of infancy in past times and its relationship with health, morbidity and mortality (e.g. Dupras and Tocheri, 2007; Herrscher, 2013; Katzenberg et al., 1996; Kaupová et al., 2014; Knipper et al., 2016; Nájera-Colino et al., 2010; Pearson et al., 2010; Redfern et al., 2012; Schurr, 1998; Waters-Rist et al., 2011). Most research on human health conditions has been based on qualitative analyses, e.g., the study of non-specific stress indicators (Larsen, 2015; Schurr, 1998). However, quantitative analysis has become possible (Katzenberg et al., 1996) through the study of isotopic composition, especially $\delta^{15}N$ values, which are related to a greater or lesser intake of proteins of animal origin, and can also be used to estimate legumes vs non-legumes or aquatic vs terrestrial animals consumption as main food resources (DeNiro and Epstein, 1981; Hedges and Reynard, 2007). The combined study of collagen isotopic values and paleopathologic features of human bones may lead to major advances in anthropological research (Larsen, 2015).

Stable isotope ($\delta^{15}N$ and $\delta^{13}C$) analysis has been widely utilized to investigate dietary patterns, including infant feeding in different chronological and geographical populations (e.g. Dupras et al., 2001; Dupras and Tocheri, 2007; Fogel et al., 1989; Fuller et al., 2006a, 2006b; Herring et al., 1998; Jay et al., 2008; Katzenberg et al., 1996; Kaupová et al., 2014; Prowse et al., 2008; Schurr, 1998; Waters-Rist and Katzenberg, 2010). During the breastfeeding period, consumption of maternal tissue through breast milk ingestion by the newborns places them one trophic level above their mothers in the food chain, with an enrichment in $\delta^{15}N$ of ≈ 2‰ and in $\delta^{13}C$ of ≈ 1‰ in comparison to maternal values (Fogel et al., 1989; Reynard and Tuross, 2015). Infant $\delta^{15}N$ values then decrease during weaning through the gradual substitution of breast milk with supplementary foods. Weaning is a process, not a single event, which starts when non-breast milk foods (liquids or solids) are first introduced and ends when the consumption of breast milk ceases entirely (Reynard and Tuross, 2015). When the infant is fully weaned and breastfeeding has ceased, the reduction to maternal

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levels is supposedly more rapid for $\delta^{13}C$ values than for $\delta^{15}N$ values (Fuller et al., 2006b). Hence, the study of $\delta^{13}C$ values may be useful to trace the introduction of solid foods into the diet, while $\delta^{15}N$ data are especially relevant to indicate the length of the breastfeeding period (Fuller et al., 2006a; Katzenberg et al., 1996). Finally, variations in stable isotope ratios in bone can yield information on episodes of disease or nutritional stress that cannot be macroscopically identified from the archaeological skeletal record. Thus, the study of $\delta^{15}N$ in non-adult skeletons can contribute to revealing cases of death from nutrition-related disease (Fogel et al., 1989, 1997; Katzenberg et al., 1996; Katzenberg and Lovell, 1999).

Sellen (2009) proposed a model about the weaning process comprised of 4 stages: i) exclusive breastfeeding, ii) breastfeeding plus complementary feeding (specific food for babies), iii) breastfeeding plus complementary and family foods (foods shared by older children and adults), iv) complete cessation of both breastfeeding and complementary food consumption and exclusive family food consumption. As suggested by Reynard and Tuross (2015), we also considered that the weaning process comprises three of the four stages proposed by Sellen (2009): considering stage ii as the beginning and stage iv as the end of the weaning process.

It is also important to keep in mind the assumptions summarised in recent research (Beaumont et al., 2015; Reynard and Tuross, 2015), which warn to be cautious with overly definitive conclusions about weaning ages and subsequent interpretations. They recommend that the sole investigation of bone collagen is not adequate to detect the successive phases of dietary changes during infancy as it implies several general assumptions difficult to take into account for archaeological studies and propose the additional use of teeth micro-samples or other isotope ratios. Among them, the supposition that the $\delta^{15}N$ and $\delta^{13}C$ composition of the bone collagen of non-adults represents their diet at approximately the time of death, and that those infants who died are representative of the diet and physiology of the individuals belonging to that age group (Beaumont et al., 2015). Especially this last assumption is in conflict with the “Osteological Paradox” (Wood et al., 1992), which recommends that non-adults (or also adults) who have died may not be representative of the health condition of the entire population.

Osteoarchaeological material from the pre-Roman/Celtic Seminario Vescovile necropolis (3rd to 1st century BCE) in Verona (Italy), attributable to the *Cenomani* Gauls population, provides an exceptional opportunity to analyze infant remains during the first days and months of life. There have been only a few anthropological studies on this particular Celtic group, mostly carried out in the 1980s (Capitanio, 1989; Corrain, 1987), with a few more recent ones (Teegen, 2014a, 2014b). This extensive new collection was subjected to a detailed anthropological and isotopic study to evaluate health status and dietary habits of the individuals (Laffranchi, 2015; Laffranchi et al., 2016).

The isotopic results obtained reveal a diet mainly based on terrestrial animal protein and C_4 plants, with no isotopic signals indicating the consumption of freshwater or marine foods (Laffranchi et al., 2016). These data are consistent with the archaeobotanical record from older and contemporary archaeological sites in Northeast Italy (Rottoli, 2014) and with ancient reports on the use of millet (C_4 plants) in the daily diet of populations in northern Italy by Pliny the Elder (*Naturalis Historiae* XVIII, 83–84) and Columella (*De Re Rustica*, 2, 9, 14–16). Unfortunately, there is no information from contemporary historical sources (3rd-1st century BCE) on breastfeeding and weaning practices in these Celtic populations, and descriptions are only available from writers of the Roman Imperial period (e.g. Soranus of Ephesos, Galen of Pergamum), who indicate a highly flexible weaning timetable. Recommendations by ancient medical sources were to start transitional feeding after the 6th month and to stop breastfeeding from 2 years of age, introducing cow or goat milk, diluted wine, honey, and porridge, among other weaning foods; however, there is likely to have been a wide variability in weaning practices according to local customs and family circumstances (Killgrove and Tykot, 2013; Prowse et al., 2008).

Bioarchaeological analyses of the diet in ancient Roman society have provided direct evidence on the timing of breastfeeding and weaning timing. Prowse et al. (2008) studied a skeletal Roman sample from Isola Sacra, Rome (1st–3rd century CE) and found that transitional feeding commenced by the end of the first year and weaning by the age of 2–2 1/2 years. In contrast, Fuller et al. (2006b) described a gradual and prolonged period of transitional feeding from around 2 years to 3–4 years of age in a Late Roman sample from Oxfordshire, England, dated from 4th to 6th century CE. Killgrove and Tykot (2013) published isotopic data on 12 non-adults from the Imperial Roman necropolis (1st–3rd AD) of St. Callixtus, Casal Bertone, and Castellaccio Europarco and observed that children aged 2–3 years old were still being nursed, although they were probably weaned shortly afterwards. Finally, in another sample from the Roman period in Dakhleh Oasis, Egypt, dated from 250 to 450 CE, isotopic evidence indicates the introduction of complementary foods early in life, at around 6 months of age, with the completion of weaning at around 3 years of age (Dupras et al., 2001, Dupras and Tocheri, 2007).

Given the lack of information on feeding practices among Celtic populations in Italy, we combined bioarchaeological and biochemical methods in order to investigate their feeding practices. The main objective of this study is to offer a reliable estimation of the age of different feeding transitions, by mostly detecting changes in stable $\delta^{15}N$ and $\delta^{13}C$ ratios in rib samples of a population of pre-Roman Celtic culture.

2. Archaeological and historical context

The construction of an underground garage in the main courtyard of the Bishop's Seminary at Verona (Italy) (Fig. 1a–b) between 2005 and 2010 led to the discovery of a large pre-Roman necropolis (3rd to 1st century BCE) of a Roman-influenced Celtic population (*Cenomani* Gauls). The Seminario Vescovile necropolis is located in the eastern Veronetta district of Verona between the left bank of the river Adige (Fig. 1b) and the first hills (Thompson and Bersani, Unpublished report).

During the pre-Roman period, *Cenomani* Gauls settled in an area corresponding to the current provinces of Brescia and Verona in Northeast Italy, as reported by ancient sources (e.g. Polybius, Titus Livius, Pliny the Elder etc.). The necropolis under study, although used by the local Celtic population, was already strongly influenced by some typical aspects of Roman culture, through trade and military alliances, as evidenced by a preliminary study of grave goods (see below). The historical context is characterized by a transition from the pre-Roman phase dominated by *Cenomani* Gauls and the advent of Roman domination, which was gradually established over the 1st century BCE (Late Republican times). The culmination of this long process of assimilation and integration by the Romans (“Romanisation”) was the foundation in the *Cenomani* Gauls territory of two Latin colonies, *Brixia* (now Brescia) and Verona in 89 BCE, and their subsequent acquisition of the status of *Municipium* in 49 BCE (Grassi, 1995, 2009; Malnati et al., 2004).

The necropolis contains 163 simple burial graves that yielded a minimum (MNI) of 174 skeletons: 108 non-adults and 66 adults. They are all in a good state of preservation. The burials are currently under archaeological study and all results have not yet been published. The necropolis was tentatively attributed to the 2nd century BCE, based on the type of funeral grave goods observed in a preliminary study of the metal materials (Cavalieri Manasse, 2014). Although previously considered to have functioned from the 2nd century BCE until the subsequent construction of a Roman craft workshop in the first half of the 1st century CE, absolute dating from bone collagen analysis in some skeletons indicate its utilization starting from the 3rd century BCE (Laffranchi, 2015; Laffranchi et al., 2015).

Individuals are laid out in supine position in single graves, whereas the typical funerary rituals in other pre-Roman/Celtic cemeteries include not only inhumations but also cremations, which were more