LUND UNIVERSITY

Dieta y Crecimiento Infantil Medieval en una Sociedad Rural del Norte de Europa

Iregren, Elisabeth; Alexandersen, Verner ; Jungner, Högne ; Isberg, Per-Erik

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Poblaciones Humanas, Genética, Ambiente y Alimentación

María del Pilar Montero López Consuelo Prado Martínez Paula Acevedo Cantero Margarita Carmenate Antonio del Valle Jesús Herrerín Juan Francisco Romero Collazos Kristin Keller Noemí López Ejeda Ana Isabel Mora Urda (Editores)

FACULTAD DE CIENCIAS

SOCIEDAD ESPAÑOLA DE ANTROPOLOGÍA FÍSICA
SEAF

Campus Internacional
excelencia UAM
CSIC+

Diet and Growth of Medieval Children in a Rural Society in Northern Europe

Dieta y Crecimiento Infantil Medieval en una Sociedad Rural del Norte de Europa

Elisabeth Iregren[1*], Verner Alexandersen[2] , H. Jungner [3], P-E. Isberg[4]

[1] Dept. of Archaeology and Ancient history, Lund University, Sweden [2] Lindevænget 25, DK-2750 Ballerup, Denmark [3] Dating Laboratory, University of Helsinki, Finland [4] Dept. of Statistics, School of Economics and Management, Lund University, Sweden

*Autor para correspondencia / Corresponding author: Dept. of Archaeology and Ancient history, Lund University, PO Box 92, SE-221 00 Lund, Sweden. elisabeth.iregren@ark.lu.se

ABSTRACT

Introduction: Scientists from many disciplines have studied population, church and burials from the Early Medieval churchyard Västerhus/Westerhus in Middle Sweden. Archaeology, anthropology, odontology and demography of this population have been investigated. The present project group has, above all, investigated teeth, bones and bone chemistry. But also many archaeological questions have been enlightened during the work.

Methods: In this contribution, we penetrate the diet of the children through investigations of the trace element Strontium and of Nitrogen isotopes, which have been used to map breast-feeding as well as diet during later child-hood.

Results: Most children have been wet-nursed up to the age of 1.5-2 years. From the age of about 5 years, the children consumed similar food as the adults. It seems as if most children, regardless of family relation, were breastfed by women

working at the manor. Bone elements from all body parts of the children have been measured meticulously. In this article we have focused on growth of the skeletal elements from the lower extremity. Teeth have also been measured and used for age determination. Occurrence of cribra orbitalia and enamel hypoplasia has, further, been registered.

Conclusions: We demonstrate how bone size of the leg related to age has been influenced by nutrition and disease as expressed by occurrence of cribra orbitalia.

Keywords: Medieval churchyard, children, diet, growth.

RESUMEN

Introducción: Científicos de diferentes disciplinas han estudiado la población medieval de la Baja Edad Media a partir de las tumbas y el cementerio de la iglesia de Västerhus/Westerhus (Suecia central). Utilizando estos restos se ha estudido la arqueología, antropología, odontología y demografía de esta población. En esta investigación se estudiaron sobre todo dientes, huesos y composición química de los mismos, pero también se elucidaron muchas cuestiones arqueológicas durante el trabajo.

Metodología: Para esta comunicación, se investigó sobre la alimentación infantil a través de elementos traza de Estroncio e isotopos de Nitrógeno, que fueron utilizados para describir los patrones de lactancia así como la alimentación en la niñez.

Resultados: La mayoría de los niños y niñas fueron amamantados hasta los 1.5- 2 años de edad. Desde los 5 años aproximadamente los niños tenían una alimentación similar a la de los adultos. Parece ser que la mayoría de los niños, eran amamantados por mujeres que trabajaban en el señorío, independientemente de la relación familiar. Se midieron meticulosamente los huesos de niños de todas las partes del cuerpo. En esta comunicación nos centraremos en elementos óseos de la extremidad inferior. Los dientes fueron medidos y utilizados para la determinación de la edad. Se registró también la presencia de cribra orbitalia y de hipoplasia del esmalte.

Conclusiones: Se observó relación entre la longitud del hueso de la pierna por edad y nutrition y enfermedad, mediante la presencia de cribra orbitalia.

Palabras clave: cementerio medieval, niños, alimentación, crecimiento.

INTRODUCTION

Västerhus population has, since its excavation and thorough anthropological study by Gejvall in 1960 awoken the interest of many

researchers. Gejvall, thus, published a startling publication on anthropology and archaeology. Further, Swärdstedt (1966) defended another important doctoral dissertation, on changes and illnesses of the dentition, in 1966. The children of the population have up till now not been studied in detail with the exception of age.

Our research project on medieval people resulted in publications (Alexandersen & Iregren 2000; Iregren et al., 2000; Iregren & Redin 2000; Redin, 2000) and in several articles in a concluding anthology on the Västerhus population and church (Iregren et al., 2009). One important goal was to establish the period of use of the churchyard. 14C-dating was applied to skeletons. The radiocarbon measurements gave a maximum time period of A.D.1029 until 1356.

Demographic calculations of the Västerhus population revealed that 23 individuals were living at the same time at this manor. Half were children. The expected life length at birth was 16.6 years for males and 17.6 years for females. When reaching 20 years, the expected length of life was 18 years, for both sexes (Siven, 2009). Two evident social strata have been identified, the owner family and the workers at the manor, some perhaps thralls (slaves). This partition is clearly visible in differences in stature, diet, sharp trauma, and diseases (leprosy etc.). It is often expressed in the position of the burial and by the presence of wooden coffins or not. We claim, that only the individuals owning, living and working at the manor were buried in the churchyard – not those living at close farms (Iregren et al., 2009).

MATERIAL AND METHODS

The Västerhus population, Jämtland County, Sweden was dug out in the 1950-ies. The number of excavated individuals is 371 and the churchyard is damaged to a very small part. The state of preservation of the skeletal material is excellent, as having been buried in a district rich in calcareous soils. One problem confronting us during the new analyses was that many children had been buried in mass-burials (cf. Iregren & Redin, 2000). Thus, it was sometimes difficult to separate bones from different individuals. The number of children's skeletons, including foetuses and adolescents below 18 years is 226.

Alexandersen and Iregren (2009) have pinpointed the ages of all young ones in Västerhus with great care. Regarding children 0-1 years, the methods by Liversidge (Liversidge et al., 1993; Liversidge, 1994) were applied. Older children were often aged by the methods published by Massler and co-authors (1941) or Johansson (1971, M3). On some occasions the publication by

Moorrees and co-authors (1963) has been used. Alexandersen was responsible for this work.

Iregren has measured bones of all body parts of the children according to the definitions suggested by Fazekas & Kosa (1978). Occurring enamel hypoplasia was registered in adults by Swärdstedt (1966), while Alexandersen studied children (Alexandersen & Iregren, 2000). Also occurrence of Cribra orbitalia was mapped (cf Alexandersen & Iregren, 2000).

Trace elements as Zink, Strontium and others have been analysed (cf. Iregren et al., 2000; Iregren et al., 2009). The individuals were randomly sampled within every age group. The bone surface was cleaned and a bone powder was bored out and homogenized. The element content of bones was measured by the PIXE method (Proton Induced X-ray Emission) using a Van der Graaf accelerator in the Department of Physics at the University of Helsinki, Finland. Regarding Strontium, the consumed diet was calculated from bone values according to the suggested corrections by Rivera and Harley (1965).

Also stable isotopes of Carbon and Nitrogen were investigated. The data used here were derived from an Elementary Particle Analyzer (Europe Scientific ANCA-SL, PDZ Europe Ltd, Norwich, Cheshire, UK), which was linked to an Isotope Ratio Mass Spectrometer (Europe Scientific 20-20 Europe Ltd, Norwich, Cheshire, UK) (see further Ohlsson & Wallmark, 1999; Iregren et al., 2009). Håkan Wallmark performed all the analyses in the Laboratory of Forest Ecology, Department of Ecology and Environmental Sciences, University of Umeå, Sweden.

As we have analysed bone instead of tooth dentine gives us reasons to be cautious, as the amount of e.g. Nitrogen isotopes are not equal in these human tissues. The difference might be >0.3 ‰ (Beaumont et al., 2015). The values of dentine, when samples are properly selected, also better identify consumption during shorter periods in an individual's life. We might have been mapping a little longer period of life. In this case bones were initially selected as they better fitted the technological equipment available. These considerations are kept in mind when details of the Nitrogen values are discussed.

RESULTS AND DISCUSSION

When finding out the time of weaning in a population several methods within bone chemistry measurements can be used, as increasing Strontium values as such as decreasing levels of $\delta^{15}N$. Also mathematical models might

help in the interpretations. For this purpose, the bone contents of Calcium, Strontium and Zink are taken in account here. Knowledge on weaning in a population gives an important understanding of the quality of nourishment provided for the children, the attention and care given to infants and their probable immunity to infections.

Weaning of babies

Strontium is often used as an indicator of the amount of plant food in the diet. It has, among other things, been applied to demonstrate when the change from breast milk to cereal products and vegetables occur. We know that the level of Strontium increases when porridge, gruel or mashed vegetables are introduced in a baby's food. Our measured values of Strontium in the bones are, further, recalculated to amount of Strontium in the diet (Figure 1).

From figure 1 it is clear that the weaning obviously often started at the age 1.5-2 years in Västerhus. But already from 1 year of age the variation between individuals increases and it seems plausible that some children already then were given complementary food. We consider mainly cereal products, vegetables, and cow or goat milk. This time of weaning coincides well with experiences from other medieval populations in Northern Europe, as in Germany (Grupe, 1986a; 1986b) and in Denmark (Becher, 1999).

Figure 1. Strontium/Calcium ratio in the diet of children in Västerhus medieval popu- lation in Sweden. The values are calculated from measurements on bones in accordan- ce to the methods by Rivera & Harley (1965). Ages in logarithmic scale. Ages from Alexandersen & Iregren, 2009.
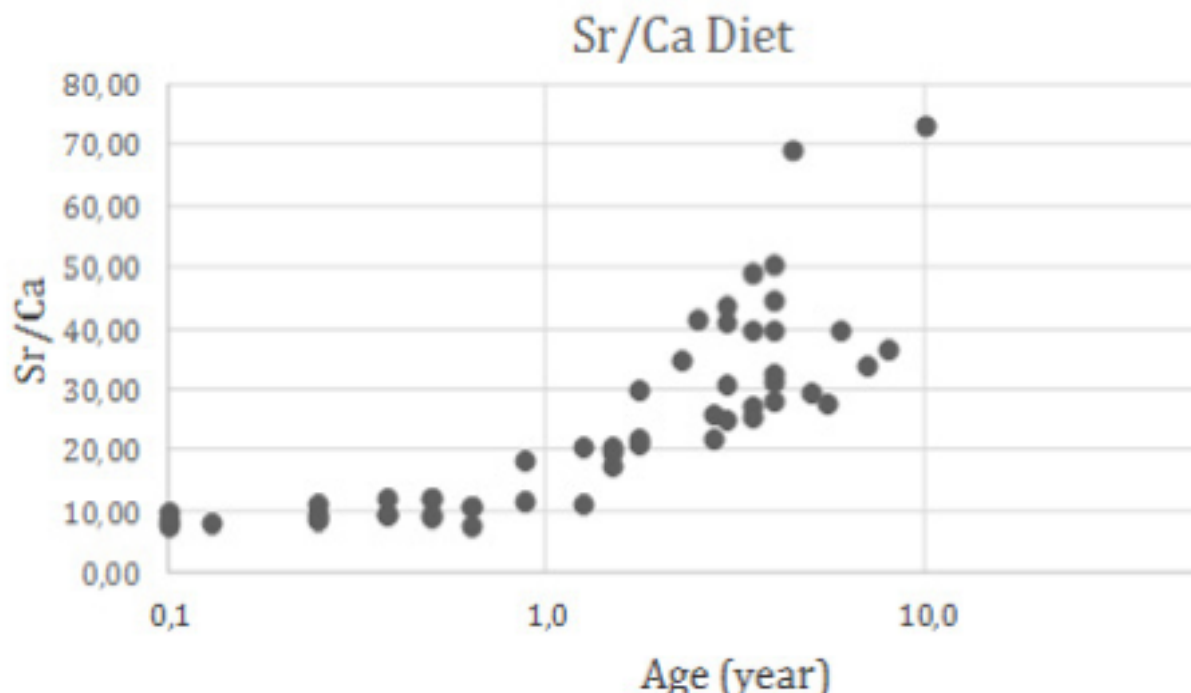
Mothers and babies

The trophic level of an individual's consumption is indicated by the value of delta [15]Nitrogen. The higher the value, the higher the position in the food web is the food. The increase from level to level in the food web is often found to be around 3‰. The difference between a breast-feeding mother and her child has recently been estimated to 2-4‰ (Fogel et al., 1989; Fuller et al., 2006 cited by Beaumont et al., 2012), when investigating living families.

In figure 2, exposing delta [15]Nitrogen data, we can see that the general variation between individuals in this rural population is relatively low. The variation in a medieval town is significantly higher, especially among women, as Kjellström et al. (2005) have shown for Sigtuna, Middle Sweden. So it seems as if the social inequalities are greater in an early town than in the countryside – even if the town was small and we have studied the inhabitants of a manor.

Figure 2. Individual values of delta 15 Nitrogen in children, women and men in the Västerhus population. Values in ‰. Note that the ages are shown in a logarithmic sca- le. Ages from Alexandersen & Iregren, 2009. Symbols: children open circles; women open rhombs; men open squares.

Further, it is evident from Figure 2 that the delta [15]Nitrogen values of children are generally low. Though, we can easily identify the time of weaning within this population of two social strata from the graph. It seems as if the majority of infants were breastfed up to the age of 1.5-2 years, thus confirming the results of our studies using Strontium readings. Swärdstedt (1966) who studied remaining enamel hypoplasia among adults stated that these were rarely found before this age, thus confirming good living conditions for many
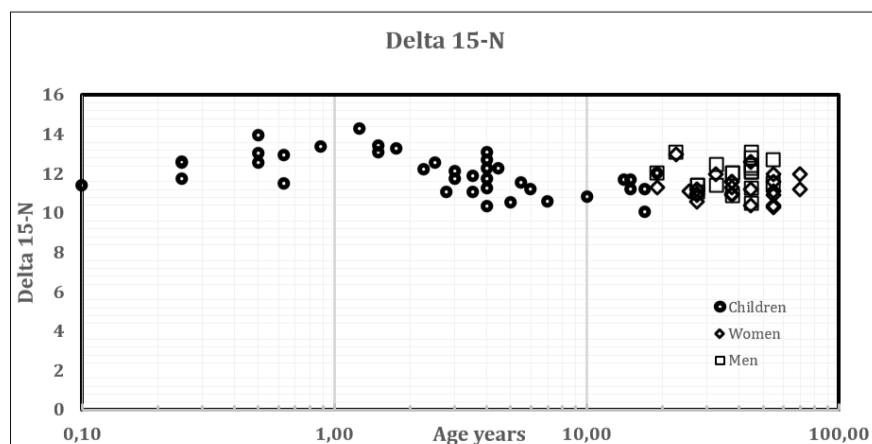
(surviving) small children. Several enamel hypoplasias occurred instead during the interval 2.5-4 years. Evidently, this was a difficult period even among those reaching adulthood. Later during infancy, the frequency decreases. We expect, though, that children between 2-5 years generally received cow or goat milk. Rickets has not been found in Västerhus (Alexandersen & Iregren, 2000). At the age of 5 the Zinc values suggest that the children were fed with similar food as the adults. The bone values of Strontium points to a diet of young individuals based on vegetables and cereals (Iregren et al., 2000).

The Nitrogen levels (Figure 2) also reveal that is questionable if all babies were breastfed initially, as there are very small differences between values of young children and fertile women. The mean δ^{15}N value of children (0-3 years) is 12.60‰ and the mean value of women, aged 18 – 50 years, 11.37‰. The lowest amount of delta ^{15}N in a woman is 10‰, inducing a value of 12-14 ‰ ca. in an infant breastfed by her. But some small children, though, demonstrate lower values than this. It is also clear from studies of living people that the mother and her baby do not always hold identical values at birth (Beaumont et al., 2015). Note, also, that not all women were investigated, but around one third of the females from 18 years and above (N = 27/80) – though selected by a statistical sampling procedure. Apparently, a few children were not breastfed at all or only to a minor extent. The female values, further, seem to indicate that the female labourers of the manor also were wet-nursing the babies of the owner's family. If this holds true, the social situation at the manor certainly led to an increase of the infant mortality. The mortality is unexpectedly high during the interval 3-6 months of age, which we interpret to be an effect of insufficient nutrition. The mortality of infants mounts 310.4 ‰ (Siven, 2009). In available Historical statistics for Sweden the corresponding figure was 213.3 for baby boys in the late 18th century. The hard working mothers might have been obliged to neglect their own infants due to the general load of work. However, women with a better diet may have given some infants human milk, but rarely. Though, we must remember that our analyses record infants that died, not the children that survived and reached adult age.

In an important article by Julia Beaumont and co-authors (2015) late populations (19th century) from England and Ireland as well as prehistoric ones were studied. They relate to new and relevant literature in their comprehensive methodological work, demonstrating a number of factors influencing the Nitrogen values of children and pregnant and lactating women. Many conditions, though, make the Nitrogen level to increase and in our study the "problem" is the small difference between children and mothers. Such factors in pregnant women can be e.g. nutritional stress; that may increase female delta ^{15}N value. It

is not likely that we deal with an increase of female values making the mother-child distance short. The opposite (lowered values), may also occur when e.g. sufficient dietary protein is available for the mother, an excretion of Nitrogen might then take place. It is not likely, however, that protein was redundant in this population where delta ^{15}N values of most individuals are relatively low compared to other populations. Beaumont and co-authors (2015) stress that unexpectedly high or low values of a perinatal infant might actually mirror an intra-uterine value.

In part the delta ^{15}N values of women and men in Västerhus overlap, but men were more often found at higher nutritional levels (cf. Iregren et al., 2009), thus consuming more food rich in animal protein. The mean value of males is 11.93‰ and of females 11.29‰. There exists a significant difference in the delta ^{15}N values between men and women in Västerhus. In fact, one tested pig bone shows the same delta ^{15}N value as the woman with the lowest value of the population. Further, it ought to be mentioned here that enamel hypoplasia developed during the prenatal face have been found in six children in Västerhus. This is a definite indication of bad health and nutrition in some pregnant mothers. This dental malformation has also been reported from medieval populations in Denmark and Scotland (Alexandersen & Iregren, 2000).

*Growth, body proportions and health*

Growth is a continuous process during childhood and adolescence but its runs at different pace during different periods. During the first year of life the increase is larger than during later years of the child's development. Further, during the years prior to puberty a rapid growth takes place at. Many bodily measurements reveal, thus, glimpses on nutritional and health status of young ones. However, growth takes at different pace in different skeletal elements and body parts. This makes it possible to explore when in children's lives growth retards or even ceases. Also, growth runs at a slower pace in the upper part of the body. It has, thus, been demonstrated that between birth and puberty the legs grow relatively faster than the upper body. Evidently, skeletal elements of the lower extremity map the growth and wellbeing of an individual up to puberty (Bogin et al., 2014).

Bogin and Baker (2012) studied total length, leg length and sitting height. Further, they calculated relative leg length (RLL), as tibia seems very sensitive to external influences. From about the age of 8 years, Bogin and Baker found RLL to demonstrate a stable relation to total length during further growth.

Knee-height has, though, often been used as a proxy for pre-pubertal growth. The growth of the tibia is, thus, the slowest relative to total body height (Bogin et al., 2014). Bad living conditions affect the tibia length more than the femur length. Over the last years, many studies have, also, demonstrated that short leg length has a bearing on many serious diseases in adulthood, as diabetes, coronary problems, stroke and some cancers. The risks of diseases enhance due to the circumstances that have led to shorter bone elements of the leg not the extremity length per se (Bogin & Baker, 2012).

Figure 3. Femur length divided by tibia length in the same individual. Further, cribra orbitalia has been registered in the children. Open circles indicate no sign of this change, but a filled circle marks that cribra orbitalia is present in the individual. An x denotes that information is missing. Regression lines have been calculated for chil- dren with ($r2 = 0.697$) and without changes in the orbits ($r2 = 0.631$). Ages from Alexandersen & Iregren, 2009.

In figure 3 the lengths of femur and tibia of children and adolescents in Västerhus are compared to their age respectively. Also included in the figure is occurrence of cribra orbitalia. (All individuals do not have a registration). Cribra orbitalia and similar porosities develop as consequences of anaemia. The cause of anaemia is debated, but it might be an effect of repeatedly occurring infections (Stuart-Macadam 1992). In the graph, we can see that
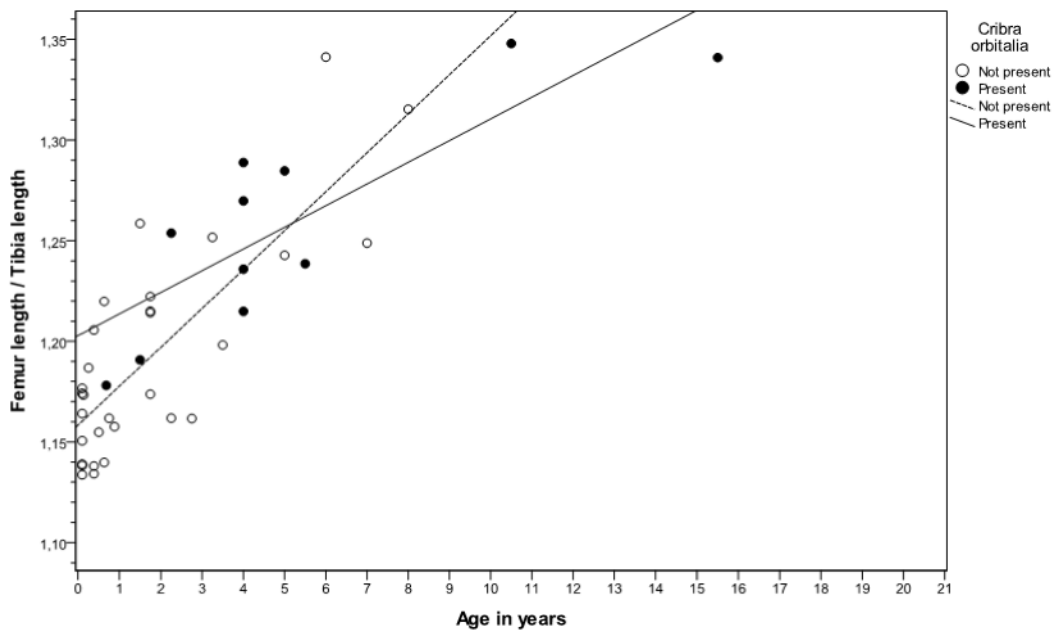
among the youngest children, the slowest growth of the tibia takes place amongst individuals with signs of cribra in the eye-sockets. Evidently, the children with these indications of illnesses have survived and thus been able to develop a cribra orbitalia. This cannot take place during acute, severe illnesses quickly followed by death. Later, during childhood, this pattern shifts and among children above app. 5 years without these signs of sickness the tibia apparently grows more slowly than the others. Both the level and the slope of the regression lines of these two groups of children are significantly different (with occurrence of cribra orbitalia: $r^2 = 0.697$; without: $r^2 = 0.631$).

Looking at only tibia lengths it is clear that the variation is at its highest between 4 – 8 years. Note, however, that there are fewer measurements of the older children, as mortality rate has decreased. It is implied in figure 3, that the ratio femur to tibia length is relatively fixed already from the age of six years.

Early in life, growth is influenced by many factors as infections, and physical and psychological stress. Further, amount of available nutrition and its quality is of utmost importance to health and proper growth of an individual. Of course, also the endogenous composition of the child is a factor to mention, although we cannot examine it here.

Other external factors, which might influence the leg length is e.g. shortage of Iodine (Bogin & Varela-Silva, 2010). This does not seem relevant to our population settling less than 200 km from the Atlantic coast of Norway. On the other hand, based on values of delta ^{13} Carbon, very few individuals of the population have consumed marine foods (Iregren et al., 2000).

In this case, we have, thus, used the quota of femur to tibia in children in Västerhus. It is almost equivalent to the RLL in living people. We investigated this proportion to understand growth as well as the health situation among the young members of this population. The adult height of the population is quite impressive but varies a lot, especially in women (Table 1). In fact, in spite of the social heterogeneity, the Västerhus males are among the tallest in Swedish medieval populations (Werdelin et al., 2000). Many young girls, with in general better survival than boys, might have been members of the families working at the manor. If so, also these families seem to have been residents of the manor for generations. Here we may add that the permanent teeth of the Västerhus population inhabit similar size as the present-day population in Scandinavia. However, the teeth of the deciduous dentition are significantly smaller than those of today's population.

Gejvall (1960) and Alexandersen and Iregren (2000) have investigated the frequency of cribra orbitalia in Västerhus. Among children aged 0 to 1 year the frequency was very low. Presumably, breastfeeding protected the babies

from anaemia. During the interval 1-7 years almost every third child had been through events leading to cribra orbitalia. Among children 7-14 years 40% had developed these changes in the eye-sockets. In spite of mortality the incidence rises by age in the population.

Table 1. Mean heights and ranges, femur length, and tibia length in the Västerhus medieval population (data from Gejvall, 1960). Bone measurements and height calculations according to Trotter and Gleser (1952).

Alexandersen, however, found among three children that tooth malformations had occurred immediately after birth indicating too little or the wrong type of food being given to these infants (Alexandersen & Iregren, 2000). The mineralization of these teeth was affected.

Further, Swärdstedt (1966) investigated enamel hypoplasia of adults. Thus, he could collect knowledge on childhood in individuals that survived until adolesence or longer. Trusting these data the most difficult time during childhood was the interval 2.5 – 4.5 years. However, when looking at the tibia lengths the cessation of growth in some children aged 4 – 8 years seem better to coincide with increasing occurrence of cribra orbitalia.

CONCLUSIONS

It is important to remember that all individuals made visible in the graphs died during childhood or adolescence. Beaumont and co-authors (2015) point to their results exhibiting a marked variation in nutrition over time in individuals who died before they reached adulthood. A further point of departure has Katzenberg and fellow authors (1993). They stress the problem of using children that died of unknown diseases that might influence the isotopic signals. However, we do not expect metabolic diseases, as we have found no signs of such illnesses. In this population, thus, the main causes of death have been interpreted to be acute infections in ear, throat and lungs (Gejvall, 1960). During later centuries, we have proves from historical records, that many deaths occurred just after birth due to tetanus. There are also evidences among living children that poorly fed individuals are more susceptible to

	Males	Females
Total body height cm	174 (164-185) N = 66	162 (144-171) N = 73
Femur length mm	469 (421-530) N = 61	424 (357-475) N = 71
Tibia length mm	372 (321-413) N = 57	339 (273-384) N = 72

bronchitis (Leitch, 1951), which certainly sometimes has been the case here. Further, an unusual large number of children in this population have been investigated regarding isotope and/or trace element contents (Trace elements N= 55; N-Isotopes N=39), which, though, give us a broad perspective on early life. In models, however, it is often hypothesized that dead infants of one age would be representative for all children of this particular age, which might be false.

From our studies, we can definitely claim that breast-feeding continued, for many children, up to the age of 1.5-2 years. This is clear from the analyses of Strontium, Zinc and the Nitrogen isotopes. This period of lactation ought to have given these children a good start of their lives, as breast milk is an excellent and hygienic source of nutrition. Early, also the infant is protected against infections through the antibodies of its mother/ wet-nurse that are passed over through the milk. However, some few children might not have been allowed to suckle at all but given less-appropriate food. This is interpreted as an effect of hard labour among the working women of the Västerhus population and/or the likely scenario that the female labourers also had to breastfeed the infants of the owner family.

It is most interesting to note that children below the age of 5 years with cribra orbitalia demonstrate a better growth than those without these changes in the eye-socket. The first ones mentioned have survived possible infections perhaps due to good care and a better nutritional status. The other children of similar ages might instead have died by acute, more serious infections. Above this age interval the situation is the opposite, which was expected.

Our investigations of growth, cribra orbitalia and enamel hypoplasia reveals that the period following weaning was difficult to many children. During the ages between 4 – 8 years it appears that growth shows a large variation and, thus, indicating severe living conditions for some children. Evidently, life of a child in Västerhus might comprise several difficulties that must be overcome by the individual to survive to adulthood.

ACKNOWLEDGEMENTS

REFERENCES

Alexandersen, V; Iregren, E. 2000. "Westerhus – Børnenes tænder" (Children's teeth). *Hikuin* 27: 203-218.

Alexandersen, V; Iregren, E. 2009. "Sociale, økonomiske og familiemæssigee strukturer på kirkegården Västerhus." (Social, economic and family structures at the churchyard Västerhus.) In *Kapell, kyrkogård och befolkning. (Chapell, churchyard and population)*, editado por Elisabeth Iregren, Verner Alexandersen y Lars Redin, 186-207. Stockholm: The Royal Swedish Academy of Letters, History and Antiquities.

Beaumont, J; Geber, J; Powers, N; Wilson, A; Lee-Thorp, J; Montgomery, J. 2012. "Victims and survivors: Stable isotopes used to identify migrants from the Great Irish Famine to 19th century London". *Am. J. Phys. Anthropol.* 150: 87-98. doi: 10.1002/ajpa.22179.

Beaumont, J; Montgomery, J; Buckberry, J; Jay M. 2015. "Infant mortality and isotopic complexity: New approaches to stress, maternal health, and weaning." *Am. J. Phys. Anthropol.* 157: 441-457. doi: 10.1002/ajpa.22736.

Becher, A. 1999. *Bone Chemistry in Danish Medieval Populations. A Study in Biological anthropology.* Master thesis. Odense: University of southern Denmark.

Bogin, B; Baker, J. 2012. "Low Birth Weight Does Not Predict the Ontogeny of Relative Leg Length of Infants and children: An allometric analysis of the NHANES III ample." *Am. J. Phys. Anthropol.* 148: 487-494.

Bogin, B; Harper, D; Merrell, J; Chowdhury, J; Heinrich, M; Garaj, V; Molik, B; Thompson, JL. 2014. "Influence of Adult Knee Height, Age at First Birth, Migration, and Current Age on Adult Physical Function of Bangladeshi Mothers and Daughters in the United Kingdom and Bangladesh." *Journal of Anthropology* ID 808634.

Bogin, B; Varela-Silva, MI. 2010. "Leg Length, body Proportion and Health: A Review with a Note on Beauty." *Int. J. Environ. Res. Public Health* 7: 1047-1075.

Fazekas, IG; Kosa, F. 1978. *Forensic Fetal Osteology.* Budapest: Akadémiai Kiadó.

Fuller, BT; Fuller, JL; Harris, DA; Hedges, REM. 2006. "Detection of breastfeeding and weaning in modern human infants with carbon and nitrogen stable isotope rations." *Am J Phys Anthropo*l 129(2): 279-93.

Gejvall, NG. 1960. *Westerhus*. *Medieval population and church in the light of skeletal remains*. Stockholm: The Royal Swedish Academy of Letters, History and Antiquities.

Grupe, G. 1986a. "Ernährungsgewohnheiten im Mittelalter. Rekonstruktion aus dem Elementenspektrum bodengelagerter Knochen". *Fortschritte der Medizin* 42: 801-804.

Grupe, G. 1986b. "Rekonstruktion bevölkerungsbiologischer Parameter aus dem Elementgehalt bodengelagerter Knochen" In *Innovative Trends in der prähistorichen Anthropologie*. Editado por Bernd Herrmann 39-44. Berlin.

Iregren, E; Jungner, H; Räisänen, J; Alexandersen, V. 2000. "Dieten hos barn och vuxna i Westerhus." (Diet in children and adults in Westerhus) *Hikuin* 27: 179-202.

Iregren, E; Redin, L. 2000. "Assemblages of children's bones in a Medieval churchyard in Sweden – Results of epidemics, warfare, infanticide or simply, disturbed graves?". En *Investigaciones en Biodiversidad Humana*, editado por Tito A. Varela, Sociedad de Antropología Biológica, 250-269. Santiago de Compostela.

Iregren, E; Alexandersen, V; Redin, L. 2009. (Editors) *Västerhus*. *Kapell, kyrkogård och befolkning*. (Chapell, churchyard and population). Stockholm: The Royal Swedish Academy of Letters, History and Antiquities.

Johanson, G. 1971. "Age determination from human teeth". *Odontologisk Revy* 22, suppl. 21. Lund.

Jonsson, K. 2009. "Practices for the Living and the Dead. Medieval and Post-Reformation Burials in Scandinavia." In *Stockholm Studies in Archaeology* 50. Stockholm: Stockholm University.

Katzenberg, MA; Saunders, SR; Fitzgerald, WR. 1993. "Age differences in stable carbon and nitrogen isotope ratios in a population in prehistoric

maize horticulturalists." *Am J Phys Anthropol* 90(3): 267-281.

Kjellström, A; Storå, J; Possnet, G. 2005. "Dietary Patterns and Social Structures in Medival Sigtuna, as reflected in Stable Isotope and Trace Element Values in Human Skeletal Remains." In Kjellström, Anna. Diss. The Urban Farmer. *Theses and Papers in Osteoarchaeology No. 2,* Stockholm: Stockholm University.

Leitch, I. 1951. "Growth and health." Cited by Bogin & Baker 2012.

Liversidge, HM. 1994. "Accuracy of Age Estimation from Developing Teeth of a Population of Known Age (0.5-4 years)." *International Journal of Osteoarchaeology* 4:37-45.

Liversidge, HM; Dean, MC; Molleson, TI. 1993; "Increasing human tooth length between birth and 5.4 years." *Am. J. Phys. Anthropol* 90: 307-313.

Massler, M; Schour, I; Poncher, GH. 1941. "Developmental Pattern of the Child as Reflected in the Calcification Pattern of the Teeth." *American Journal of Diseases of Children* 62: 36-67.

Moorrees, CFA.; Fanning, EA.; Hunt, EE. 1963. "Age variation of formation stages for ten permanent teeth." *Journal of Dental Research* 42: 1490- 1502.

Ohlsson, KE; Wallmark, H. 1999. "Novel calibration with corrections for drift and nonlinear response for continuous flow isotope ratio mass spectrometry applied to the determination of ∂15N, total nitrogen, ∂13C and total carbon in biological material." *Analyst* 124: 571-577.

Redin, L. 2000. "Arkeologiska perspektv på Westerhus ödekyrkogård på Frösön i Jämtland." (Archaeological perspectives on the abandoned churchyard of Weterhus, Frösö island in Jämtland County.) *Hikuin* 27: 155-178.

Rivera, J; Harley, JH. 1965. "The HASL bone program: 1961-1964." U.S. Atomic *Energy commission Health and Safety Lab* Report no. 163.

Siven, CH. 2009. "Västerhus – befolkning och samhälle". (Population and society). In *Kapell, kyrkogård och befolkning. (Chapell, churchyard and population),* editado por Elisabeth Iregren, Verner Alexandersen y Lars

Redin, 164-185. Stockholm: The Royal Swedish Academy of Letters, History and Antiquities.

Stuart-Macadam, P. 1992. *Anemia in Past Human Populations*. Edited by Stuart-Macadam, P. & Kent. S. Diet, Demography and Disease. New York: Aldine de Gruyter.

Swärdstedt, T. 1966. *Odontological aspects of a medieval population in the province of Jämtland/Mid-Sweden*. Stockholm: Diss.

Trotter, M; Gleser, G. 1952. "Estimation of Stature of Long Bones of American Whites and Negroes". *Am. J. Phys. Anthropol* 10 (4): 463-514.

Werdelin, L; Myrdal, J; Sten, S. 2000. "Patterns of stature variation in Medieval Sweden". *Hikuin* 27: 293-306.