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A new approach for assessment of asymmetry in paleoanthropological material

A. Nacheva

Institute of Cell Biology and Morphology,
Bulgarian Academy of Sciences, Sofia

An original method for assessment of asymmetry in paleoanthropological material is given. The informative possibilities of this method are shown on the results of its applying to published metrical data for long bones [5].

Key words: paleoanthropology, long bones, asymmetry.

The enrichment and detailing of information, got by studying anthropological bone remains, are of great importance for the reconstruction of morphologic characteristics of ancient people, and for getting some knowledge on their ontogenesis. The anthropological bone remains are mainly studied for: sex and age determination; morphologic characterization on the base of scopic and metric data; description and documentation of pathologic finds. The skull bones are studied metrically in details, while in the postcranial bone material, the lengths of the long bones, are measured only, in order to determine the hight of the individuals [1, 3, 7]. However, rich biometric information, which could be used as a base of reason-consequens analysis of age-sex differences through the different ontogenesis stages of population in near and remote past, remains uncollected and unstudied [5].

The metric bilateral differences of the pair long bones are relatively less studied. The results published concern mainly the crossed asymmetry in lengths of: humerus, which is right dominant, and radius, which is left dominant [4, 5]. That statement is based on rending an account of the direction of the metric dominance only, while the size of asymmetry remains without discussion. One of the most important reasons for neglecting it, is probably the lack of objective base for comparison of the differences between right and left values in pair features, whose main dimensions are of different orders. For example, bilateral difference of 2 mm does not show high asymmetry for a feature with main dimension over 500 mm, but it is significant for a feature with main dimension less than 50 mm.

There have been published attempts for objectifying the comparative assessment of bilateral differences on bone remains and living population, by initiating different indices, but they all provide comparison on intergroup level, as they use mean values [2, 6]. Rubrications, based on the data of these indices, do not render an account of the size of the feature's asymmetry shown, even at the group level. For example, there are three possibilities for Duncker's index: when the index is 0 there is no asymmetry, when it is +1 rightside asymmetry presents and, when it is −1 leftside asymmetry presents.

The results of our investigations (using our method) on asymmetry in different social-professional groups of contemporary population, show that the features of morphologic body asymmetry possess high ecosensitivity and give rich information about intersex and interage differences [8]. This results give us the base for seeking similar information in bone material, having in mind that any successful attempt for its enrichment would be of great importance for the paleoanthropological studies.

The purpose of the present work is to study the applicability and informativeness of our method for comparative assessment of asymmetry in paleoanthropological material.

Materials and methods

Published metric data of bilaterally studied long bones from ancient slavic necropolis in Czechoslovakia, dated IX century, are used in this investigation [5]. The publication of these authors gives extensive metric material about the base pair long bones of adult individuals of both sexes in four age groups from 20 to 60 years. There are bilateral data for: humerus, radius, ulna, femur, tibia, and fibula bones for sufficiently great number of individuals, shown in Tables 1 and 2 respectively. At the same time the possibility for comparative assessment of asymmetry, on the base of the absolute differences between right and left dimensions of the features, is summarized in the only conclusion about the asymmetry. The cited authors establish that: "...The long bones of the upper limbs, in mean values, are longer at the right side, and on contrary, the long bones of the lower limbs, in mean values, are longer at the left side..." [5].

Our method is based on introducing nondimensional standardized indices of asymmetry, named "Units of Asymmetry" (UA). They provide objective comparative assessment of the size of the manifested asymmetry on individual, group and intergroup levels, independent on the primary feature's value or dimension. UA are calculated easily and quickly. They are the differences between 100 and the percentage ratio of right and left values of the features. UA are positive when right dominance is present and negative, when left dominance is present.

Results and discussion

The mean values of the right and left dimensions of the features studied – grouped in decades – taken from the publication cited, and the absolute differences between them and the corresponding UA, computed additionally by us, are presented in Table 2. The combined data for all the period

Table 1. Metrical data of bilaterally investigated long bones commonly for 20-60 years of age

Features	Men					Women				
	n	$\bar{X}_r$	$\bar{X}_l$	dif.	UA	*n*	$\bar{X}_r$	$\bar{X}_l$	dif.	UA
Humerus	158	333,4	329,5	3,9	1,2	97	303,2	300,2	3,0	1,0
Radius	116	250,9	248,9	2,0	0,8	74	227,1	225,1	2,0	0,9
Ulna	44	270,7	268,9	1,8	0,7	32	245,0	243,1	1,9	0,8
Femur	223	458,3	460,2	1,9	−0,4	167	416,2	417,1	0,9	−0,2
Tibia	166	375,5	377,2	1,7	−0,5	130	341,3	341,6	0,3	−0,1
Fibula	13	367,8	366,6	1,2	0,3	9	334,6	336,0	1,4	0,4

Table 2. Metrical data of bilaterally investigated long bones – in decades

Features	Indicators	(20-30) – I age group		(30-40) – II age group		(40-50) – III age group		(50-60) – IV age group	
		♂	♀	♂	♀	♂	♀	♂	♀
Humerus	*n*	15	16	29	33	70	41	44	7
	$\bar{X}_r$	336,3	304,3	332,4	299,1	331,1	307,8	336,8	307,4
	$\bar{X}_l$	332,7	300,3	328,5	297,3	326,8	301,9	333,4	304,3
	dif.	3,6	4,0	3,9	1,8	4,3	5,9	3,4	3,1
	UA	1,1	1,3	1,2	0,6	1,3	2,0	1,0	1,0
Radius	*n*	6	14	21	22	54	28	35	10
	$\bar{X}_r$	252,0	227,4	252,2	224,5	249,9	229,4	251,5	226,2
	$\bar{X}_l$	247,0	226,5	250,3	222,2	248,0	227,2	249,7	223,4
	dif.	5,0	0,9	1,9	2,3	1,9	2,2	1,8	2,8
	UA	2,0	0,4	0,8	1,0	0,8	1,0	0,7	1,2
Ulna	*n*	3	5	7	11	20	10	14	6
	$\bar{X}_r$	278,7	242,6	264,0	243,0	268,7	247,8	275,8	246,0
	$\bar{X}_l$	273,3	243,2	262,0	241,2	267,9	245,2	272,9	243,2
	dif.	5,4	−0,6	2,0	1,8	0,8	2,6	2,9	2,8
	UA	2,0	−0,2	0,8	0,7	0,3	1,1	1,1	1,2
Femur	*n*	19	32	32	46	101	63	71	26
	$\bar{X}_r$	453,1	416,9	455,5	412,1	457,3	418,0	462,3	418,1
	$\bar{X}_l$	455,5	417,7	458,1	413,2	458,9	418,9	464,3	418,6
	dif.	−2,4	−0,8	−2,6	−1,1	−1,6	−0,9	−2,0	−0,5
	UA	−0,5	−0,2	−0,6	−0,3	−0,3	−0,2	−0,4	−0,1
Tibia	*n*	16	22	21	43	78	50	51	15
	$\bar{X}_r$	366,4	340,9	375,9	336,8	373,1	344,5	382,1	343,7
	$\bar{X}_l$	369,8	341,9	377,5	337,5	373,5	344,7	383,1	342,7
	dif.	−3,4	−1,0	−2,6	−0,7	−0,4	−0,2	−1,0	1,0
	UA	−0,9	−0,3	−0,4	−0,2	−0,1	−0,1	−0,3	0,3
Fibula	*n*	1	–	3	3	5	5	4	1
	$\bar{X}_r$	355,0	–	359,0	320,7	363,8	340,8	382,5	352,0
	$\bar{X}_l$	350,0	–	358,7	320,7	362,2	341,6	382,3	354,0
	dif.	5,0	–	0,3	0,0	1,6	−0,8	0,2	−2,0
	UA	1,4	–	0,1	0,0	0,4	−0,2	0,1	−0,6

from 20 to 60 years are presented in Table 1. As it is can be seen from the data in Tables 1 and 2, and even more clearly, from their graphic expression for humerus and femur, taken as examples, at Fig. 1, one could hardly derive richer information, using only the absolute values of right and left dimensions of the features and their differences than that of the authors cited, i. e. that the humerus

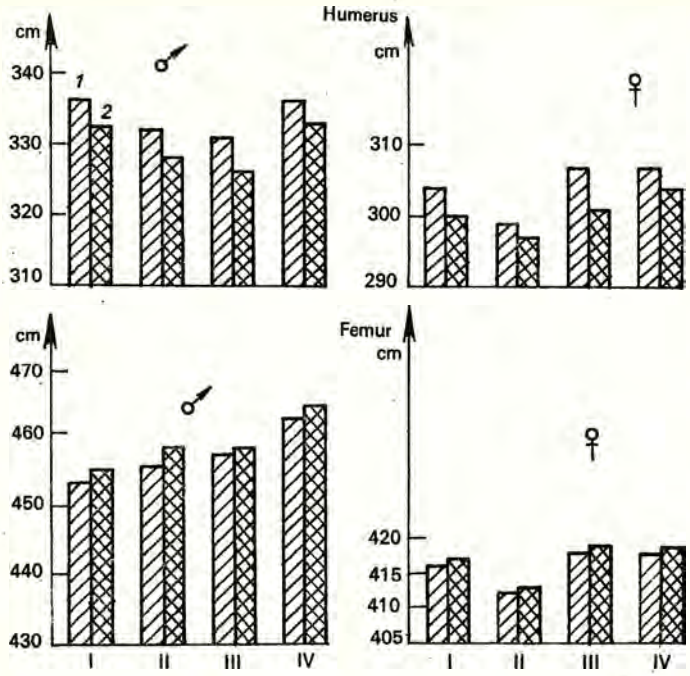

Fig. 1. Manifestation of asymmetry, expressed by absolute right/left values of features
1 – right; *2* – left
I age group – 20-30 years; II age group – 31-40 years; III age group – 41-50 years: IV age group – 51-60 years

is right dominant and the femur is left dominant. In order to compare the informativeness of the absolute values of the bilateral differences and the proposed standartized indices of asymmetry – UA, their values are juxtaposed in Table 3. The juxtaposition in the first part of Table 3 shows, for example, that UA, equal to 2, corresponds to different absolute differences: for the humerus – 5,9 mm, for the ulna – 5,4 mm, and for the radius – 5,0 mm. On the other hand, 5 mm absolute difference for the fibula corresponds to 1,4 UA, and so on. The second part of Table 3 illustrates that absolute differences of 2 mm for the femur, ulna, and fibula correspond to different asymmetry, expressed in UA equal to 0,4, 0,8 and 0,6 respectively.

That data give convincing grounds to accept that UA objectify the comparative assessment of asymmetry manifestations, giving the possibility to analyse the size of asymmetry for different features, independently on their main dimensions. When studying the bone material, UA give rich additional information. The long bones of the upper limb for both sexes reveal higher asymmetry than that of the long bones of the lower limb, during the whole period (20-60 years) (Fig. 2). Anyway, the intersex differences are more distinct for the asymmetry of the long bones of lower limb for which the women have comparatively smaller UA. The fact, that men's fibula show rightside asymmetry, that is laterality different from their known leftside stereotype, and UA showing that the established rightside asymmetry is significant, is of interest too. The women's fibula show the known leftside asymmetry of the lower limb (Fig. 3). The UA values give more detailed and richer information when following the age

Table 3. Comparison between UA and absolute value of right – left differences of some investigated features

	UA	Differences, mm
I	2,0	5,9 (Humerus – women, III age gr.) 5,4 (Radius – men, I age gr.) 5,0 (Ulna – men, I age gr.)
	1,4	5,0 (Fibula – men, I age gr.)
	1,1	3,6 (Humerus – men, I age gr.) 2,9 (Radius – women, IV age gr.) 2,6 (Radius – women, III age gr.)
	0,6	2,6 (Femur – men, II age gr.) 2,0 (Fibula – women, IV age gr.) 1,8 (Humerus – women, II age gr.)

	Differences, mm	UA
II	2,0 (Femur – men, IV age gr.)	0,4
	(Radius – men, II age gr.)	0,8
	(Fibula – men, IV age gr.)	0,6

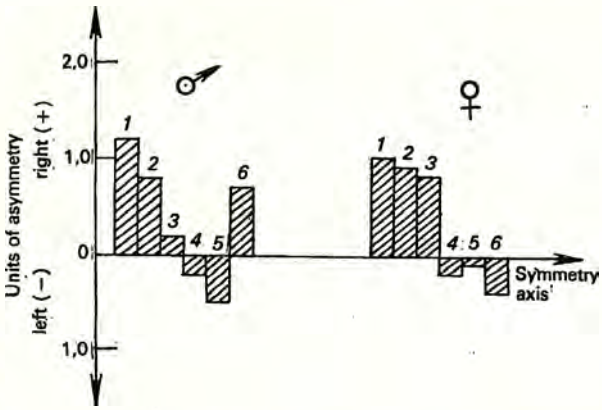

Fig. 2. Manifestation of asymmetry, expressed by UA commonly for 20 to 60 years
1 – humerus; *2* – radius; *3* – ulna; *4* – femur; *5* – tibia; *6* – fibula

dynamics of asymmetry. The data about long bones studied show that, also for the bone material the size of asymmetry occurs to be a characteristics of higher ecosensitivity, while laterality remains relatively constant for all the age groups of the period studied. Each of the bones studied shows specific tendency of asymmetry size dependence on age and sex. The asymmetry for men's humerus increases gradually up to 50 years. That is, during the active labour period of men, and after that decreases. Such a tendency is not observed for women. The manifestation of asymmetry for radius shows enhanced sex dimorphism – asymmetry decreasing with age for men, and on contrary for women – chronologically increasing. The tendency for the ulna is similar. This type of reactivity is evidently in connection with the functional engagement of the upper limb, typical

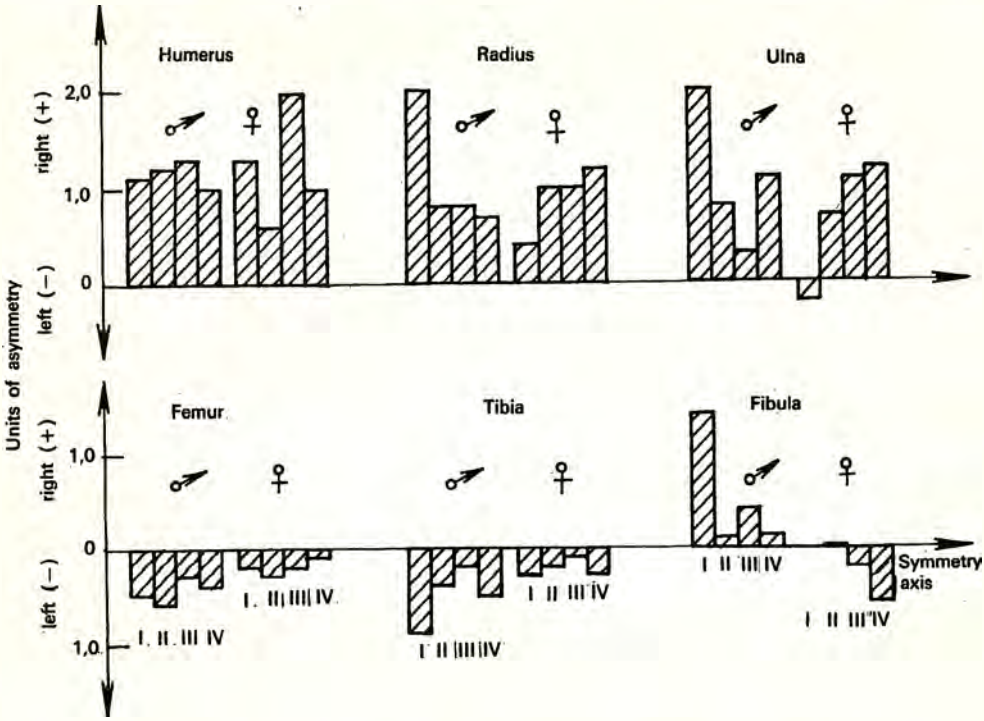

Fig. 3. Manifestation of asymmetry, expressed by UA – in decades
I age group – 20-30; II age group – 31-40; III age group – 41-50; IV age group – 51-60

for both sexes. The leading role of the humerus for asymmetry manifestation is determined by stronger physical efforts of arm and shoulder men's muscles. For the women the manipulation is usually finer and with less physical efforts so the asymmetry manifestation is determined by ulnar and radial muscles. A tendency for decreasing the asymmetry with age is traced for the long bones of the lower limb for both sexes. That enhances the significant functional dependence of the asymmetry size once again. Fibula shows specific interage differences in asymmetry manifestations with the age, being rightside and decreasing for men, and – leftside and increasing for women.

Conclusions

1. Information with rich biological content for long bone asymmetry is achieved by using our method of assessment. This information is much more objective, extensive and detailed comparatively to the only conclusion about the asymmetry given in the paper cited.

2. The established specific intersex and interage differences in asymmetry manifestations of the long bones studied show that the asymmetry is a biometric characteristic with great information possibilities and can be used as a model for tracing some of the changes occurring in man's morphological characteristic during the different stages of ancient people's ontogenesis in paleoanthropological studies.

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