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TRACE AND HEAVY METAL ANALYSES OF A SKELETAL MATERIAL IN THE ESTIMATION OF HEALTH STATUS IN 16th – 17th CENTURY TURKU (ÅBO), FINLAND.

Introduction

History of the health of past populations belongs to the realm of history of medicine. Skeletal remains offer material for different aspects of the health of populations in periods of scarce written sources. Skeletal material can be used in several ways in studies of the health of the population: 1) to estimate the life expectancy of the population, 2) in paleoepidemiological studies of those diseases which leave marks in bone, 3) to provide several indicators of nutrition of population and 4) heavy metal exposure.

During the last two decades new methods have been introduced for studying living conditions of past populations. Trace and heavy metal analysis of bone have emerged as a tool for reconstructing ancient diets and lead exposure. The elemental composition of bone tends to represent a composite summary over a period of several years due to the quite long remodelling period of the bone.

Especially strontium (Sr) concentrations in bone are used in the paleodietary reconstructions. Sr is a nonessential trace element. The paleodietary application of Sr analysis of bone is based on the premise that within the same environment, diets rich in plant foods should yield higher concentrations than those rich in animal products. Another interpretation of the variation of observed Sr values is based on the fact that they reflect the Sr content in lithosphere. In an urban context we must always pay attention to the migration of people. Because of the slow turnover rate of Sr in bones the Sr values of migrated people might reflect more the place of origin than the place of destination. This is especially problematic in an urban context when people died within a couple of years of their arrival in a town, because of the new microbe-environment they faced. It has been argued that urbanism throughout the early modern Europe was possible only because of the continuous flow of young migrants from the countryside. The toll of mortality was especially high among these immigrants. A modification of the lithospheric origin of the variation of Sr values is that they reflect the Sr values of the grain (e.g. barley and rye), cabbage and turnip, which are all good sources of strontium, consumed in the town.

Study material and methods

During Swedish rule (1155–1809) Turku (Åbo) was the administrative capital of Finland and one of the most important towns in Sweden outside of Stockholm. On the basis of the pool-tax the estimated population of Turku in the first half of the 17th century varied between 3500–5500 people (Ranta 1975). There were at least 8 cemeteries in or very near Turku during the 14th(17th centuries (Pihlman & Kostet 1986). The Julin site in the city or Turku was excavated in 1964, 1983-5 and 1987. On this site are the remains of the Holy Spirit church with its cemetery.

The aim of the study was to describe the gender and age distribution of the element concentrations of the excavated skeletal population from the site of Julin in Turku, Finland, evaluate the role of diagenesis, and to study the temporal and social variations of nutrition and lead exposure of this population. In this presentation I will concentrate on the strontium and lead concentrations.

The total number of excavated graves was around 650. It has been estimated that they were only 60% of the total number of burials. More than two thirds of excavated burials occurred inside the already ruined church. The burial period of the excavated skeletons lasted most probably from the 1580s to the 1650s. The burials in the graveyard and in the church of the Holy Spirit have been analyzed and compared to burials in and around the Cathedral of Turku. (Pihlman 1994)

Enough skeletal material for an age-estimation was recovered for 416 individuals. Ribs from skeletal remains of 141 individuals were chosen for elemental analysis. During the 1985 excavations, soil samples were also taken near the ribcage at the ex-stomach site. The sodium (Na), phosphorus (P), calcium (Ca), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), bromine (Br), strontium (Sr) and lead (Pb) concentrations of ribs from skeletal remains of 141 individuals were analyzed. (Vuorinen et al. in press) The element analysis of the bone was carried out using two different ion-beam methods: proton induced x-ray (PIXE) and gamma-ray (PIGE) emission.

Results and discussion

On the basis of the skeletal material, the late 16th-17th century population had a short life expectancy. However the whole idea of estimating the life expectancy from a skeletal population is very problematic. (Wood et al.1992) In an urban context the assumption of a stationary population [on which the estimation of life expectancy is based] is ill-founded.

The study indicates that problems caused by post-mortem (diagenetic) processes are inevitable. The combination of different types of methods to estimate the role of diagenesis is essential. In this study the following measures were used to estimate the role of diagenesis in the elemental values; 1) comparison of elemental concentration of soil and bone, 2) soil characteristics, 3) relation between bone quality and elemental concentrations and 4) multivariate statistical techniques. The use of soil analyses and taking into account local variation of soil conditions is necessary. The observation of bones' preservational status, e.g. fungal growth, is also essential. However, even bones under quite a heavy diagenesis seem to contain a biological signal. Those elements which contain this signal are zinc, strontium and lead. The position of sodium, phosphorus, calcium, copper and bromine is problematic in the continuum biogenic-diagenetic. Manganese and iron in bones are explicitly indicators of diagenetic processes. Considering diagenesis the comparisons of elemental concentrations must be made within the same burial place. This study indicates that Sr and Pb concentrations reveal age, gender and burial period differences.

Starting from the premise, that within the same environment, diets rich in plant foods should yield higher concentration than those rich in animal products the increasing trend of Sr with age in women can be interpreted to mean an increasing consumption of plant foods. In men the consumption of plant foods decreased with age. In both periods older women tended to have diets richer in plant foods than men. In earlier period (as compared to the later period) the consumption of plant foods was higher in both sexes. (Table 1.)

Table 1. *Age distribution of strontium values in females and males*

Estimated age (years)	Women (N)	Men (N)	Men Range (ppm)	Women Median (ppm)*	Men Median (ppm)**	Women Range (ppm)
16 – 25	9	4	11	88,0	0 – 137	13 – 214
26 – 35	13	7	30	9,0	6 – 202	4 – 135
over 35	8	6	138	8,5	6 – 209	5 – 62
All	30	17	42,5	13,0	0 – 209	4 – 214

Jonckheere-Terpstra test for trend: J=199, J=2,01, p=0,022
**Jonckheere-Terpstra test for trend: J=69, J*=1,35, p=0,089

Another interpretation of the variation of observed Sr values is based on the fact that they reflect the Sr content in lithosphere. The mean annual replacement of Sr in ribs has been calculated to be 4,7% (range 2,2 – 10%). The turnover of Sr in cortical bone (analyzed in this study) is even less than the mean value for whole bone. Because of the slow turnover rate of Sr in bones the Sr values of migrated people might reflect more the place of origin than the place of destination. This is especially true if people died within a couple of years of their arrival in the town. The available sources indicate that people even migrated hundreds of kilometers to Turku during the 17th century from southwestern and central Finland (Ranta 1975). The map of Sr concentrations of the soil, was obtained from the Department or Geochemistry of the Geological Research Institute in Finland. In this map there are ten-fold differences in the Sr concentrations between different areas of possible origin of the migrants. The observed gender, age and temporal variation of Sr values might originate from the different native place of the different groups.

A modification of the lithospheric origin of the variation of Sr values is that they reflect the Sr values of the grain (barley and rye), cabbage and turnip, which are all good sources of strontium, consumed in the town. During the 17th century part of the grain was imported to Turku from the same areas from where people migrated to Turku and part of the grain came by boat from Ostrobothnia or from Estonia. Some of the areas of grain import had distinctly higher soil Sr values as compared to others near the town. Cabbages and turnips were imported from rural areas nearer the town with quite low soil Sr values. Hence, one interpretation for the variation of Sr levels is that they indicate a different mix of cabbage, turnip and grain of different origin in the diet of different groups. Pb exposure seems to be small in both periods, but somewhat higher in the earlier burial period than in the later (Table 2).

Table 2. *Age distribution of Pb concentrations, ppm, (over detection limit) in ribs of earlier and later burials and the numbers of ribs over detection limit/total number of bones that group*

Estimated (years)	Median	Earliest period* Range	> detectin limit/toal	Median	Later period** Range	>detection limit/total
– 15	43,9	20,4 – 67.4	2/3	12,0	1,7 – 27,9	15/28
16 – 25	22,5	20,7 – 61,5	3/4	9,0	1,8 – 42,0	21/38
> 35[b]	16,9	3,1 – 58,8	4/7	8,6	2,7 – 34,5	8/21
Total	22,5	3,1 – 67,4	11/22	9,1	1,7 – 57,9	55/114

* Jonckheere-Terpstra test for trend: J=32, J*=1,63, p=0,052

** Jonckheere-Terpstra test for trend: J=574,5, J*=0,83, p=0,203

[b] There lower burials inside church walls (3.1, 17.6 and 58.8 ppm), all the other earlier burials with Pb values over detection limit located in the churchyard.

As a whole a large number of Pb values were under the detection limit and the low concentrations detected in bones in both phases support the conclusion that Pb exposure in early modern population in Finland was at a very low level. The principal source of lead in the town were lead-glazed ceramics, pewter and cauldrons of copper-alloy. An occasional occupational exposure (artisans and their families working with metals and ceramics) might produce at least part of the observed Pb concentrations.

CONCLUSION

This study indicates that problems caused by diagenesis may be easier to solve than those originating from the role of different cultural factors on elemental values in bones. In this study a considerable body of knowledge (migration, commerce) about the population in Turku at the turn of the 17th century was available. However, questions concerning the role of migration and source of grain and vegetables on the variation of elemental values remained unanswered. The unknown distribution of ancient people to relevant cultural, social or epidemiological subgroups is a general problem concerning the interpretation of elemental values of bones in an urban context.

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