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Cephalic index in crania Bosniaca since prehistoric times to recent hominids

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ABSTRACT

By this study we tried to identify autochthonous types of skulls in Bosnia and Herzegovina observed through a long period of time. We also made an effort to examine the correlation between the observed parameters: Cephalic index and its categorization which arises from the above mentioned parameter in reference to the time period the skull originates from.The research was conducted on a specimen of 196 macerated and degreased skulls, 82 of which belong to the osteological collection of the Department of Archeology-Chair of Prehistory, Antique Period and Middle Ages-of the State Museum of Bosnia and Herzegovina in Sarajevo. From the osteological collection of the department of Anatomy of the Medical Faculty in Sarajevo, a total of 114 skulls have been examined, 57 of which were skulls of male gender and 57 of female gender. On each of the examined skulls we determined length and width of the skull by applying the osteometric method. The cephalic index is in positive correlation with the period the skulls originate from. The cephalic index is not in correlation with gender structure of skulls in frames of recent period of time. The cephalic index suggests tendency of slight downfall from the prehistoric times to the Antique period, with a tendency of growth afterwards. Our results suggest that in the areas of today's Bosnia from the prehistoric times to the Antique times there was a slight decrease in average value of cephalic index, which had a tendency of growth after wards. Categorization of skulls goes in direction of dolichocrany to brachicrany moving toward more recent time period the skulls originate from, considering that in the anthropological development two evolutional tendencies began: Gracilization and brachycranization.

1. Introduction

Measurable, quantitative traits of a skull can be determined by anthropometric (osteometric) method. In this manner, we evaluate skull dimensions, such as its width and length, exactly and quantitatively. By grasping the look of Crania Bosniaca since the prehistoric till recent times, we gain a better insight into development of human species in these areas. Considering that the standard category of cephalic index has been followed for a long period of time (Gavrilović, 1967; Gavrilović, 1969; Sovtić and Bevc, 1974; Mikić, 1987), it is to be emphasized that since the Metal Age, over Bronze Age, Antiquity, Middle Ages till recent times, efforts have been made to the correlation within this category and to contribute to findings regarding features of Crania Bosniacain this way.

By this study we tried to identify autochthonous types of skulls in our country observed through a long period of time from the prehistoric Bronze and Iron Ages, over Antique and Middle Ages till nowadays. We also made an effort to examine the correlation between the observed parameters: cephalic index and its categorization which arises from the above mentioned parameter in reference to the time period the skull originates from. By doing so, we wanted to provide our humble contribution to the understanding of evolution processes in the area of today's Bosnia. This way helped consideration of a part of the great picture of development of human society history through a very long period of time

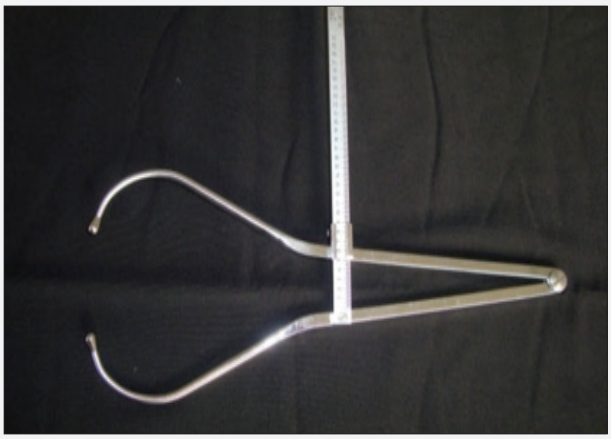

Fig. 1. Cephalometer

in our areas, which was a subject of interest to many other authors from different aspects (Benac et al., 1984).

2. Material and methods

The research was conducted on a specimen of 196 macerated and degreased skulls, 82 belong to the osteological collection of the Department of Archeology-Chair of Prehistory, Antique Period and Middle Ages-of the State Museum of Bosnia and Herzegovina in Sarajevo. The skulls originated from various periods of time and from different locations, being: Prehistory 16 (geographical site: east of Bosnia-Neolithic settlements); Antique Period 9 (geographical sites: middle and east of Bosnia); Middle Ages, total 57 (geographical sites: Herzegovina and middle of Bosnia). From the osteological collection of the Department of Anatomy of the Medical Faculty in Sarajevo, a total of 114 skulls have been examined, 57 of which were skulls of male gender and 57 of female gender.

Bioanthropological methods and instruments

Anthropometry encompasses a series of methods for examining quantitative traits of human organism. Anthropometric methods are primarily applied in examining quantitative (measurable) features (Hadžiselimović et al., 2009).

Bioanthropological instruments

Prior to the beginning of the measurements, the following conditions were ensured:

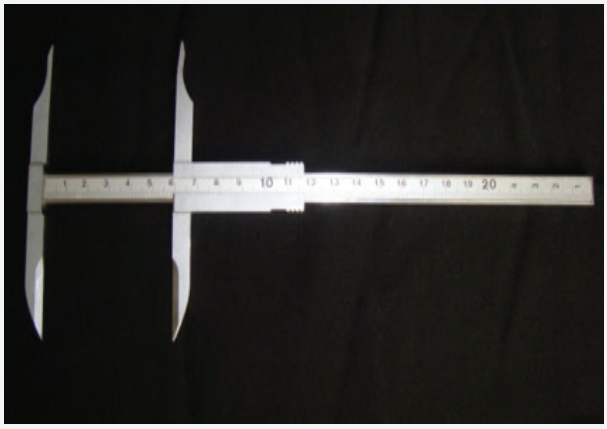

Fig. 2. Vernier caliper

1. All instruments were calibrated in metric system;
2. Accuracy of the instruments corresponds to the standard Vernier caliper;
3. The measurements were performed by the same examiner;
4. The same instruments were used in a single research series;

The following anthropometric instruments were used in our prospective study:

On each of the examined skulls we determined length and width of the skull by applying the osteometric method. Prior to the measurements, each skull was set in the position of "Frankfurt horizontal plane". Actually in horizontal position we bring external acustic meatus (porion) and low edge of orbit (orbitale).

Skull length was measured with cephalometer and it refers to the maximum sagittal distance between glabella and opisthion (Fig. 1.).

Skull width was measured with cephalometer and it refers to the maximum transversal distance between left and right porion (Fig. 1.).

On the basis of the obtained parameters we calculated the skull (cephalic) index which expresses the percentage of ratio between skull width in relation to its length.

$$Ic = \frac{100 \cdot b}{a}$$

Ic-head size (cephalic index)
a-head length (cm)
b-head width (cm) (Hadžiselimović et al., 2009)

On the basis of cephalic indices categories determined by Martin-Saller scale, we performed an analysis and classification of cephalic indices from individual time periods into separate standard categories. In classical antropology this indicator is very often reputable like one of reliable differential criterion race. New research have shown that some of the categories of cephalic index could be frequency in race for what they are not typical (Hadžiselimović et al., 2009).

Standard categories of cephalic index are as follows:

Ic<70.9	hyperdolichocephaly,
71.0-75.9	dolichocephaly,
76.0-80.9	mesocephaly,
81.0-85.4	brachycephaly,
85.5-90.9	hyperbrachycephaly,
91.0<Ic	ultrabrachycephaly. (Hadžiselimović et al., 2009).

Statistic design

The data were processed by applying:

- Graphic presentations,
- Descriptive statistics,
- Structural analysis and structural crosstabulation ,
- T-test (for two independent samples) for distributions which do not comply with the assumption of "normality",
- ANOVA (for more than two independent samples) for distributions which do not comply with the assumption of "normality",
- Correlational analyses,
- Chi-square and measures of association.

In frames of descriptive statistics for the analyzed

Fig. 3. *Cranium*-front view; Osteological collection of the Department of Archeology-Chair of Prehistory, State Museum of Bosnia and Herzegovina in Sarajevo

Fig. 4. *Cranium*-side view; Osteological collection of the Department of Archeology-Chair of Prehistory, State Museum of Bosnia and Herzegovina in Sarajevo

variables according to the groups which differ by gender, the following parameters were calculated:

- Minimum and maximum value of the analyzed variable,
- Average or mean value calculated by applying arithmetic mean value,
- Standard deviation as absolute measure of variability,
- Standard error of the arithmetic mean value assessment,
- Coefficient of variation as relative measure of variability which enables comparison.

3. Result

Cephalic index

We follow average values of the variable of cephalic index through the observed periods of time by means of the graphic presentation (Fig. 6).

We can notice that a slight decrease of cephalic index value took place from the prehistoric times to the Antique times, after which it had the tendency of growth (Fig. 6).

We verified with statistic tests how much the above mentioned differences were significant. In the variable of cephalic index the assumption of 'normality' was complied with, so we used parameter tests in comparisons.

P-value of ANOVA test is lower than 0.05 and the conclusion follows that a statistically significant difference exists between periods according to the value of cephalic index variable. We therefore perform matching of periods and we do comparisons.

The bold cells in the table suggest the periods between which the values of the cephalic index variable significantly differ. Therefore, the difference is significant between the Prehistory and recent times for female skulls, and between the Middle Ages and the recent times for female skulls. No significant difference between the recent times for male and female gender exists (Table 1).

Standard categories of cephalic index

The descriptive variable is also a subject here, and we use crosstabulation and Chi-square test for proportions for comparison between periods of time.

With help of crosstabulation, Chi-square test and measures of association, we can conclude that there is a statistically

Fig. 5. *Cranium*-side view; Osteological collection of the Department of Archeology-Chair of Antique, State Museum of Bosnia and Herzegovina in Sarajevo

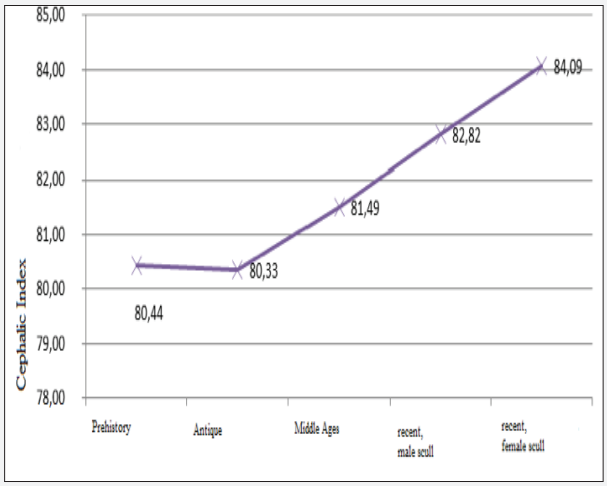

Fig. 6. Trend of movement of cephalic index average value

significant difference between standard categories of cephalic index with reference to the period the skulls originated from.

In order to test whether significant difference between genders exists, Chi-square test is performed only within frames of the recent period of time (Table 2).

Hence, by means of crosstabulation, Chi-square test and measures of association, we can conclude that there is no statistically significant difference between standard categories of cephalic index with reference to the gender of recent skulls.

The results obtained on the basis of numerical values for skull width and categorical values of standard categories of cephalic index are compliant, as confirmed by justification of standard categories of cephalic index.

No significant difference between proportions or representation of various standard categories of cephalic index in recent period between skulls of different genders exists, i.e. representation of various standard categories of cephalic index is not different depending on gender The measures of association are not significant, as confirmed by the conclusion of Chi-square test.

4. Discussion

A very complex and special issue is the one regarding biogenesis and ethnogenesis in the area of today's Bosnia. It is a subject of natural sciences, as well as of humanities. Concrete issues can be classified into several levels: Anatomic, anthropological, archeological etc.

One of the postulates of medical anthropology is typing of skull as such. The most important methods for determining the range of a series of variables that come in question on the occasion of typing are primarily anthropometry and anthroposcopy, as well as psychometry, but in this study dealt with the first method. It is known from bibliography that exactly anthropometry and anthroposcopy are the main methods of physical and medical anthropology (Švob, 1976). The task of anthropometry is to present morphological traits of human body (Larsen et al., 1998). On the other hand, anthroposcopy is a method of anthropometry which presents morphological traits of human body in quantitative manner. With help of these methods, one can study humans and human groups from the ontogenetic and phylogenetic point of view (Švob, 1976).

Our results suggest that in the areas of today's Bosnia from the prehistoric times to the Antique times there was a slight decrease in average value of cephalic index, which had a tendency of growth afterwards.

In the prehistoric times the cephalic index was relatively heterogeneous, even though dolichocephaly (31%), and mesocephaly (25%) prevailed (Mikić, 1981). The results of our measurements were similar to those found in necropolis Gonur (Turkmenistan). A total of 89 male and 66 female skulls were observed by craniometrical method. The skulls predominantly belonged to the category of long and narrow skulls. Regarding cephalic index, it is visible that predominant type was dolichocephaly (86.57%) (Babakov et al., 2001).

Hence, numerous authors state that at the beginning of the early Bronze Age there were heterogeneous ethnic groups, and groups living in isolates, which could accept the material culture of the Bronze Age by cultural diffusion. The skulls processed by anthropotypological observation are considered by authors to belong to the Nordic and to the Mediterranean type (Larsen et al., 1998).

In the Antique period we had predominant cephalic index in direction of mesocephalic form (56%), with accentuated variability of the sample taken.

During the Middle Ages, brachycephaly (30%) was predominant in our research. This finding confirms our expected results i.e. categorization of skull goes from dolichocrany to brachicrany moving to more recent time period the skulls originate from, considering that in the anthropological development two evolutional tendencies began: Gracilization and brachycranization. We found precisely such findings in other conducted studies. In special edition of Academy of Science and Art of Bosnia and Herzegovina we find indications that in Mesolithic, which represents the transition period from younger Paleolithic and Neolithic inanthropological development, these two evolutional tendencies-gracilization and brachycranization began (Mikić, 1981).

Gracilization refers to reduction of size and robustness in the sense of comparison of findings from younger Paleolithic with later findings (Mikić, 1981). Mikić (1989) made an assessment that in average, from robust inhabitants to Starčevo Culture, which was already a gracile population

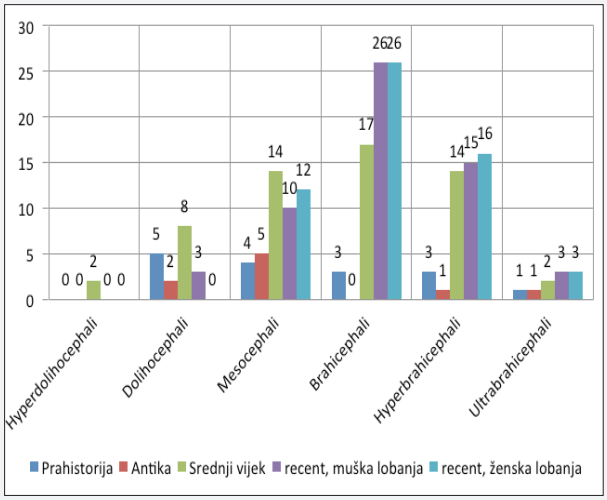

Fig. 7. Standard categories of cephalic index through periods of time

Table 1. T-test results between the periods, the cephalic index variable

	Prehistory	Antique	Middle ages	Recent, male skulls	Recent, female skulls
Prehistory		t=0.038 P=0.970>0.05	t=-0.636 P=0.527>0.05	t=-1.844 P=0.064>0.05	t=-3.038 P=0.003<0.05
Antique			t=-0.507 P=0.614>0.05	t=-0.861 P=0.412>0.05	t=-1.301 P=0.227>0.05
Middle ages				t=-1.369 P=0.174>0.05	t=-2.732 P=0.007<0.05
Recent, male skulls					t=-1.649 P=0.102>0.05

in average, about 35 to 40 generations had to pass, which achieved the greatest effects of gracilization process, which in global account equals about one millennium. The author emphasizes that short stature was dominant in both genders of this population and that brachycranicskulls were present. The author clarifies that the reasons of this microevolutional change of population cannot be explained anthropologically precisely, but its individual elements can be examined. For example, the way of commerce by means of nutrition certainly had a direct influence on metabolism, because a transition for baked-protein nutrition (meat/fish) into cooked mineral-vitamin (milk/cereals) took place (Mikić, 1989).

Brachycranization was carried out by reduction of allometric relation on the occasion of skull development i.e. human skull was shortened and its width was expanded (Larsen et al., 1998). This citation regarding linear dimensions of skulls (its width and length) matches our results, where they suggest that after the Antique period in the upcoming periods we had a constant decrease in length values of skulls, unlike the width of skulls, suggesting tendency of average value growth, with exception of the Middle Ages.

We have seen that our results show domination of dolichocrany (31%) in prehistory, mesocrany (56%) in Antique and brachycrany (30%) in middle Ages. In recent period of time, for both genders: The dominant category was brachycephaly (46%). Similar findings in predomination of brachycephaly among peoples in the area of former Yugoslavia was established in attesting performed by Predrag Softić and Zdravko Bevec on a representative sample of 7.787 young persons in their twenties (Sovtić and Bevc, 1974). Similar results regarding predominance of brachycephaly in these areas were confirmed in testing by other authors from the same region (Gavrilović, 1967; Gavrilović, 1969; Mikić, 1987).

Eventually, we arrived to the recent period, where we explored the cranial capacity for male and female skulls separately.

As expected and observed earlier in the discussion, in recent times for male gender, the dominant category was brachycephaly (46%). Our results with the results of the study conducted in 2002 on 198 men living in Gorgan, Northern Iran. Width and length of head were the observed parameters. The average cephalic index was 80,4 and it was established that they belonged to the category of brachycephaly (Golalipour et al., 2007).

The same way, as expected and observed earlier in the discussion, in recent times for female gender, the dominant category was brachycephaly (46%). Our results with the results of the study conducted on Albanian population. Width and length of head were observed by craniometrical method. The study included 204 examinees, 101 of which were men and 103 women. The study showed that the Albanian population in Kosovo had brachycephalic head type (44.61%) (Staka et al., 2013). On top of that, similar results were obtained from the study performed in Rijeka, Croatia. The study was conducted on a sample of 615 students, 443 men and 372 women. The results showed that brachycephaly was the predominant category (Buretić-Tomljanović et al., 2007).

And finally, we arrive at the most interesting analysis within our study, referring to comparison of the observed parameter (cephalic index) between the above mentioned periods of time.

Table 2. Chi-test results, recent period, matched genders

Chi-square test results	Chi-square empiric=3.214 df=4 P=0.523>0.05==> no significant difference between proportions or representation of various standard categories of cephalic index in recent period between skulls of different genders exists, i.e. representation of various standard categories of cephalic index is not different depending on gender
Measures of association	Cramer's V=0.168, p=0.523>0.05 Contingency coefficient=0.166, p=0.523>0.05 ==> The measures of association are not significant, as confirmed by the conclusion of Chi-square test.

Statistically significant difference exists between values of cephalic index variable. The difference is significant between the prehistory and the recent period for female skulls, and between the Middle Ages and recent period for female skulls. No significant differences were noticed within the recent time between genders. Similar results were found in the study conducted on population of Northern China, which included a total of 718 skulls of adult men from the North Chinese collection kept at the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, and the Research Center for Chinese Frontier Archaeology of Jilin University. A total of 338 skulls were measured at the Institute, while the data for the remaining 380 skulls were obtained from published papers. The craniometrical method was applied. For this analysis, 21 cranial traits were observed (12 linear measures and 9 indices). A total of 21 measurements were performed for populations from various periods of time. The study results showed that craniofacial variation between the Bronze Age and modern human population in 14 measurements out of 21 conducted, had significant differences. Out of the processed measurements, the most interesting ones for us are those regarding width, length and height of skull. The obtained results match our results (Wu et al., 2007).

Presentation of crosstabulation (i.e.standard categories of cephalic index through the periods of time) and Chi-square test in frames of our statistic processing, confirm our previous observations, which refer to existence of significant differences between proportions or representation of various standard categories of cephalic index with reference to the period the skulls originate from. It is evident that skull categorization goes from dolichocrany to brachycrany moving toward the younger period of time. We have already agreed that brachycephaly (46%) is predominant in recent time in both genders, so by cross-reference of Chi-square test and measures of association we can conclude that statistically significant difference between categories of cephalic index in relation to gender of recent skulls exists.

Numerous authors dealt with observation of cephalic index. Results of the research conducted in India showed predominance of dolichocephalic or mesocephalic skull type (Monoharrao-Salve et al., 2011). The study conducted at the Institute of Anatomy of Medical Faculties in Mumbai showed predominance of dolichocephaly in male skulls and mesocephalic forms in female skulls (Salve and Chandrashekhara, 2012). The study carried out in Gujarat showed tendency to brachycephalization, which was described by many authors as continuous growth of brain sideways (Shah and Jadhar 2004).

On the basis of analysis of the obtained results of this complex prospective-longitudinal osteometric study, we can elaborate on the following conclusions: The cephalic index is in positive correlation with the period the skulls originate from. The cephalic index is not in correlation with gender structure of skulls in frames of recent period of time. The cephalic index suggests tendency of slight downfall from the prehistoric times to the Antique period, with a tendency of growth afterwards. Categorization of skulls goes in direction of dolichocrany to brachicrany moving toward more recent time period the skulls originate from.

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