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31 May 2017

Version of attached file:

Published Version

Peer-review status of attached file:

Peer-reviewed

Citation for published item:

Mays, Simon and Gowland, Rebecca and Halcrow, Siân and Murphy, Eileen (2017) 'Child bioarchaeology : perspectives on the past 10 years.', *Childhood in the past.*, 10 (1). pp. 38-56.

Further information on publisher's website:

<https://doi.org/10.1080/17585716.2017.1301066>

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Childhood in the Past

An International Journal

ISSN: 1758-5716 (Print) 2040-8528 (Online) Journal homepage: <http://www.tandfonline.com/loi/ycip20>

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To cite this article: Simon Mays, Rebecca Gowland, Siân Halcrow & Eileen Murphy (2017): Child Bioarchaeology: Perspectives on the Past 10 Years, *Childhood in the Past*, DOI: [10.1080/17585716.2017.1301066](https://doi.org/10.1080/17585716.2017.1301066)

To link to this article: <http://dx.doi.org/10.1080/17585716.2017.1301066>



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Child Bioarchaeology: Perspectives on the Past 10 Years

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ABSTRACT

This article aims to provide an overview of some of the more important developments in the bioarchaeology of childhood over the past decade. Analysis of publication trends in the major osteoarchaeology and physical anthropology journals demonstrated a rise in research papers dealing with skeletal remains of children, with dietary and palaeopathological studies especially predominant. Innovations in these areas are discussed in more detail, together with some important developments in theoretical frameworks for using skeletal evidence to situate children in past societies. Among these latter is the life course approach, in which childhood is considered within the context of the trajectory of the entire life course. The integration of studies of child skeletal remains with those of adults helps to provide a more complete picture of communities in the past.


KEYWORDS

Bibliometry; life course; stable isotopes; palaeopathology; breastfeeding; physiological stress

Introduction

Until the 1990s children¹ had largely been excluded, or certainly marginalized, within human bioarchaeological discourse. Observations of children were primarily concerned with their under-representation at archaeological cemetery sites and likely high mortality rates in the past (e.g. Hassan 1981, 95–123). Two distinctive strands of research converged towards a more considered approach and a burgeoning interest in childhood within archaeology. Firstly, the historical strand led by Ariès (1962) much-cited study on medieval childhood resulted in a plethora of further publications (e.g. Shorter 1976; Stone 1977; Pollock 1983) which sought to explore the variable perceptions and treatment of children in the past. The second strand was inspired by gender and feminist discourse, influenced by sociologists, which sought initially to make 'invisible' demographics (e.g. women and children) at least a topic of discussion (Lillehammer 1989; Baker 1997; Kamp 2001). This research was also informed by the growing number of childhood studies within the disciplines of anthropology and sociology, which highlighted the socially constructed and hence culturally contingent nature of past identities. By the 1990s, the importance of

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 Supplemental data for this article can be accessed at doi:10.1080/17585716.2017.1301066.

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children as economically and socially vital and active agents, and the need to properly integrate experiences of childhood into archaeological narratives was established (e.g. papers in Crawford 1991, 1999; Scott 1992; Sofaer Derevenski 1994; Moore & Scott 1997).

The most direct way to 'access' children in the past is through their skeletal remains, and some milestone publications have recently appeared that have facilitated progress in this field. Scheuer and Black's (2000) volume, *Developmental Juvenile Osteology*, is a key reference work detailing the anatomy and development of the immature skeleton, and an abridged version and a revised edition have since been produced (Schaeffer, Black, and Scheuer 2004; Cunningham, Scheuer, and Black 2016). Baker, Dupras, and Tocheri (2005) published a field guide for the identification and recovery of infant and child remains on archaeological sites. To maximize the potential of skeletal evidence, however, it needs to be interpreted in relation to its specific archaeological and funerary context. Lewis' (2007) *The Bioarchaeology of Children* provided the first volume synthesizing this area specifically for child remains, and was a benchmark of the status of research in the field 10 years ago. Since that time, the archaeology of children, including their bioarchaeology, has made major advances, and it is now clearly recognized that the analysis of juvenile skeletons can be used effectively to address broader archaeological questions about past societies. Increasing numbers of regional biocultural studies have improved our understanding of the experiences of everyday life for children in different parts of the world across a variety of time periods (e.g. Lewis 2010; Penny-Mason and Gowland 2014; Halcrow and Ward 2017). Our aims in this paper are to assess, using bibliometric analysis, some publishing trends in child bioarchaeology over the past 10 years, and to outline what we consider to be some of the more important theoretical and analytical developments in the bioarchaeology of childhood over that same period.

Publication trends: the rise of the bioarchaeology of the child

The bibliometric study of publications was based upon papers appearing in seven major physical anthropology / osteoarchaeology journals. Articles from 2006 to 2015 were chosen to give an overview of trends over a period of 10 years (2015 was the latest completed year at time of writing). The journals selected were: *American Journal of Physical Anthropology*, *International Journal of Osteoarchaeology*, *Journal of Archaeological Science*, *Homo-Journal of Comparative Human Biology*, *Anthropological Science*, *Anthropologischer Anzeiger* and *International Journal of Paleopathology* (published from 2011 onwards). This part of the paper attempts to analyse secular trends in work on child remains, to investigate the locations in the world where such work is being conducted and by whom, and to identify the principal sub-disciplinary foci of the research. To these ends, articles were ascribed to country on the basis of the affiliation of the lead author. The gender of the lead author was also noted. A theme and subtheme of each article were identified according to what was judged to be the main focus of the paper. This methodology is as previously described (Mays 2010) but, in brief, the themes are: bone chemistry (i.e. biomolecular analyses), palaeodemography, normal skeletal variation and palaeopathology. For the current purposes, bone chemistry and palaeopathology were divided into further subthemes: DNA, elemental or isotopic analyses; and type of pathology studied (e.g. metabolic, infectious, trauma, etc.), respectively. In addition, papers were classified according to whether the main focus was on the study of adult remains, child remains, or an integrated study of both.

Some caveats should be borne in mind regarding the methodologies used here. The approach provides only a partial overview of human bioarchaeology as there are myriad other publishing venues for articles in this field besides the journals analyzed. Secondly, the picture obtained is one that is distorted by the editorial policies of the journals studied. Nevertheless, the work should provide some insight into practice. Papers published in academic journals cannot be considered independent entities for the purposes of statistical analysis. This means that the levels of statistical significance of patterning in the data may not be as great as suggested by standard inferential statistical tests.

A total of 1642 papers were analyzed. Overall, 1294 (79%) dealt with adult remains, 242 (15%) with child remains and 106 (6%) focussed on both. For the purposes of statistical analyses, these latter two categories were collapsed to give a measure of articles that are substantially based on the study of child remains ($N=348$). There was no link between the gender of the author and whether the paper concentrated on adult or child remains. Trends in publications over the 10-year period are shown in Figure 1. Kolmogorov-Smirnov tests suggest a trend towards more publications using child remains over the period considered, both in terms of raw numbers and as a proportion of the whole ($p < 0.0001$ and $p = 0.04$, respectively). The 1642 publications emanated from 51 countries and one territory. Ten countries were the source of >50 publications. Of these, the countries where papers substantially reliant on child skeletal remains constituted the greatest proportion of the whole were Portugal, France (both 33%), Britain (27%) and Germany (24%). The countries contributing the most papers substantially based on child remains were the United States ($N=90$) and UK ($N=69$). When split according to theme, the greatest numbers of studies substantially based on child remains were devoted to palaeopathology ($N=130$) or bone chemistry ($N=73$). In the latter category, the majority ($N=53$) comprised isotopic studies, of which 46 dealt with weaning/diet. In

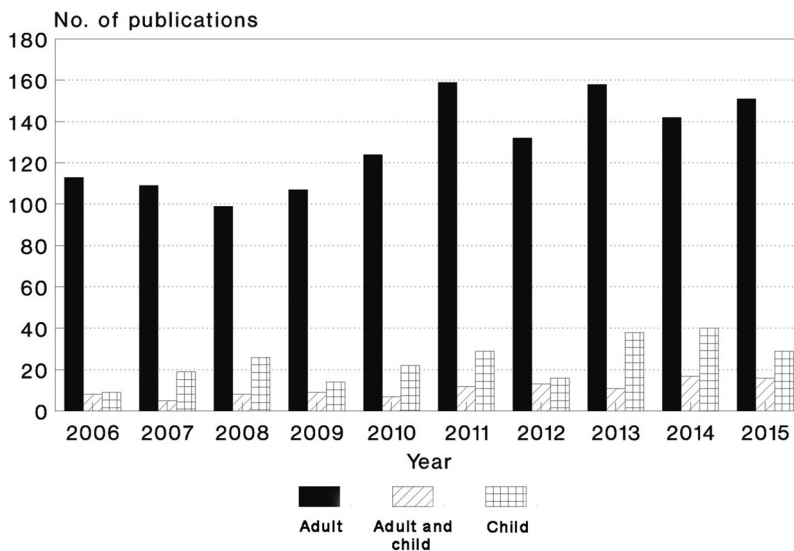


Figure 1. Publications in human bioarchaeology focused on adult and child remains, split by year of publication.

the field of palaeopathology, articles most often fell into the categories of non-specific stress ($N = 33$), metabolic disease ($N = 22$) or infectious disease ($N = 21$). These results are tabulated in the Supplemental Materials.

In summary, bibliometric analysis suggests that about one paper in five made substantial focus on child remains. This proportion is increasing, and is highest in some western European countries. Principal research foci are on biomolecular studies, particularly stable isotopes, and palaeopathology.

We now focus on the nature of innovation in the use of skeletal remains to study childhood in the past. In light of the results of the bibliometric analyses above, we concentrate particularly on the application of isotopic and other methods to study diet, and the use of palaeopathology to shed light on child health. However, we first consider aspects of the research orientation of the discipline: the last 10 years have seen important developments in conceptual frameworks for using skeletal evidence to situate children in past societies.

The social bioarchaeology of the child

Since the late 1960s in North America, and since approximately the 1980s in the UK, much bioarchaeological work has been conducted within a biocultural paradigm. The focus has been on hypothesis-driven work and population-level studies that emphasize the interaction between the social and natural environment and human health, mortality and various aspects of skeletal biology. This is illustrated for the bioarchaeology of childhood in early studies on growth (discussion in Humphrey 2000), demography (e.g. Molleson 1989) and palaeopathology (Lallo, Armelagos, and Mensforth 1977; Mensforth et al. 1978; Cook and Buikstra 1979). The biocultural approach continues to be the dominant model for understanding the past through human remains (Zuckerman and Armelagos 2011). Despite this approach's emphasis on human interaction with the sociocultural as well as the physical environment, until the last decade there has been a tendency for bioarchaeological research to operate largely divorced from developments within social theory. Disciplines such as sociology, which have traditionally eschewed the body as a physiological entity, started to turn their gaze towards the corporeality of human identity and social interactions (e.g. Shilling 1993). The body was reconceptualized as a dynamic mediator of social processes and 'embodiment' became a fresh topic of focus within archaeology (e.g. Joyce 2005). During the last 10 years there has been a growing dissatisfaction with the science/social theory divide within archaeology and an increasing shift towards a more theoretically informed 'social bioarchaeology'. Whilst this trend arguably began in the UK (e.g. Robb 2002; Gowland and Knüsel 2006; Sofaer 2006; Gowland and Thompson 2013), it has now become a more established paradigm within the United States (e.g. Knudson and Stojanowski 2008, 2009; Agarwal and Glencross 2011), exemplified by the numerous exciting publications emerging from the Springer book series *Bioarchaeology and Social Theory* (e.g. Osterholtz 2016). This approach more explicitly engages with theoretical understandings and constructions of the body and the impact that social as well as environmental processes have on flesh and bones. Some inspiring work over the last 10 years on childhood bioarchaeology has explicitly integrated social theory, together with historical and archaeological evidence to provide new insights into the effects of specific forms of

socially-induced stress on children (e.g. Murphy 2011, 2015; Penny-Mason and Gowland 2014; Geber 2016; Newman and Gowland 2016).

Within this approach, authors have also considered the interactions between the growing bodies of infants and children, and cultural understandings of the life course (e.g. Gowland 2001, 2006; Sofaer 2006; Halcrow and Tayles 2008; Newman and Gowland 2015; Agarwal 2016). The profound impact of cultural practices on the health and well-being of children is important to consider, but this must be integrated within an understanding of social age transitions and the interplay between age and other aspects of social identity (Gowland 2006). Childhood as a stage, or stages, of life should be contextualized within cultural understandings of the trajectory of the entire life course, from conception to death, rather than considered in isolation. A life course approach is now becoming prominent within archaeological studies and is considered less prescriptive than the 'life cycle approach', which tends to consider age as a more fixed, prescriptive series of life stages (Hunt 2005). A life course framework facilitates an understanding of the plurality of identity at any one age as well as the fluidity of identity (e.g. gender and status) over an individual's life-time (Hockey and James 2003). A bioarchaeological approach to the life course is exemplified by Mary Lewis and colleagues' recent work on medieval adolescence and puberty. This integrates different forms of evidence and situates the skeletal data firmly within an understanding of status and gender-related expectations of adolescence within the medieval life course (Shapland, Lewis, and Watts 2015; Lewis 2016).

A life course approach also recognizes the cumulative nature of individual biographies; in other words, it explicitly considers the way in which identities and experiences in early life may impact upon later stages (Hockey and Draper 2005, 43). This latter point is particularly important in relation to bioarchaeological studies of childhood because it relates well to the Developmental Origins of Health and Disease (DOHaD) hypothesis. This hypothesis developed from Barker and colleagues' epidemiological research since the 1980s, which established a link between early life adversity and chronic disease in later life (e.g. Barker and Osmond 1986; Barker et al. 2002; Barker 2012). Within this paradigm, the archaeological remains of infants and children are even more important because of the longer term consequences of poor maternal health or infant care for population health. Further work has also highlighted the inter-generational consequences of childhood adversity via epigenetic mechanisms (those that moderate gene expression) (Landecker and Panofsky 2013). Gowland (2015) argues that this has potentially profound implications for our view of individuals and life courses as discrete, bounded entities – it challenges even the point of conception as the start of an individual's biography. If social adversity affecting one's grandmother has biological consequences two generations later, then individual lives should be reconceptualized as entangled and, to borrow Strathern's (1988) term, 'partible' (Gowland 2015). A number of studies within palaeopathology have provided support for this hypothesis from archaeological contexts, noting correlations between indicators of health stress such as enamel hypoplasia and growth stunting, and reduced adult longevity (e.g. Armelagos et al. 2009; Watts 2011, 2013). Ultimately, in terms of the bioarchaeology of childhood in the past, the DOHaD hypothesis should at the very least, result in a deepening appreciation of the significance of the analysis of the remains of infants and children for understanding population well-being.

Diet in infants and children in the past

Infant and child dietary and weaning studies are important in bioarchaeology as they can inform us of subsistence change, infant feeding practices, food choice, and differential access to foods as a result of social factors (Stuart-Macadam and Dettwyler 1995; Lewis 2007; Larsen 2015). Childhood diet and the weaning process have important implications for early and later life health, mortality patterns and fertility in past societies (Stuart-Macadam and Dettwyler 1995; Lewis 2007; Halcrow and Tayles 2008). There is also a synergistic relationship between diet and infection, with poor diet making a person more susceptible to infection, and infection leading to poor nutrient absorption (Lewis 2007).

For over 20 years there has been a research focus in child bioarchaeology on weaning and diet using chemical (isotopic) analyses of bones and teeth (Jay 2009). As was demonstrated above, there has been a proliferation of studies in this area over the past decade (e.g. Fuller et al. 2006; Dupras and Tocheri 2007; Kinaston et al. 2009; Beaumont et al. 2013, 2015; Tsutaya and Yoneda 2013; Beaumont and Montgomery 2016). The analysis of carbon and nitrogen stable isotope ratios is now routinely used to evaluate breastmilk lipid and protein, respectively, and study of oxygen stable isotope ratios is occasionally used to evaluate breastmilk in the diet. Carbon and nitrogen isotopes are also used to investigate components of the supplementary weaning and childhood diet. Recently, bone phosphate oxygen isotope methods have been developed (Britton et al. 2015), which may complement multi-component isotopic studies. The traditional / standard sampling methods of bone of infants and children for the analyses of weaning produces a cross-sectional assessment of isotopic ratios of the non-survivors of the sample (e.g. Richards, Mays, and Fuller 2002; Fuller et al. 2006). Tsutaya and Yoneda (2013) have recently developed a quantitative method for the reconstruction of weaning profiles using Bayesian statistics and incorporating estimated bone turnover rates.

Developments in sampling techniques in archaeological isotopic studies are extending our knowledge of weaning and stress across the life course. Approaches of sampling different tissues that grow at different times and rates (e.g. Dupras and Tocheri 2007; Eerkens et al. 2014) and new incremental dental sampling methods (Eerkens, Berget, and Bartelink 2011; Beaumont et al. 2013) provide the opportunity to track dietary change across an individual's early development. These methods of incremental dentine sample preparation (Eerkens, Berget, and Bartelink 2011; Beaumont et al. 2013, 2015; Beaumont and Montgomery 2016) allow for the high-resolution temporal comparison of carbon and nitrogen stable isotope ratios from the gestational period through to childhood and are being rapidly adopted in studies of infant feeding and weaning (e.g. King et al. 2016). These exciting developments may allow us to compare isotope ratios between survivors and non-survivors, thus enabling further insights into the veracity of the osteological paradox (Wood et al. 1992; DeWitte and Stojanowski 2015). The application of incremental sampling methods (Figure 2) has also led to a reconsideration of how nitrogen stable isotope ratios are interpreted, suggesting that the variables affecting the isotopic relationship between mother and child are more complex than the traditional dietary weaning model posits, and that high nitrogen stable isotope ratios may also represent physiological stress (Beaumont et al. 2015; Beaumont and Montgomery 2016).

Other techniques are beginning to provide additional information on infant and childhood diets. Oral health of infants and children (e.g. Halcrow et al. 2013; Stránská,

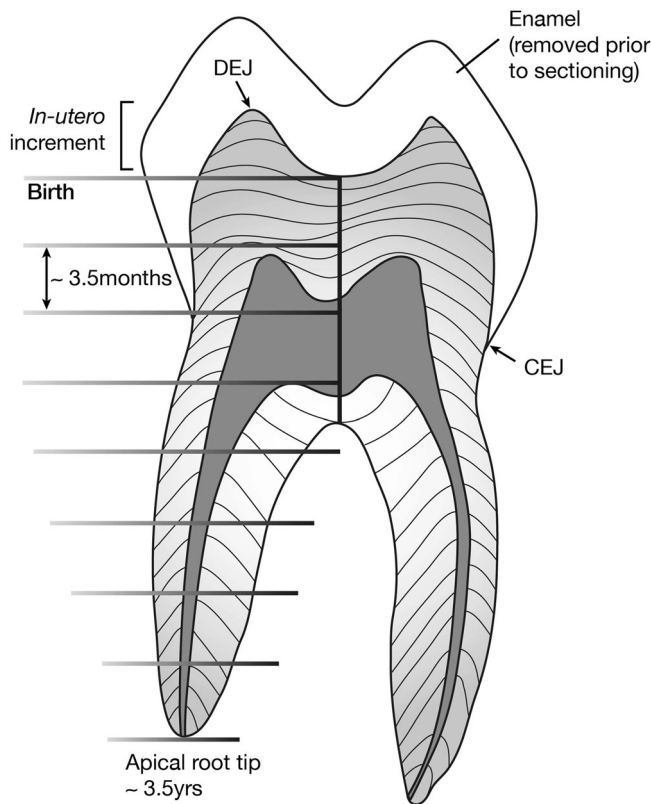


Figure 2. Incremental sampling techniques for dentine isotopic analysis across the development of the tooth (deciduous second molar). The time represented by each increment depends upon how many parts the tooth is divided into and can be calculated using Beaumont and Montgomery (2016).

Velemínský, and Poláček 2015), and dental wear patterns, including new macroscopic and microwear techniques (Mahoney et al. 2016; Mays 2016; Scott and Halcrow 2017) are starting to be used by bioarchaeologists to assess weaning food types and the timing of weaning. Although oral health is not necessarily a direct reflection of diet, it may be informative of infant feeding types (e.g. bottle feeding) and the cariogenicity of weaning food (e.g. Halcrow et al. 2013; Bonsall, Ogden, and Mays 2016). There is limited research on oral health of infants and children from archaeological samples, but the work that has been done highlights the usefulness of this endeavour. For example, Halcrow et al.'s (2013) analysis of caries in deciduous and permanent teeth of infants and children from prehistoric Southeast Asia indicates that the deciduous teeth are more sensitive to carious decay than the permanent dentition. Bonsall, Ogden, and Mays (2016) present a differential diagnosis of oral pathology in a 3–4-year-old child from a Late Roman site at Ancaster, England. They argue that the child had early childhood caries, or rampant caries, informative of the cariogenic nature of the infant diet.

Mays (2016) presents a method to estimate weaning in infants and children using macroscopic levels of wear in deciduous teeth from the English medieval site of Wharram Percy and compares these patterns with the isotopic weaning data from the site. The new application of microwear methods in infant deciduous teeth is a promising

sensitive indicator of weaning (Scott and Halcrow 2017). Mahoney et al. (2016) have published the first three-dimensional dental microwear texture analysis of human deciduous teeth from medieval Canterbury, England. Results show that weaning occurred earlier than previously documented, and that diet increased in toughness and hardness with age. Schmidt, Kwok, and Keenleyside's (2016) recent research on infant weaning and diet from a Greek colonial site from Bulgaria presents an interesting example of the integration of multiple lines of evidence including stable isotopes, deciduous oral pathology including caries, calculus, antemortem tooth loss, periapical infections and macroscopic tooth wear.

Many bioarchaeological studies of non-specific stress indicators such as dental enamel defects interpret their results within the context of a 'weaning stress' model, despite previous critiques based on the non-specific aetiologies of these indicators (Katzenberg, Herring, and Saunders 1996). It is also unlikely that physiological stress would be elevated around the complete cessation of the weaning process, which generally occurs gradually over a long time period. Pearson et al.'s (2010) research that assesses if there is a relationship between weaning and mortality at Early Neolithic sites in Anatolia makes the important distinction between the time of exclusive breastfeeding (EBF) and the total time of breastfeeding, on the basis that EBF is more useful for investigating impacts on fertility, morbidity, and mortality in past populations. The future investigation of stable isotope ratios using incremental sampling techniques in conjunction with careful reconstruction of stress events during tooth development using dental enamel defects may help to unravel the interaction between nutrition, stress, and mortality in past populations (Inglis and Halcrow, *forthcoming*).

The palaeopathology of childhood

Pathological juvenile bones (e.g. Figure 3) are generally represented to a lesser extent than their adult counterparts in classic palaeopathological textbooks, but a number of more recent papers have focused specifically on the pathological responses of immature bone (e.g. Lewis 2011). A combined palaeopathological and aDNA approach has been particularly fruitful for the investigation of infectious diseases, including leprosy, which can be difficult to definitively identify in children's skeletons (Rubini et al. 2014).

Childhood physiological stress – traditionally identified through an examination of conditions such as cribra orbitalia, porotic hyperostosis of the cranial vault, linear enamel hypoplasia (Figure 4) and stunted or delayed growth – has long been the focus of palaeopathological studies in past populations (Temple and Goodman 2014) and this has continued to be the case over the past 10 years. A provocative paper by Walker et al. (2009) somewhat reinvigorated such studies by challenging the well-established interpretation of cribra orbitalia and porotic hyperostosis as indicators of childhood iron deficiency. They posited that iron deficiency could not physiologically cause the lesions associated with marrow hyperplasia, although this assertion has been challenged by other researchers (Oxenham and Cavill 2010; Mays 2012). Further research has concluded that, while iron deficiency may not be responsible for the lesions, it is the end result and part of the body's defence mechanism against infection (Rothschild 2012; Steyn et al. 2016). Walker et al. (2009) also suggested that orbital and vault lesions may not necessarily be caused by precisely the same processes. In general terms, however, they proposed that they may have



Figure 3. Lesions characteristic of tuberculosis in SK 1155, an 8.5–10.5-year-old child, from Medieval Ballyhanna, Co. Donegal, Ireland. (a) Bone destruction and pitting on the neural arches of T2–8, with particularly pronounced lytic activity on T3. Note that T4 and T5 had formed a partial block vertebra which is a developmental defect. (b) Lytic activity and pitting on the auricular surface of the left ilium. (c) Periosteal new bone formation and lytic activity on fragments of right ribs. Note the destruction of the heads in three of the ribs. (d) Periosteal new bone formation on the anterior surface of the distal right humerus. (e) Extensive bone destruction of the inferior body surface of L5 (photographs by Jonathan Hession).

been caused by a number of factors, including poor diet, a lack of hygiene, infectious diseases, gastrointestinal parasitic infections, and cultural practices associated with weaning.

Cribra orbitalia and porotic hyperostosis remain reliable indicators of childhood physiological stress and recent studies have moved beyond the focus on poor health to use them as a means of gaining subtle information about other issues including migration. Gowland and Redfern (2010), for example, compared the prevalences of cribra orbitalia and enamel hypoplasia in individuals from Roman London with contemporary sites elsewhere in England and in Italy. They suggest that the high prevalence of cribra orbitalia in the Italian populations may have been due to malaria. They were struck by the similarity in

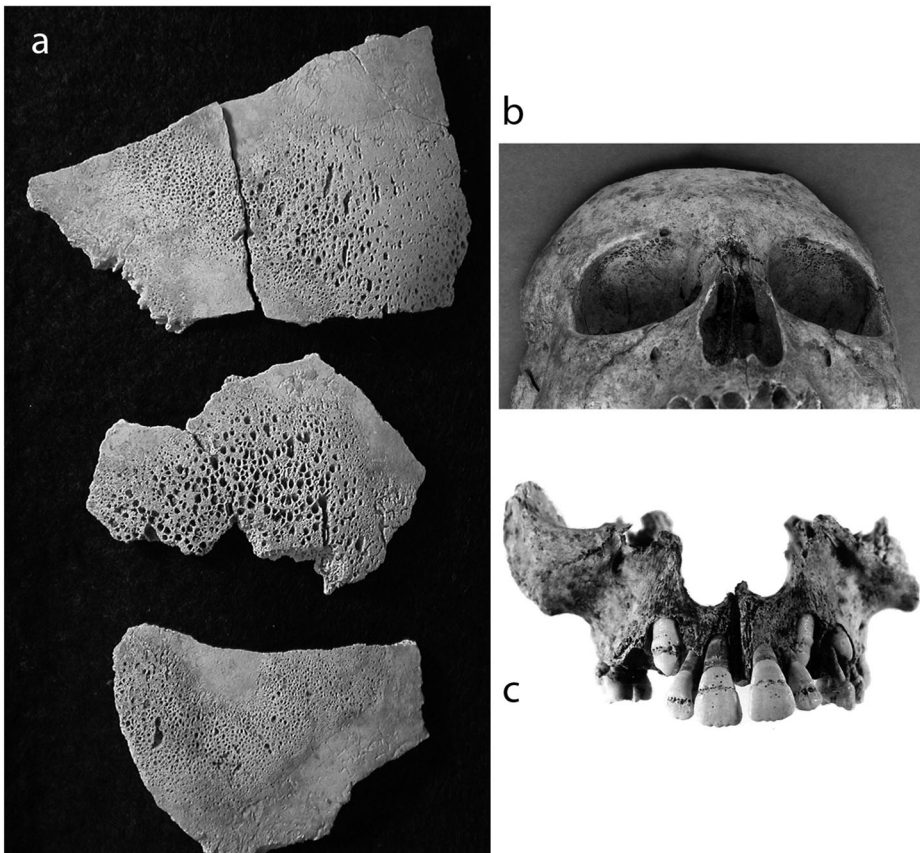


Figure 4. Examples of childhood physiological stress markers. (a) Porotic hyperostosis of the cranial vault in burial V10, a 6-month-old child from Medieval Wharram Percy, England (photographs by Simon Mays), (b) Cribra orbitalia in SK 225, a 7–10-year-old child, from Medieval Ballyhanna, Co. Donegal, Ireland (photograph by Jonathan Hession). (c) Linear dental enamel hypoplasia in the permanent dentition of SK 251, a 9–11-year-old Medieval child, from Armoy, Co. Antrim, N. Ireland (photograph by Tony Corey).

the lesion profiles for adults in London and the Italian sites, and hypothesized that London was anomalous in a British context as a result of the influx of a substantial migrant population who had spent their childhood in the Mediterranean. A lower prevalence of cribra orbitalia in the juvenile population was considered to be a reflection of the fact that they had lived and died in London.

Developments have also been made in the manner in which linear enamel hypoplasia can be used to understand the impact of physiological stress during childhood. Most studies that involve linear enamel hypoplasia examine the lesions as indicators of stress in relation to susceptibility to mortality. An innovative study by Temple (2014), took a life-course perspective on hunter-gatherers from the Late/Final Jomon period of Japan. This work introduced consideration of the plasticity/constraint and predictive adaptive response models to enable an exploration of the relationship between stressors in early life, future physiological stress and mortality. It postulated that in the predictive adaptive response model early stress effects would have a limited impact on age-at-death. The

converse would be true for the plasticity/constraint model. This would be characterized by a negative relationship between the age of formation of the first defect and the number and duration of the defects, together with a positive correlation between the age at which the first defect formed and age-at-death. The findings were consistent with the latter model, and it was concluded that stress in early life had a negative impact on an individual's ability to cope with future stress events (see discussion of DOHaD above).

A study by Robbins Schug and Goldman (2014) has also advanced the manner in which growth disruption can be used to assess levels of population stress. Measures of juvenile whole bone morphology were correlated against the geometry and histology of compact midshaft femoral bone for the purposes of comparing levels of physiological stress in Early Jowre (1400–1000 BC) and Later Jowre (1000–700 BC) populations from Inamgaon, India. The latter group is known to have lived in a period of environmental and socio-cultural stress and the results demonstrated that the children in this population had suffered from increased levels of skeletal emaciation, as demonstrated by a combination of short stature and low body mass index for age, a decreased bone mass and strength, and an increased volume of pores within the compact bone.

There have been advances in the study of vitamin deficiencies in children, particularly scurvy (vitamin C deficiency) and rickets (vitamin D deficiency), and methods have been established that enable the reliable identification of both conditions in child skeletons (Mays, Brickley, and Ives 2006; Brickley and Ives 2008). Studies have demonstrated differences in the affected age profile and severity of rickets in children living in urban and rural environments (Mays, Brickley, and Ives 2006). The broader age profile and less severe lesions in urban populations have been interpreted as a direct indication of the constant smoggy environment, whereas the somewhat unexpected severe lesions restricted to infants in rural environments are thought to have been due to familial efforts to care for already sickly children by keeping them indoors (Mays, Brickley, and Ives 2006; Murphy 2015). Recent research based on clinical advances has proposed a new interpretative model for assessing the impact of vitamin D deficiency in past populations. It considers its impact on the entire body and notes that it is often a risk factor for other conditions, including tuberculosis, certain cancers and cardiovascular disease (Snoddy, Buckley, and Halcrow 2016). Scurvy is increasingly being identified in past child populations from around the world (e.g. Brown and Ortner 2011; Klaus 2014). Mays (2014) undertook a timely review of the current level of palaeopathological knowledge about the disease which demonstrated how it is very much a disease of children unless the population has derived from a group living in conditions of extreme hardship, such as might be caused by famine or prolonged sea voyages. He warned that in the case of vitamin C deficiency it may not be correct to view the situation of children as an indicator of the status of the entire population and that rather it may have been related to child-specific diet and weaning practices. Interpretive issues remain to be resolved in relation to both vitamin D and vitamin C deficiency, but the level of knowledge is now at a stage where co-identification of rickets and scurvy can be made on the basis of skeletal lesions in a convincing manner, as evidenced by the research of Schattmann et al. (2016) on a sixteenth- to eighteenth-century AD population from France. The consideration of non-dietary aetiologies of scurvy is also becoming acknowledged (e.g. Buckley et al. 2014; Halcrow et al. 2014; Mays 2014).

A recent study by Newman and Gowland (2016) has demonstrated the value of examining multiple indicators in research of child stress and disease. They used a combination

of tibial diaphyseal length, appositional growth of the femoral diaphysis, vertebral neural canal size, rickets, scurvy, periosteal new bone formation and enamel hypoplasia, as a means of assessing the health status of four eighteenth- to nineteenth-century AD populations of a variety of socio-economic classes from London. Their findings indicated that children in the lower classes were under the greatest levels of physiological stress, but the upper classes were not immune to such stressors, probably as a result of trends in child rearing practices rather than poverty. A similar approach which used multiple indicators, this time Harris lines, linear enamel hypoplasia, growth disturbances and cribra orbitalia, was undertaken by Geber (2014) in his study of children who died in the Great Irish Famine of the nineteenth century. The signs of physiological stress evident in these juveniles would undoubtedly have been associated with malnutrition and infections related to the famine. He also notes, however, the importance of appreciating that the major psychological stress that young children, in particular, would have experienced because of institutionalization in the workhouse, could also have manifested itself physically.

While studies of childhood physiological stress have grown exponentially over the past decade, research on the evidence for trauma in child skeletons has progressed to a lesser extent, perhaps because of the difficulties of identifying certain types of injuries in the growing skeleton (see Lewis 2013). Fibiger (2014), however, has undertaken a major review of cranial trauma in children from Neolithic Germany in which she concludes that children were both actively involved in, and affected by, violent conflict. Interpretive models of childhood trauma have also been attempted. Gaither (2012) undertook a study of the levels of childhood trauma in a Peruvian population that spanned the periods before and after the Spanish conquest. Violence was sub-divided into three categories – ‘Violence associated with Extreme Cultural Conflict’, ‘Culturally Sanctioned Ritual Violence’ and ‘Likely Caregiver-Induced Violence’ and it was proposed the stresses of the conquest may have resulted in an increase in this last type. The results did not support the hypothesis, although cases of ‘Likely Caregiver-Induced Violence’ were identified. The use of such categories within bioarchaeological studies would seem to have the potential to facilitate more nuanced interpretations in relation to the significance of violence against juveniles in different cultural contexts. Indeed, a case of child abuse has been convincingly identified in a 2–3-year-old Romano-Christian period child from the Dakhleh Oasis, Egypt. An integrated approach, which included a macroscopic, radiographic and histological analysis of the traumatic injuries, in conjunction with analysis of stable carbon and nitrogen isotopes of the hair and bone, revealed evidence for concomitant metabolic disturbances and dietary change (Wheeler et al. 2013).

Conclusions

The past 10 years have seen increased focus on childhood and child remains in bioarchaeology in general, but with particular flourishing of isotopic and palaeopathological studies. The devising and adoption into bioarchaeology of major methodological innovations that we have described in these latter two areas illustrate the wider observation that, as a subfield, human bioarchaeology has been assiduous in developing new scientific methodologies and applying them to the study of past populations. Although most workers take a biocultural approach to understanding past populations, the discipline

as a whole has been slow to adopt theoretical innovations in the social sciences that would enable the benefits of this approach to be more fully realized. In the past decade this has begun to change, as exemplified for the bioarchaeology of childhood by the rise of studies taking a life course perspective. This illustrates the value of engaging with modern social theory, not only for providing fresh perspectives on childhood in the past, but also for using child remains to shed light on past lives as a whole.

There has been synergy between new theoretical orientations emphasizing life course perspectives, and methodological innovations in human bioarchaeology. Study of dental hard tissues, that do not remodel once formed, mean that adult as well as child skeletons can be used to investigate childhood in the past. Integrated approaches using adult and child remains help us to understand life-long implications of factors such as infant feeding practices, childhood diet and disease. They can also help us to tease out the effects of the osteological paradox on our data, for example, by permitting studies aimed at investigating the existence of dietary differences in the early years between those who died in childhood and those who survived to become adults. The value of integrating studies of adult and child remains has also been evident in the field of palaeopathology, where it has helped provide a more nuanced interpretation of vitamin deficiency disease than would have emerged had one or other sector of the population been analyzed in isolation. Children were active agents who contributed socially and economically to the functioning of past communities. Integrated bioarchaeological study of children and adults will contribute towards a more holistic view of societies in the past.

Note

1. In keeping with the scope of the journal, in this article we use the terms children, childhood, child, etc. in their broadest senses to refer to individuals aged from the foetal period up to approximately 18 years.

Acknowledgements

We are grateful to Charlotte King for her help in preparing Figure 2 and to Libby Mulqueeny, Archaeology and Palaeoecology, Queen's University Belfast, for preparing Figures 3 and 4.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

S. H. acknowledges the support of the Department of Archaeology at Durham University and was supported by a Durham Senior Research Fellowship cofunded with the European Union under [grant number 609412].

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