Diet, Health and Agriculture

The Late Neolithic-Early Bronze Age Example of Abbekås, Southern Sweden

BY ANNA TORNBERG

Abstract

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Diet and health during the Late Neolithic and Early Bronze Age Scandinavia have never been under systematic study. Still, high statures have been reported from osteologists, statures that indicate good health. This article is based on a pilot study examining health changes in relation to dietary changes due to intensified agriculture and the possible Secondary Products Revolution as discussed by Sherratt in the early 1980s. Several different bioarchaeological methods for investigating health are applied to the Late Neolithic-Early Bronze Age graves of Abbekås, southernmost Sweden, showing several parameters connected to health and viewing tendencies of health changes possibly connected to an agricultural intensification.
Anna Tornberg, Department of Archaeology and Ancient History, Lund University, Box 117, 221 00 Lund, Sweden. Anna.Tornberg@ark.lu.se.

Introduction

Typology, burial customs and buildings have traditionally been used for examining and understanding the past. These parameters are intended to give insight into both past societies in larger terms and past populations on a smaller scale. The South Scandinavian Late Neolithic and Early Bronze Age (*c*. 2300–1100 BC) seems to have been a period of consolidation as regards social formations as well as subsistence, diverging from the Middle Neolithic cultural chaos. Despite this, the periods have seldom been subjected to extensive study, and have never been systematically examined with bioarchaeological methods to discuss diet and health. Analysing diet and health during the Late Neolithic and Early Bronze Age can give insight and further information about the population on a smaller scale as well as further contribute to the discussion of the society in larger respects.

The aim of this study was to use a wider spectrum of bioarchaeological methods to discuss health and shed light on a small body of material in connection with a wider archaeological discussion, giving a more nuanced picture of different aspects of health. The study was performed as a three months long pilot study regarding health at the Late Neolithic-Early Bronze Age burial site of Abbekås. The aim was to study skeletal changes connected to health, discussing this in relation to agrarian transformations during this period and the Secondary Products Revolution discussed by Sherratt (1981).

Diet, health and agricultural intensification

A history-changing event such as the replacement of subsistence base also, in some respects, changes the biology in humans. A shift from hunting and gathering to farming changes activity patterns, diet and living conditions, many of them traceable in the skeleton. Examples of this have been recorded from the Early Neolithic Linear Band Culture (LBK) area in Central Europe, where skeletal changes are clearly shown following the transition to agriculture (Meiklejohn *et al.* 1984; Wittwer-Backofen & Toma 2008; Meiklejohn & Babb 2011; Mummert *et al.* 2011). The shift to agriculture in Central Europe is considered to have been a rapid one, probably due to demic diffusion (e.g. Cavalli-Sforza 2002; Richards 2003; Bramanti *et al.* 2009). However, we do not see a dramatic change in the skeletal material in connection with this shift in Southern Scandinavia (Bennike 1985), possibly related to a more gradual adoption of farming instead of a rapid one (e.g. Richards 2003; Cramon-Taubadel & Pinhasi 2011; Isem & Fort 2012), perhaps also because of the sparse material and too little research on the subject.

Earlier focus on Neolithic health has mainly considered the Early Neolithic in the LBK and health changes in connection with the transition to agriculture. The investigations show a decline in health, regarding both stature and skeletal and dental evidence of malnutrition (Meiklejohn *et al.* 1984; Papathanasiou 2005; Larsen 2006; Wittwer-Backofen & Toma 2008; Meiklejohn & Babb 2011; Mummert *et al.* 2011). We cannot see this decline in Southern Scandinavia (Bennike 1985), but neither can we see any notable changes at all following the transition to agriculture.

Something seems to happen in the Late Neolithic, however, regarding both the bioarchaeological and the archaeological record. Earlier studies, both published and unpublished, tell of high statures during this period (Brøste 1956; Gejvall 1963; Bennike 1985), strongly correlated to good health. There are also tendencies in an ongoing study by the author, that the frequency of dental caries increases during the Late Neolithic. There might be many reasons for these shifts in human biology, but it is possible that one factor is the new technological innovations and new ideas, leading to the possibility to live a fully sedentary life with an agricultural subsistence more resembling modern versions. These technological innovations are a part of the Secondary Products Revolution (Sherratt 1981). Although debated (e.g. Chapman 1982; Greenfield 2010; Marciniak 2011), the theory posits that at the beginning of agriculture, only the carcass products were utilized (meat), while technical innovations and knowledge about secondary products (e.g. milk and traction) led to the ability to intensify and diversify agriculture as subsistence base during the Chalcolithic, i.e. the Secondary Products Revolution, probably spanning from the 4th millennium BC in the Near East to the beginning of the 3rd millennium in Central Europe (Sherratt 1981). This intensification resulted in a more reliable and diversified nutritional outcome within agricultural subsistence, according to Sherratt.

The task of this paper is to investigate the issue of Late Neolithic-Early Bronze Age health further, giving examples from the burial site of Abbekås, southernmost Sweden. What was the diet and health status of the population of Abbekås, and is it possible to detect diet and health changes in the material that can be put in relation to intensified agricultural subsistence and the Secondary Products Revolution?

Bioarchaeological approaches to diet and health

Diet and health can be analysed and studied by a number of different bioarchaeological methods. This paper aims to investigate diet and health in relation to an agricultural intensification, and therefore four different methods for examining health have been used: dental health, nutritional deficiency, stature and trauma. Age at death is also briefly used to discuss health in the population.

Dental health should be seen as a method for studying both diet and health in a skeletal assemblage. Dental caries reflects both the intake of cariogenic food (i.e. carbohydrates) and the well-being of the individual, since caries can be very painful and also lead to secondary complications, at worst blood poisoning. The study of dental caries and dental health as a whole can therefore give insight into the amount of carbohydrates in the diet, crucial for discussing a rise in the consumption of agricultural products. Dental caries was studied under a bright light and only cavities seen with the naked eye were recorded. Initial caries without cavities has not been recorded since it can easily be undetected and does not affect the individual's well-being. Dental caries mostly affects the molars and premolars and more rarely the incisors and the canines. It is therefore important to be specific as to whether all teeth are studied or only the post-canine teeth, since the frequencies can differ quite a lot between the two modes of study. In this paper the given values are for post-canine teeth unless otherwise stated.

As agriculture intensifies, more nutrition can be extracted from farming. Intensification should result in a higher proportion of domestic products in the diet and a more reliable subsistence base. This would in turn give lower frequencies of nutritional deficiencies. The two most frequently documented skeletal changes depending on nutritional deficiency are *cribra orbitalia*, porosity in the vault of the eye socket probably due to iron deficiency anaemia, and linear enamel hypoplasia, discussed as enamel growth defects without specific aetiology, except for poor nutritional intake or sickness during childhood (Waldron 2009, pp. 136 f., 243 ff.). Both of them have been recorded in the Abbekås material.

One of the most commonly used parameters for discussing health is stature. Human stature is affected by several biological factors, 80% of which are considered to be genetic and 20% environmental (Philips & Metheny 1990; Carmichael & McGue 1995), mainly shown to correlate with nutritional status and disease history (Silventoinen *et al.* 2000; Carson 2011a; Carson 2011b). Human stature has fluctuated through history, with the fastest and largest increase in the 20th century, reaching its peak in the present day (Arcini 2003, pp. 56 f.; Statistiska Centralbyrån 2013). However, there have been times in history – the South Scandinavian Late Neolithic and Early Roman Iron Age – when humans reached almost the same high statures as today (Arcini 2003, pp. 56 f.).

Because 80% of human stature is considered genetic and thereby not possible to alter, it is of great importance to see to stature in a wider perspective, integrating large populations and including the average stature instead of individual stature in the analysis. In doing so, human stature is a good health indicator that quickly adapts to nutritional and disease relations, so that changes in a population can be seen in times of only a generation (Silventoinen *et al.* 2000; Heijmans *et al.* 2008).

Stature in past human populations is calculated from the measurements of long bones, preferably the femur. In the Abbekås material the femur's maximum length was measured and used to calculate stature. The statures given in this paper are based on both

Torsten Sjøvold's formulae (1990) and Trotter and Gleser's formulae for whites (1952; 1958). I consider Sjøvold's model more accurate, but because of the widespread usage of the Trotter and Gleser model, both are displayed here for the sake of comparison. To avoid measuring the same individual more than once, femurs that were measurable, but could not without doubt be attributed to a specific individual, were excluded.

Finally, the frequency of trauma is not in direct correlation to diet and health in past populations, but it gives an insight into both the presence of conflict that could explain other health conditions and the possibility for the individual to heal. If the individual is given the opportunity to heal from an injury, there probably was someone to care for that person and the injured individual had strength enough to heal. It is often very hard to decide whether an injury was accidental or the effect of violence, so there is always a need for interpretation. Injuries commonly connected and often studied in relation to violence are skull traumas and parrying fractures in the lower arms (Larsen 1997, pp. 119 f.).

The osteological paradox

Even though all of the methods stated above are good and generally accepted for discussing human health, there are problems connected to this kind of approach, known to bioarchaeologists as the *osteological paradox*. As discussed by Wood *et al*. (1992), the osteological paradox means that morbidity in human remains does not necessarily entail poor general health. Skeletal changes are not instant but take time to develop. Humans with skeletal pathological changes therefore had good enough general health to survive long enough for the pathological changes to occur. If the pathological change is healed, the person must have had even better general health. The persons that died, but did not show signs of skeletal pathological changes, might therefore in fact have a lower health status than the ones that did express them. Studies of nutritional stress and other pathological conditions are most relevant in discussions about health in populations and should be an integral part of a bioarchaeological approach to health in past populations, but caution and insight into the osteological paradox is necessary for the interpretations not to be severely biased. The osteological paradox affects most bioarchaeological approaches to health, and palaeopathology as a health indicator is therefore best applied in relation to other health-indicating methods, for example demography and stature, to broaden and nuance the results. The osteological paradox is a problem of source criticism not easily avoided and must therefore be accepted as a possible risk of bias in any bioarchaeological record.

The Abbekås material

Abbekås is a small fishing village in Skivarp parish, Skurup municipality in southernmost Sweden. During the years 1921–1923 the Swedish archaeologist Folke Hansen excavated three burial mounds in the area. The first mound (Lund University Historical Museum, LUHM 20797) and the second mound (LUHM 20918) contained inhumation graves underneath and in the mound, dating from both the Late Neolithic and the Early Bronze Age. The third mound (LUHM 20919) contained both inhumation and cremation graves, all dated to the Bronze Age. The skeletal remains in the inhumation graves in mound three were so badly preserved that they could not give insight into questions of diet or health and they were therefore excluded from this osteological analysis.

In total 15 graves (1, 4, 6, 8, 9, 10, 11, 13, 14, 15 in mound one and 2, 3, 5, 7, 10 in mound two) consisting of 18 individuals in mound one and mound two were analysed.

Unfortunately, several graves that were documented in the field had to be excluded from the osteological analysis for various reasons. Grave 7 in mound one was excluded since it proved to be commingled with other skeletal remains from an unknown locality post-excavation. There are also a number of graves from both mounds that could not be found in the museum storage and it is possible that some of these graves are commingled with grave 7 in mound one. Besides flat earth burials underneath and in the mound, mound one also contained a Late Neolithic gallery grave. The skeletal remains from the gallery grave unfortunately had to be excluded due to poor bone condition and documented disturbance of the grave in the early 20th century.

Diet and health in the Late Neolithic and Early Bronze Age: the Abbekås example

All skeletons in the Abbekås material were assessed as to age and sex when possible, following the standards of Buikstra and Ubelaker (1994). Studies of age differences of the sacro-iliac joint were also supplemented with Buckberry and Chamberlain's model (2002).

^{14}C dates show that a majority of the dated individuals are from the Late Neolithic, but the youngest date, the individual in grave 6, is as recent as the Late Bronze Age (Table I). The identified individuals are outnumbered by males, but individuals from all ages are present in the material (Fig. 1). It is possible that some of the individuals not suitable for sex determination are in fact female. It is very difficult to discuss health and survival from such a small sample, especially given that the bones were deposited over a longer time span, and therefore I will not examine these aspects further here. However, the distribution is largely what is to be expected from this period, with quite a large number of children and the highest age-at-death values in the older age groups, correlating quite well with Danish data (Bennike 1985, p. 39).

Dental health

Agricultural intensification is not exclusively beneficial. The risk of dental caries and by extension periapical abscesses and premature tooth loss increases with a higher intake of carbohydrates, e.g. cereals. There is no substantial increase of dental caries from the Mesolithic to the Middle Neolithic in southern Scandinavia, indicating that no considerably higher amount of cariogenic foods was ingested. Data from Swedish Middle Neolithic farmers suggest a frequency of dental caries of 2–3% in relation to 0–1% in Danish and Swedish Late Mesolithic skeletal assemblages (Ahlström 2003, p. 49). In my ongoing study of health in the Late Neolithic and Early Bronze Age, I recognize tendencies that the frequency of dental caries in the Scanian skeletal assemblages is clearly higher than the Middle Neolithic Swedish data, indicating an increase in cariogenic foods, possibly linked to an agricultural intensification.

The frequency of dental caries seems relatively low in the Abbekås material in relation to other Swedish Late Neolithic skeletal material under study. The investigation of Abbekås resulted in a caries frequency of 6.9% in post canine teeth, which is substantially higher than the Swedish Middle Neolithic data (Ahlström 2003, p. 49). It should yet again be stressed that only cavities visible to the naked eye have been recorded, leaving out early caries attacks that do not have any substantial negative effect on the living individual. The caries lesions in Abbekås have mainly been registered as interproximal caries in mature individuals, showing that age is relevant for the accumulation of caries. It can also be seen that the caries cavities are connected to the presence of periapical

Grave no.	Lab. no.	^{14}C-age (BP)
1	LuS 10618	3700 +/-50
4:1	LuS 10619	3600 +/- 50
4:2	LuS 10620	3585 +/- 50
6	UB_22839	2645 +/-34
11	UB_22836	3197 +/-21
14	UB_22835	3144 +/- 49
15	UB_22838	3111 +/-35

Table I. ^{14}C dates (uncalibrated, BP) from mound one (LUHM 20797).

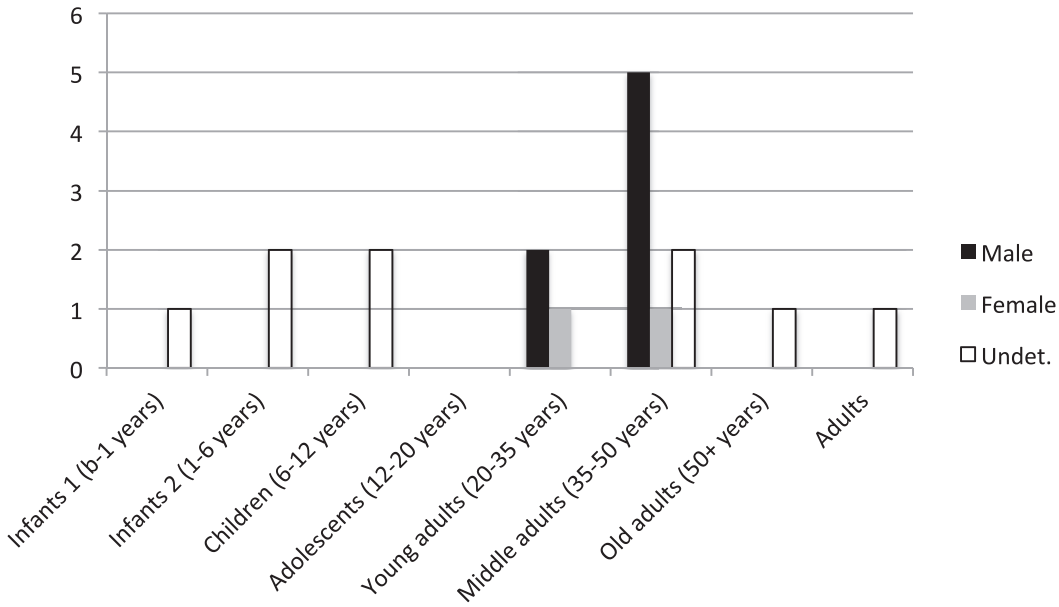

Fig. 1. Sex and age at death of the individuals from Abbekås.

abscesses, i.e. an infection in the pulp resulting in cavities for pus drainage. However, caution must be exercised given to the fact that there are other reasons for bacteria to enter the pulp chamber than caries, e.g. trauma and severe attrition. Periapical abscesses are detected in association with three post-canine teeth, two of which also suffer from dental caries.

Nutritional deficiency

Earlier publications of nutritional deficiency in South Scandinavian Neolithic-Bronze Age skeletal assemblages are sparse and new research on the subject is much needed. Bennike (1985, p. 210) states that in the Danish material cribra orbitalia is found in approximately 50% of the children and 10–20% in adults. It seems quite static over all prehistoric periods, including the event of Neolithiza-

tion, differing from examples of a rise in both cribra orbitalia and linear enamel hypoplasias with the transition to agriculture in central Europe (Meiklejohn *et al*. 1984; Papathanasiou 2005; Larsen 2006; Wittwer-Backofen & Toma 2008; Meiklejohn & Babb 2011; Mummert *et al*. 2011). The frequency of both cribra orbitalia and enamel hypoplasias in Abbekås is fairly low, only one adult female with healed cribra orbitalia and two adult or mature individuals with enamel hypoplasias. This is a frequency of 7.7% for cribra orbitalia and 15.4% for enamel hypoplasias for adults. None of the children was recorded with either cribra orbitalia or enamel hypoplasias. The values from Abbekås are about the same or slightly below Bennike's reported frequencies for adults in Denmark and markedly below those for children.

Considering the relatively high number of children in the Abbekås material (five out of 18 individuals), it is noteworthy that none of them expressed signs of active or healed cribra orbitalia. It should be stressed that the material for Abbekås is quite small, but it does correlate well with other Late Neolithic assemblages in Scania that are presently under study. It is also notable that all the individuals that were affected by nutritional stress during childhood survived into adulthood or even beyond, even if one must take the osteological paradox into consideration, given that it is possible that the children in the Abbekås material died before expressing skeletal changes.

Stature

As stated above, stature is a good parameter with which to study health in past populations. The problem with assessing stature is that one needs complete bones, preferably femur, for calculations. This means that the skeletal assemblage needs to be extremely well preserved, something that is rare in very old materials. In Abbekås only four femurs from four different individuals could be measured for stature calculation. All of the individuals come from grave 4 in mound one and are dated to the Late Neolithic, both typologically and by ^{14}C dates on two of the individuals (LuS 10619 & LuS 10620). One of the individuals in the Abbekås material could not be calculated through Trotter and Gleser's model since the sex could not be determined (Table II).

Even though the calculated statures are few, they correlate well with statures from the Late Neolithic in Denmark (Bennike 1985). Bennike (1985, p. 51), using Trotter and Gleser's formulae for femur, reports mean statures in the Late Neolithic as 176.2 cm for males and 162.8 cm for females. The results are based on 50 male and 16 female skeletons from Denmark. This may be compared to her results from the Mesolithic-Middle Neolithic, which are considerably lower (by 10–15 cm for males and about 10 cm for females). However, the number of individuals constituting the data is low, so that the results should be considered with some caution. Bennike's data for the Bronze Age in comparison to the Late

Femur (max, mm.)	Stature (Sjøvold 1990)	Stature (Trotter & Gleser 1952; 1958)	Sex
440	165,1	162,8	F
486	177,6	178,3	M
474	174,3	175,5	M
458	170	-	?

Table II. Calculations of statures from Abbekås, both male and female.

Time period	Bennike 1985 (Denmark) Male	Gejvall 1963 (Dragby, Sweden) Male	Tornberg 2013 (Abbekås, Sweden) Male	Bennike 1985 (Denmark) Female	Gejvall 1963 (Dragby, Sweden) Female	Tornberg 2013 (Abbekås, Sweden) Female
MN	169,3	-	-	149,7	-	-
LN	176,2	181,4	176,9	162,8	169,0	162,8
BA	172	-	-	163,7	-	-
ERIA	174,3	-	-	162,3	-	-
LRIA	177,4	-	-	162,3	-	-
IA	174,8	-	-	159,6	-	-

Table III. Mean statures (cm) in Southern Scandinavia in comparison to the Abbekås material (Gejvall 1963; Bennike 1985, p. 51; Tornberg 2013, author's results).

Neolithic show a lower stature for males (172 cm) and about the same stature or somewhat higher for females. The Late Roman Iron Age shows statures similar to the Late Neolithic, for both males and females, while stature for both males and females is lower during the rest of the Iron Age and the Middle Ages (Table III).

The Swedish data are limited. Some data on Middle Neolithic foragers are available, but are not relevant as comparison in this study (Sjøvold 1974). Gejvall (1963) analysed a Late Neolithic gallery grave from Dragby, central Sweden. The number of individuals is relatively small (8 males and 13 females), but the reported mean stature is very high, 181.4 cm for males and 169.0 for females. One must however take into consideration that Gejvall also used other long bones than femur for his estimations, giving somewhat skewed data. Modern (2010/2011) mean stature in Sweden is 179.4 cm for males and 165.7 cm for females (Statistiska Centralbyrån 2013), making the statures in Dragby at least equally high for males and higher for females. The stature seems improbably high, although based on a small number of individuals. The skeletons from Dragby will therefore be re-examined by the author, re-evaluating the results through modern methods.

The measurements from Abbekås show high statures among both males and females, 176.9 cm and 162.8 cm respectively. It is clearly evident that the statures are significantly higher than the Middle Neolithic data from Denmark reported by Bennike (1985), and do suggest more beneficial living conditions and better health in the Abbekås assemblage.

Trauma

Recent studies have been made showing a prevalence of skull trauma of 16.9% and 9.4% in Neolithic Denmark and Sweden respectively. The examined material was mainly recovered from Middle Neolithic collective graves (90%) but a smaller number of individuals also came from Middle–Late Neolithic single burials and stone cists (Fibiger *et al.* 2013). The study also shows a somewhat higher degree of interpersonal violence among men than women.

The presence of skull trauma in Abbekås is 16.7%. However, considering it is only a small sample, the number of affected individuals is only three. Two out of the three individuals are male or probably male while the third individual has not been suitable for sex determination. It is interesting that all three

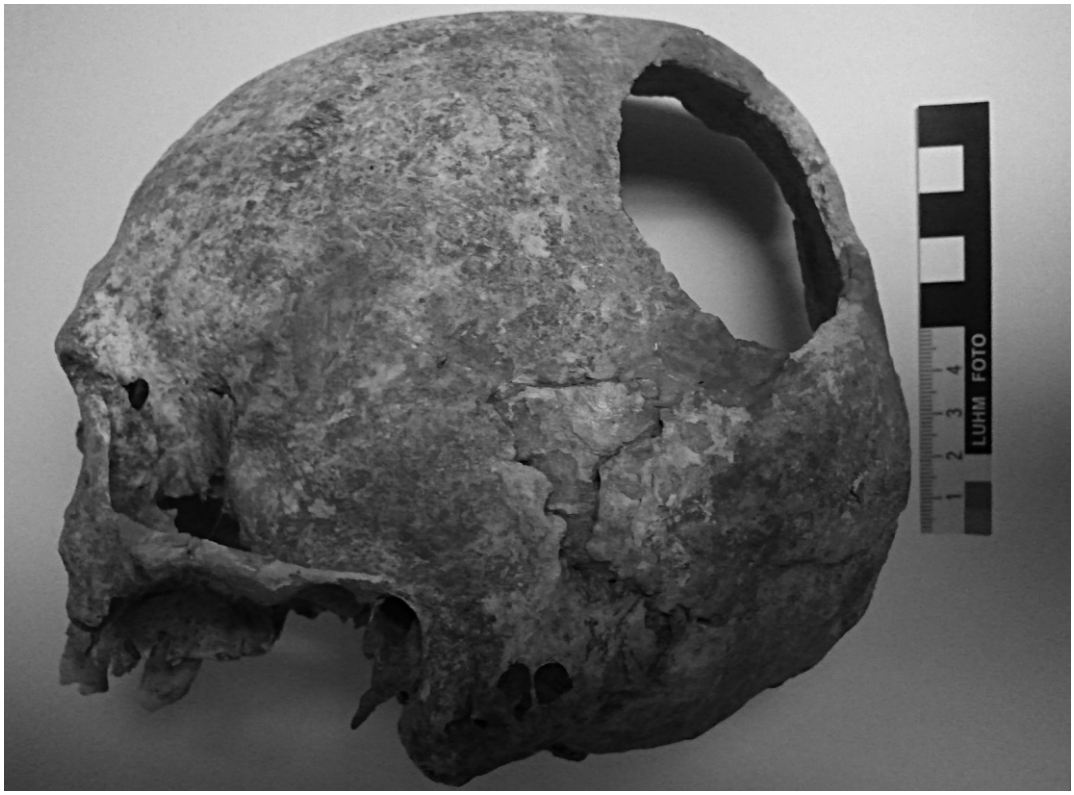

Fig. 2. Large trepanation on the left parietal bone showing signs of healing. Photo by A. Tornberg.

individuals are in the age class Middle Adults.

Of the three, only one individual, probably Late Neolithic, has a penetrating skull trauma that shows no signs of healing and was therefore probably fatal. A male individual in grave 15, dating to the Early Bronze Age, has a c. 62 × 56 mm large trepanation on the left parietal bone (Fig. 2). The area around the wound is smooth, showing some healing, indicating that the individual survived some time after the operation. There are no traces of other skull injury in relation to the trepanation. The third individual (grave 1), dating to the Late Neolithic, did not suffer from a penetrating trauma, but blunt force to the right parietal bone. The area of the wound measures c. 43 × 15 mm and it shows significant healing. It is uncertain whether the trauma was accidental or due to violence.

It is difficult to conclude whether there was a rise or a decline in violence during the Late Neolithic and Early Bronze Age Abbekås considering the limited data available for comparison. However, the percentage is quite high and correlates well with the Danish (Middle) Neolithic data described above. The prevalence of interpersonal violence is not in direct correlation to either diet or health unless it leads to secondary complications, but it gives more insight into social organization, which could in turn tell us about people's diet and health. A rise in violence and warfare often also affects food supplies and the spread of infectious diseases that do have a great impact on human diet and health. The opportunity to heal after injury also shows better general health than for individuals who died shortly after the trauma and did

not show any great signs of healing. Even though healing is evident in two out of three examples, the situation of violence in relation to health in the Abbekås material has to be seen as inconclusive because the number of individuals is too small and because of the limited data available for comparison.

Conclusion

With such a small investigation as the one presented here, it is very difficult to give clear answers as to whether and how diet and health were affected by an intensification of agriculture during the Late Neolithic–Early Bronze Age. There is a need for further study, which was also the goal when the three months' long project of the Abbekås investigation was started. However, many interesting tendencies and preliminary results have been demonstrated.

The high statures connected to good living conditions are confirmed to correlate well with the Late Neolithic Danish skeletons and quite well with earlier reports from central Sweden, as well as being markedly higher than during the Middle Neolithic. Also, the frequency of dental caries is significantly higher than in the Middle Neolithic, showing an increase in cariogenic foods from the Middle to the Late Neolithic in southern Sweden. The frequency of nutritional defects, especially in children, is somewhat lower in the Abbekås assemblage than in Denmark where the frequencies are seemingly static in prehistory. Trauma is present and correlates well with the Danish material, but neither a rise nor a decline from earlier periods can be shown. It is notable that two out of three injuries had the possibility to heal some time before death, indicating a somewhat higher general health providing strength to do so.

Weighing all these parameters together, we see tendencies for the health of the population of Abbekås during the Late Neolithic and Early Bronze Age to be quite good, with a solid nutrition base. The statures were high and frequencies of nutritional deprivation low. There seem to have been occasions of interpersonal violence comparable to the frequencies in Neolithic Denmark. However, survival for some time seems to have been common, indicating social care as well as fairly good general health.

It cannot be said that the diet and health reflected in the Abbekås material is definitely connected to intensified agricultural subsistence; to be able to say that, more research would be needed. What can be said is that the general health in Abbekås seems to have been good, and health-indicating parameters such as stature suggest that health is better in the Late Neolithic and Early Bronze Age as a whole in relation to both earlier and later periods. This also goes for Abbekås. The degree of cariogenic carbohydrates in Abbekås is best reflected by the degree of dental caries, which is considerably higher than in Middle Neolithic Sweden and Denmark. This strongly suggests a higher intake of cereals than in previous periods and could be connected to intensified farming.

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