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MORTALITY STRUCTURE IN MESOLITHIC, NEOLITHIC AND EARLY BRONZE AGE POPULATIONS OF CENTRAL EUROPE AND UKRAINE: A NEW METHODOLOGICAL APPROACH*)

ABSTRACT: The analysis of the mortality structure was based on the following premises: (1) the mortality structure may be derived from frequency distribution of the categories of the age at death and, (2) the mortality structure may be considered as a complex relational system which ought to be investigated on both the elementary and synthetic levels. In the first case, a particular trait is analysed in view of the mean age at death. In the second case, the linear combinations of elementary traits (here, by use of the principal components method) are analysed.

KEY WORDS: Palaeodemography – Mortality structure – Central Europe – Neolithic – Early Bronze Age – Principal components analysis

INTRODUCTION

Systematic studies on the differentiation of the mortality structure of human populations have been initiated by G. Acsádi and J. Nemeskéri (1970). During the recent decades numerous attempts at new solutions as well as critical papers were published (Aleseev 1972, Buikstra, Konigsberg 1985, Jackes 1988, Lanphear 1989, Marciniak 1992, Piontek 1986, Piontek, Henneberg 1981, Piontek, Weber 1990, Rewekant 1993, Van Gerven, Armelagos 1983).

The authors of this paper propose to consider a set of variables which describe the age structure of the individuals buried at a cemetery (i.e. the series of skeletons diagnosed in respect to the age at death) in analogical way as a set of measurements of crania or long bones, and to analyse its variability by use of the standard methods of anthropology: measures of central tendency and dispersion and the multivariate measures (principal components analysis). All of them will be applied only to the series of adults.

Our analysis stems from the following premises:

(a) the cognitive possibilities of palaeodemography are limited by the level of accurateness of the diagnoses of sex and age at death of individuals;
(b) the estimation of the relation between the biological age (based on the skeleton) and calendar age of the individual demands further investigations;

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TABLE 1. List of populations of Central Europe: Neolithic to Early Bronze Age.*)

Population	N	Authors of data
I. The Odra and Vistula Rivers		
1. Chodzież, GAC	19	M. Henneberg *et al.*, 1982
2. Żerniki, CWC	31	A. Kempisty, 1978
3. Złota, CWC	36	B. Miszkiewicz, 1958
4. Złota, Neolithic	70	B. Miszkiewicz, 1958
5. Poland, Neolithic	241	J. Gładykowska-Rzeczycka, 1973
6. Żerniki, Trzciniec Culture	130	A. Kempisty, 1978
7. Brześć Kujawski, LBPC	25	S. Żejmo-Żejmis, 1938
II. The Elbe-Saale-Unstrute Basin		
8. Sondershausen, BPC	35	A. Bach, 1978
9. Bruchstedt, BPC	41	A. Bach, 1978
10. Casual discovery, BPC	67	A. Bach 1978
11. Different sites, BPC	143	A. Bach, 1978
12. Niederbösa, Walternienburg Culture	42	H. Ullrich, 1972
13. Nordhausen, Walternienburg Culture	33	H. Ullrich, 1972
14. Schönstedt, Walternienburg Culture	31	A. Bach, H. Bach, 1972
15. Different sites, CWC	35	H. Ullrich, 1972
III. Bohemia - Moravia		
16. Vikletice, CWC	80	M. Buchvaldek *et al.*, 1970
17. Different sites, CWC	42	J. Jelínek, 1973
18. Different sites, BBC	56	Z. K. Zoffmann, 1984
19. Nitra	47	J. Pavúk, 1972
20. Moravia, Neolithic	51	J. Gładykowska-Rzeczycka, 1973
IV. Carpathian Basin		
21. Zengövarkony, Lengyel Culture	58	Z. K. Zoffmann, 1984
22. Alsónémedi, Baden Culture	27	G. Acsádi, J. Nemeskéri, 1970
23. Magyarhomorog-Konyadomb, Bodrogkerestur Culture	30	G. Farkas, 1975
24. Tiszapolgár-Basatanya, Tiszapolgár Culture, phase I	36	Z. Bognár-Kutzián, 1963
25. Tiszapolgár-Basatanya, Tiszapolgár Culture, phase II	75	Z. Bognár-Kutzián, 1963
26. Different sites, Baden Culture	39	Z. K. Zoffmann, 1984
27. Different sites, Lengyel Culture	113	Z. K. Zoffmann, 1984
28. Different sites, Polgar Culture	67	Z. K. Zoffmann, 1984
29. Different sites, Tisza Culture	27	L. Szathmary, 1981
V. Ukraine		
30. Vovnigi, DDC	91	I. D. Potehina, 1981
31. Dereivka, DDC	96	I. D. Potehina, 1981
32. Nikolskoje, DDC	65	I. D. Potehina, 1981
33. Different sites, DDC	334	I. D. Potehina, 1981

*) Reference see: A. Marciniak 1992, J. Piontek, A. Marciniak 1992, U. Wittwer-Backofen 1990

(c) the population-oriented studies put constraints on the applicability of the models used in demography of contemporary societies due to the statistical nature of palaeodemographic samples (the theoretical modelling of populationism does provide satisfactory basis for such studies) (Piontek, Henneberg 1981, Lanphear 1989).

However, the following conclusions may be inferred from the already existing literature on the subject:

(a) the mean spans of life of the adults calculated on the basis of their skeletal age at death, display chrono-territorial variation which corresponds well to the results of studies of other disciplines (e.g. prehistory) (Marciniak 1982, Rewekant 1993, Van Gerven, Armelagos 1983);

(b) the mean spans of life of the adults descending from the exploration of cemeteries and those calculated on the basis of the archives' data do not show statistically significant differences;

(c) the mortality structure derived from the skeletal data in comparison with those derived from the data of the archives do not show statistically significant differences as well (Bocquet-Appel, Masset 1982, Buikstra,

Ubelaker 1994, Işcan 1989, Jackes 1988, Johanson, Horowitz 1986, Molleson *et. al.* 1993, Wittwer-Backofen 1988);

(d) the diagnoses of many medico-legal expertises do assess a sufficient degree of accurateness of the diagnoses of the age at death based on the skeleton (Işcan 1989).

Thus, considering the cognitive value of the studies in palaeodemography, two methodological levels ought to be distinguished and two questions posed, namely:

(a) what kind of possibilities do the estimations of the individual age at death based on the skeleton offer?

(b) which methods of analysis should be applied at the populational level?

As regards the first question, it should be stated that ontogeny lasts from the formation of the zygote up to the age at death. The tempo of morphological changes displays variable intensity during this time span. However, at any time unit of the individual life different properties appear. Consequently, ontogeny leaves readable traces on the skeletal system which may be used in the estimation of the skeletal age at death.

In any case, after a year of anthropological investigations, the well known distinction of the individual age into 6 categories was accepted: *infans I, infans II, juvenis, adultus, maturus, senilis*. There is no difficulty in assigning to those categories which express a given stage of the intensity of ontogenetic changes.

However, some discrepancies between the biological and calendar age of particular individuals might appear due to a differentiation of the life conditions.

Accordingly, it might be assumed that such difference could vary in comparisons between prehistoric and contemporary populations. If so, there is no problem in assigning to given age categories but to obtain possibly precise knowledge on the determinants of the differentiation of the tempo of ontogenetic development of particular traits used in such assessments.

In regard to the second question, it may be stated that critics of the populational studies, raised by demographers and, especially, the problem of the relation between mortality and fertility, seems to be justified. Thus, a new methodological approach is needed in physical anthropology.

METHODOLOGICAL APPROACH

Our analysis of the differentiation of the mortality structure among populations dated to the Neolithic and Early Bronze Age and descending from Central and Eastern Europe, was carried out on the basis of the following premises:

(1) the traditional categories of the biological age at death of adult individuals (i.e. *juvenis, adultus, maturus* and *senilis*) represent the intensity of ontogenetic changes in a proper way;

TABLE 2. List of populations of Ukraine(Mesolithic to Neolithic).

Population	N	Authors of data
I. Mesolithic		
Vasilevka I	13	I. D. Potehina 1981
Vasilevka III	22	I. D. Potehina 1981
Volosskoje	9	I. D. Potehina 1981
Total	44	I. D. Potehina 1981
II. Neolithic		
Vasilevka II	13	I. D. Potehina 1981
Nikolskij	25	I. D. Potehina 1981
Dereivka	80	I. D. Potehina 1981
Total	220	I. D. Potehina 1981

(2) the frequency distributions in these age categories may be considered as a relational system which ought to be studied at two levels: (a) the elementary and (b) the synthetic one (Parysek 1989).

At the elementary level, each single trait (as the basis of estimation of the general measure, i.e. the mean age at death of the adults) will be analysed.

At the synthetic level, the linear combinations of the elementary traits will be analysed (principal components).

The first level of the analysis may bring the answer to the question to what extent the studied populations (with various cultural and chronological affinities) differ from each other as to their mean age at death of the adults.

The second level of the analysis may show the principal components of the cultural and chronological differentiation of the mortality structure, and lead to a possible distinction of the characteristics of the mortality structure which significantly differentiate the studied populations.

MATERIAL

Our analysis deals with two groups of populations: (a) 33 populations of Central Europe (Poland, Elbe and Saale Basin, Bohemia and Moravia, Carpathian Basin, Ukraine), dated to the Neolithic and Early Bronze Age (*Table 1*), and (b) 6 populations of Ukraine, dated to the Mesolithic and Neolithic Periods (*Table 2*).

The mean age at death and the mortality structure of all these populations were established by different authors of the respective publications.

The age at death in the first set of populations was represented in the categories of each 10 yrs. of age, while the second set – in the categories of *juvenis, adultus, maturus* and *senilis*. The size of particular series of skeletons ranged from 19 to 300 individuals.

The first set of populations represented the following cultures: Corded Ware Culture for Poland, Linear Band

TABLE 3. Adult life expectancy for populations of Central Europe: Neolithic to Early Bronze Age.

Population	N	Adult life expectancy in years
I. The Odra and Vistula Rivers		
1. Chodzież, GAC	19	23.8
2. Żerniki, CWC	31	23.9
3. Złota, CWC	36	23.2
4. Złota, Neolithic	70	20.4
5. Poland, Neolithic	241	15.0
6. Żerniki, Trzciniec Culture	130	22.6
7. Brześć Kujawski, LBPC	25	19.3
II. The Elbe-Saale-Unstrute Basin		
8. Sondershausen, BPC	35	16.5
9. Bruchstedt, BPC	41	18.7
10. Causal discovery, BPC	67	17.6
11. Different sites, BPC	143	17.8
12. Niederbösa, Walternienburg Culture	42	15.5
13. Nordhausen, Walternienburg Culture	33	15.8
14. Schönstedt, Walternienburg Culture	31	20.0
15. Different sites, CWC	35	9.3
III. Bohemia - Moravia		
16. Vikletice, CWC	80	18.1
17. Different sites, CWC	42	16.9
18. Different sites, BBC	56	16.6
19. Nitra	47	21.0
20. Moravia, Neolithic	51	13.5
IV. Carpathian Basin		
21. Zengövarkony, Lengyel Culture	58	26.8
22. Alsónémedi, Baden Culture	27	25.2
23. Magyarhomorog-Konyadomb, Bodrogkerestur Culture	30	17.5
24. Tiszapolgár-Basatanya, Tiszapolgár Culture, phase I	36	21.0
25. Tiszapolgár-Basatanya, Tiszapolgár Culture, phase II	75	18.8
26. Different sites, Baden Culture	39	19.1
27. Different sites, Lengyel Culture	113	20.3
28. Different sites, Polgar Culture	67	21.7
29. Different sites, Tisza Culture	27	16.9
V. Ukraine		
30. Vovnigi, DDC	91	20.5
31. Dereivka, DDC	96	22.7
32. Nikolskoje, DDC	65	19.1
33. Different sites, DDC	334	20.1

Pottery Culture, Walternienburg Culture, Corded Ware Culture for the area of the Elbe, Saale-Unstrute Basin, Corded Ware Culture for the area of Bohemia and Moravia, Baden Culture for the Carpathian Basin and Dnepro-Donec Culture for Ukraine.

The second set of populations is highly differentiated in chronology and embraces 3 series from the Mesolithic and 3 series from the Neolithic Periods.

TABLE 4. Adult life expectancy (in years) for populations of Ukraine (Mesolithic to Neolithic).

Population	N	Males+Females	Males	Females
I. Mesolithic				
Vasilevka I	13	21.9	22.3	20.0
Vasilevka III	22	18.1	16.3	24.3
Volosskoje	9	23.3	24.2	21.7
Total	44	20.7	19.8	22.9
II. Neolithic				
Vasilevka II	13	21.2	21.9	20.0
Nikolskij	25	24.7	26.7	21.8
Dereivka	80	25.0	27.5	20.1
Total	22	21.8	22.9	19.7

TABLE 5. Arithmetic means and standard deviation of adult life expectancy for the 5 distiguished geographical regions and for archaeological cultures.

Regions, cultures	N	Arithmetical mean	Standard deviation
Poland	7	21.5	3.12
Elbe-Saale Basin	8	16.4	3.02
Bohemia - Moravia	5	17.2	2.42
Carpathian Basin	9	20.8	3.15
Ukraine	4	20.6	1.31
BPC (Elbe-Saale Basin)	4	17.6	0.78
CWC (Central Europe)	5	18.3	5.26
Walternienburg Culture	3	17.1	2.05
Neolithic together	33	19.2	3.54

THE RESULTS OF THE ANALYSIS

Elementary level: the mean life span of adults

Table 3 presents life expectancy of adults for 33 populations of Central Europe, while *Table 4* – for 6 populations from the territory of Ukraine.

The data included in *Table 5* represent the life expectancy of adults, calculated for particular geographical regions. They permit to assess a territorial differentiation of these characteristics.

Thus, the lowest values may be observed among the populations of Elbe and Saale Basin as well as from Bohemia and Moravia. The intermediate values appeared among the populations from the Carpathian Basin and Ukraine. The populations of Odra and Vistula Rivers show the highest figures.

At the same time, some cultural differentiation is visible too, although the number of populations assigned to the same archaeological culture is small within given territories. At any rate, the mean life span of the adults in

the Linear Band Culture from Elbe and Saale Basin was equal to 17.6 yrs. of age, in the Corded Ware Culture – 18.3 while, in the Dniepro-Donec Culture from Ukraine – 20.1 to 22.7 yrs. of age.

All the data of the Mesolithic and Neolithic populations of Ukraine were taken from the publications by V. P. Alekseev (1972) and I. D. Potehina (1981). The data show, at variance with the results obtained for Western, Central and Southern Europe, that the process of neolithisation in Ukraine caused the prolongation of the life expectancy of adults.

The synthetic level: the differentiation of the mortality structure

Instead of calculating the life tables and comparing their parameters (this type of palaeodemographic analysis has been much criticised), the principal components analysis of the mortality structure was applied. This method ought to show principal components of the differentiation. As it is known "portions" of the original characteristics, strongly intercorrelated, enter into the principal components, while the latter are not intercorrelated.

The original characteristics were labelled according to their biological significance, namely:

- mortality of individuals entering into reproduction (15-20 yrs. of age)
- mortality of young parents (20-29 yrs. of age)
- mortality of mature individuals (30-39 yrs. of age)
- mortality of individuals completing reproduction (40-49 yrs. of age)
- mortality of grand-parents (50-x yrs. of age).

In the case of the first set of populations, the transformation of original characteristics in the principal components proceeded in this way: to a higher degree only one, two or sometimes three characteristics of the mortality structure enter into each component.

The first level of differentiation is defined by the principal component which accounted for 42% of total variation; it describes the mortality of young parents, individuals completing reproduction and mortality of grand-parents. Of course, there appeared such dependence: the higher mortality of the individuals completing reproduction and the grand-parents, the lower mortality of young parents (reversed signs of the coefficients of correlation with the principal component).

The second level of differentiation is defined by the principal component which accounted for 22% of total variation; it describes the mortality of mature individuals.

The third level of differentiation is defined by the principal component which accounted for 18% of the total variation; it describes the mortality of the grand-parents and individuals completing reproduction.

Only the fourth component describes the mortality of individuals entering into reproduction (19% of total variation).

These results permit to conclude that the differentiation of the mortality structure in the Neolithic and Early Bronze Age were mainly caused by differences in the mortality of young parents, individuals completing reproduction and mature individuals (*Table 6*).

The differentiation of the studied populations in respect to the mortality of young and senile individuals is much narrower. The main differences originated from the relationship between the mortality of young parents and mortality of mature individuals. It determines the differences in the mean life span of the adults.

It is worth emphasising that such type of the mortality structure creates high opportunity for natural selection, which has been assessed in the respective anthropological literature(Piontek, Henneberg 1981).

The analysis of the differentiation of the mortality structure in 6 Mesolithic and Neolithic populations of Ukraine led to similar results (*Table 7*). The basis for calculations was constituted there by the four above-mentioned traditional age categories (*juvenis, adultus, maturus, senilis*). The first component accounted for 50% of total variation and it described the differentiation of individuals in the categories of *maturus* and *senilis* (i.e. individuals completing reproduction and grand-parents).

The second component (21% of total variation) described the differentiation of the mortality of mature individuals (*adultus*).

The differentiation of the populations in reference to the mortality of the individuals entering into reproduction (*juvenis*) and grand-parents (*senilis*) is small (19% and 10% of total variation respectively).

TABLE 6. Coefficients of correlation between original variables (x) and principal components (v): data for populations of Central Europe.

Variables/components	v_1	v_2	v_3	v_4
15 – 20 years	0.245	0.004	0.195	**–0.949**
20 – 29 years	**0.769**	**0.603**	–0.165	0.127
30 – 39 years	0.573	**–0.784**	0.178	0.152
40 – 49 years	**–0.720**	–0.142	**–0.676**	0.050
50 – x years	**–0.767**	0.259	**0.572**	0.131

Bold – significance for $p < 0.01$

TABLE 7. Coefficients of correlation between original variables (x) and principal components (v): data for populations of Ukraine (Mesolithic to Neolithic).

Variables/components	v_1	v_2	v_3	v_4
juvenis	0.474	–0.374	**0.777**	–0.171
adultus	**0.707**	**0.702**	0.014	–0.081
maturus	**–0.935**	0.332	0.121	–0.003
senilis	–0.632	–0.303	–0.356	**–0.617**

Bold – significance for $p < 0.01$

CONCLUSIONS

1. Age at death estimations of the individuals carried out in biological age categories (*juvenis, adultus, maturus, senilis*) warrant the analysis of the variability of the longevity and the mortality structure in primeval populations and give biological sense to the investigations.
2. The above-mentioned age categories reflect the intensity of the involutional changes in ontogenesis and measure their conditions. The mortality structure reconstructed on the basis of age categories creates a complicated relative system that may be examined at both elementary and synthetic analytical levels.
3. The first level (elementary) enables one to answer the following question: are the investigated groups different according to the average age at death of adult individuals? The other level (synthetic) makes it possible to indicate the main components of this differentiation, especially it permits to separate those parameters of the mortality structure which are essential for the differentiation of the investigated groups.
4. Studies at the population level related to the type of samples (skeletal materials derived from incompletely examined burial sites, different state of material preservation, the lack of data concerning fertility etc.) do not make it possible to apply standard population models which are commonly used in demography.

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