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Article

Latent cephalofacial structure of the albanian population of Kosovo

Estructura cefalofacial latente de la población albana de Kosovo

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SUMMARY

Anthropometric studies began as a methodology in biological anthropology for comparing of the anthropological features of the today's nations and previous nations too, as well as in screening and diagnosing of malnutrition. It is evident that a large number of studies have been performed on measures of body height, weight, trunk and limb dimensions, subcutaneous fatness and body composition, etc., but less attention has been paid to cephalofacial measurements. The purpose of this research was to study and explain the latent structure of the humans' cephalofacial variables.

On 754 healthy entities (561 male entities and 193 female entities), aged 18-35 years, were measured 11 cephalofacial variables. The collected data were analyzed through descriptive parameters, Correlation analysis, and Factorial analyses. Correlation analysis confirms the existing of some variables' sets, which are characterized with the higher correlations between variables within the set. Through the principal component analysis of the Factor Analysis (rotation method direct obliging, Keiser criterion) were extracted four latent factors which explain 66.39 % of the total variance: Factor of intracranial capacity; Transversal factor of the face; Longitudinal factor of the face.

Conclusion: The composition of the extracted factors was compatible with the scientific explanation of the anthropologists regarding the development of the head.

Key words: cephalofacial measurements, latent structure, anthropological.

1. Introduction

Anthropometric studies began as a methodology in physical anthropology for comparing of the anthropological features between the present populations or at the different timelines, as well as in screening and diagnosing of malnutrition (Zemel, 1997).

It is evident that a large number of studies have been performed based on measures of body height, weight, trunk and limb dimensions, subcutaneous fatness and body composition, etc., but less attention has been paid to cephalofacial measurements (Saha & Dasgupta, 2006).

The human skull (head), anatomically known as the cranium, consists of 22 bones. The head can be divided into two regions, the cranial section and the facial section. The cranial bones consist of the bones in the top of the skull while the facial bones consist of the bones that make up your face. Among the first to have studied craniocerebral topography was a French physician and anthropologist Paul Broca, who in this term has fixed the relations which exist between the scissors of the nervous surface and the sutures on the cranial surface. Broca has also established some new types of measuring instruments for measuring of craniofacial dimensions (Memoir of Paul Broca).

Cranium is a unique skeletal complex structure (Enlow, 1968; Martin, 2001; Williams, 1995) that enables a chronological anthropological study of the nations (Coon, 1954; Dhima, 1985; Rexhepi & Meka, 2008; Ylli, 1975). Using the skull-based categorization anthropologists have identified different racial groups.

Cephalometry is a branch of anthropometry that measures the dimensions of the head of a living person, taken either directly or indirectly, whereas craniometry exclusively studies the cranium. These two branches of anthropometry are widely used as diagnostic, treatment, and research tool by many medical practitioners and anthropologists (Rexhepi & Meka, 2008).

The size and shape of cephalofacial dimensions depend on many external and internal factors, such as racial and ethnical affiliation (Enlow, 1982; Morton, 1839; Yokota, 2005), climate and environmental factors (Buretic-Tomljanovic, 2007; Morton, 1839; Radovic et al, 2000), socio-economic factors (Eder, 1995), nutritional factors (Shils, 2005) and genetic influences (Rexhepi & Meka, 2008).

Although, the shape of neurocranium and face, as well as their growth, are product of phylogenetic, developmental, and functional interactions (Lieberman, 2000a), these two regions derive from embryologically different regions (Moss & Young, 1960; Enlow, 1968).

According to Lieberman (2000b) the neuro-basicranium may influence the growth of upper part of the face.

Because the anthropometric quantitative analysis and interpretation of the shape are important for developmental studies, for practical applications, as well as a fundamental area of anthropological researches, the great challenge for most of the scientists is to study and explain the latent structure of the studied phenomena. In this way an optimal explanation of the complex phenomena will be realized using the underlying and latent dimensions (factors).

This research aims to study and explain the latency of the human cephalofacial variables.

2. Material and methods

Research design. This study as a part of the project "Morphological characteristics of the Kosovo Albanian population" has been performed at the Institute of Sports Anthropology

(INASP) in Prishtina, Kosovo. By its nature, this research is a cross-sectional exploratory and descriptive study.

Site of study and sampling. Following the protocols of the International Biological Program have been measured 11 cephalofacial variables. The measurements were done on 754 entities of the Kosovo Albanian population (561 male entities and 193 female entities) aged 18–35 years, during the period 1997-2002. The examined entities were chosen randomly, respecting the rule that their psycho-physical, dental and soft tissue condition were in the normal range.

Measuring tools and data collection. The measurements, according to the definitions of Martin & Saller, 1957, were done by the trained team, using the professional anthropometrical instruments (anthropological cephalometer, anthropometric tape, as well as sliding compass) with the accuracy of 1 mm.

The following 11 cephalofacial variables were measured:

- G-Op (glabela-opistocranium) – head length.
- Eu-Eu (eurion-eurion) – head width.
- V-Po (vertex-porion) – head height.
- HC – Head circumference.
- N-Gn (nasion-gnathion) – face height.
- Zy-Zy (bizygomatic) – Maximal facial breadth;
- Go-Go (gonion-gonion) – bigonial mandibular breadth;
- N-Ns (nasion-nasospinale) – Nasal height;
- Al-Al (alare-alare) – nasal breadth;
- LH – lips height;
- LW – lips width.

Data analysis. The statistical analysis was conducted through the SPSS program for Windows, version 17. The collected data are analyzed through Correlation Analysis and Factorial Analyses.

Through exploratory factor analysis by reducing off a large number of manifest and correlated variables to a smaller number of latent and uncorrelated variables (factors), was uncovered and explained the latent structure of the cephalofacial variables (StatSoft, 2011; Ferguson, 1954).

Ethical considerations. This project was approved by the Ethics Committee of the Institute of Sports Anthropology.

3. Results and discussion

As we have indicated previously, data of this manuscript are part of our national project: "Morphological characteristics of the Kosovo Albanian population". Since this project is still under development, and the number of the tested entities may increase in the meanwhile, these data may change. As the number of tested entities in both groups is significant (male=561; female=193), we do not expect that the ratio of male/female (1:2.9) may significantly affect the gained results. Data of the correlation matrix (Table I), confirm the establishment of some sets of variables, which realize the higher correlations with each other. These relations between variables within sets appear to be as a result of morpho-functional and genetic integrations of the cephalofacial variables (Cheverud, 1996).

Table I.

Correlations between variables

	G-Op	Eu-Eu	V-Po	HC	N-Gn	Zy-Zy	Go-Go	N-Ns	Al-AL	LH	LW
G-Op	1										
Eu-Eu	.412**	1									
V-Po	.367**	.311**	1								
HC	.719**	.540**	.488**	1							
N-Gn	.499**	.349**	.360**	.452**	1						
Zy-Zy	.316**	.275**	.450**	.490**	.453**	1					
Go-Go	.378**	.379**	.186**	.354**	.335**	.329**	1				
N-Ns	.269**	.150**	.275**	.336**	.574**	.337**	.208**	1			
Al-Al	.360**	.235**	.233**	.363**	.187**	.220**	.344**	.131**	1		
LH	.201**	.120**	.116**	.046	.408**	.087*	.026	.106**	-.047	1	
LW	.299**	.232**	-.001	.172**	.218**	.124**	.375**	.156**	.403**	.125**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

In order to proceed accurately with further procedures of factor analysis, it's needed to evaluate the Kaiser-Meyer-Olkin measure (KMO) and Bartlett's test of sphericity. Both of these measurements have the same goal: to check if we can factorize the original variables efficiently.

The KMO measures the sampling adequacy; in other words, to proceed with the factorization of the measured variables, KMO-value should be greater than 0.5. Interpretive results for the KMO measure of Sampling Adequacy are: in the 0.90 as marvelous, in the 0.80's as meritorious, in the 0.70's as middling, in the 0.60's as mediocre, in the 0.50's as miserable, and below 0.50 as unacceptable.

Bartlett's test of sphericity compares the observed correlation matrix to the identity matrix. If Bartlett's test value is less than 0.05, it means that the correlation matrix is not an identity matrix (Friel, 2007).

According to the results of KMO measure (0.77) and Bartlett's test of sphericity (0.000), as shown in Table II, it can be concluded that the observed correlation matrix diverges significantly from the identity matrix (Friel, 2007). Also, it can be concluded that the strength of the relationships among measured cephalofacial variables is strong enough to proceed with further procedures of the factor analysis that is used to uncover relationships among many variables.

Table II.

Kaiser-Meyer-Olkin Measure (KMO) and Bartlett's Test

KMO Measure of Sampling Adequacy		0.77
Bartlett's Test of Sphericity	Approx. Chi-Square	2807.20
	df	55
	Sig.	0.000

The number of the extracted factors means retaining the factors that contain the most variance of the data. In this research, the number of extracted latent factors has been determined using the Guttman-Kaiser (GK) criterion, suggested by Guttman and adapted by Kaiser. This criterion suggests retaining those factors with eigenvalues equal to or greater than 1, but always respecting the law of Parsimony (Ferguson, 1954).

Based on the principal component method of Factor Analysis, and respecting the GK criterion, were extracted three latent factors that explain 60.12 % of the total variance (Table III). The communality of each variable, shown in Table III, indicates the percentage of variance explained by all the factors jointly (Table III).

Table III.

Total Variance Explained, communality

Component	λ	% of Variance	Cumulative %	h^2
1	4.08*	37.08*	37.08*	0.59
2	1.37*	12.46*	49.54*	0.42
3	1.16*	10.58*	60.12*	0.60
4	0.93	8.45	68.57	0.75
5	0.74	6.74	75.32	0.78
6	0.70	6.33	81.65	0.52
7	0.56	5.05	86.70	0.51
8	0.51	4.64	91.34	0.44
9	0.46	4.19	95.53	0.57
10	0.30	2.72	98.25	0.70
11	0.19	1.75	100.00	0.74

Extraction Method: Principal Component Analysis.
λ – eigenvalue. h^2 – communality* Extracted latent factors

For the appropriate explanation of the extracted latent dimensions, the main components have been transformed using the Obliging Rotation Method converged in 10 iterations, with Kaiser Normalization. The low number of the iterations indicates that the extracted matrix has small distribution on the latent space.

The explanation of the latent structure of the measured cephalofacial dimensions has been enabled based on analyzes of three gained matrices:

a) The pattern matrix (Table IV) – is a matrix of standardized regression coefficients for each of the original variables on the rotated factors, and offers a clearer picture of the relevance of each variable in the factor;

b) The structure matrix (Table IV) – represents the correlations between the measured cephalofacial variables and latent factors;

c) The component correlation matrix (Table V) – shows the relationships between extracted latent factors;

Table IV.
Pattern Matrix & Structure Matrix

	Pattern Matrix			Structure Matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
G-Op	0.50*	0.40	0.14	0.65*	0.57	0.29
Eu-Eu	0.44*	0.36	-0.01	0.55*	0.50	0.13
V-Po	0.82*	-0.15	-0.02	0.76*	0.10	0.12
HC	0.78*	0.23	-0.07	0.84*	0.47	0.12
N-Gn	0.44	0.10	0.64*	0.61*	0.33	0.74
Zy-Zy	0.70*	0.00	0.07	0.72*	0.23	0.22
Go-Go	0.18	0.64*	0.00	0.38	0.70*	0.12
N-Ns	0.42	-0.03	0.44*	0.50	0.16	0.52*
Al-Al	0.15	0.69*	-0.22	0.33	0.71*	-0.10
LH	-0.13	-0.01	0.85*	0.04	0.06	0.83*
LW	-0.30	0.87*	0.20	0.02	0.80*	0.26

Extraction Method: Principal Component Analysis. Rotation Method: Obliging with Kaiser Normalization. Rotation converged in 10 iterations. *The higher projections.

The similarity of the factors composition shown in pattern matrix and structure matrix, indicate clear nature of these factors, as well as enable their logical interpretation (Table IV).

The low reciprocal correlations between extracted latent factors (Table V), ensure that these factors may stay independently.

Table V.
Component Correlation Matrix

Factors	1	2	3
1	1.00		
2	0.32	1.00	
3	0.20	0.13	1.00

Extraction Method: Principal Component Analysis.
Rotation Method: Obliging with Kaiser Normalization.

Reduction of multiple measured variables in a small number of latent factors, always respecting the law of Parsimony, may help and facilitate the work of anthropology in studying and explaining of the morphological construction, and genetically development of the bones, cartilages and soft tissues of the human's head and face.

Using the principal component method of Factor Analysis, oblimin rotation method, and applying Guttman-Keiser Criterion, are extracted three latent factors that explain 60.12 % of the total variance (Table II, III, IV, V).

The data of Table IV indicate that the best projections on **the first extracted latent factor**, which explain 37.08 % of total variance (Table III), have realized the following variables: head length (G-Op), head breadth (Eu-Eu), head height (V-Po), head circumferences (HC), and facial breadth

(Zy-Zy). This factor is assumed to be a latent dimension that informs about neurocranial capacity and might be named as **the factor of intracranial capacity**.

The best projections on **the second extracted latent factor**, which explain 12.46 % of the total variance (Table III), have realized three facial variables: bigonial mandible breadth (Go-Go), nasal breadth (Al-Al), and lips width (LW) (Table IV). This latent factor seems to present the transversal dimension of the face, and rightly might be named as **the transversal factor of the face**.

The third latent factor, which explains 10.58 % of the total variance (Table III), contains the best projections that have realized three other facial variables: face height (N-Gn), nasal height (N-Ns), and lips height (LH) (Table IV). Because these variables measure the longitudinal dimension of the face, the extracted factor might be known as **the longitudinal factor of the face.**

Condensation of manifest variables in a small number of latent dimensions may facilitate the successful work of anthropologists in studying and explaining the genetic development of the bones, cartilages and soft tissues of the head and their morphological construction. Overall, the composition of the extracted factors is consistent with the anthropological explanation of the anthropologists regarding the development of the musculoskeletal and cartilage tissues of the head. For example, the composition of the first factor (four cephalic measured variables: HC, V-PO, G-Op, Eu-Eu, and one facial variable: Zy-Zy) according to Weidenreich (1941) can be explained with the fact that "the absolute breadth of the neurobasicranial complex probably constrains facial breadth".

4. Conflict of interest

The authors declare no conflict of interest and no financial or commercial benefits for the performing of this study.

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RESUMEN

Los estudios antropométricos comenzaron como una metodología en antropología biológica para comparar las características antropológicas de las naciones modernas y también de las naciones en la antigüedad, así como para el cribado y diagnóstico de desnutrición. Se han realizado una gran cantidad de estudios sobre medidas de altura corporal, peso, dimensiones del tronco y las extremidades, grasa subcutánea y composición corporal, etc., pero se ha prestado menos atención a las medidas cefalofaciales. El propósito de esta investigación fue estudiar y explicar la estructura latente de las variables cefalofaciales de los humanos. Se midieron 11 variables cefalofaciales en 754 sujetos sanos (561 hombres y 193 mujeres), de 18 a 35 años. Los datos recolectados fueron analizados mediante parámetros descriptivos, análisis de correlación y análisis factoriales.

El análisis de correlación confirma la existencia de algunos conjuntos de variables, que se caracterizan por tener las correlaciones más altas entre las variables dentro del conjunto. Mediante el análisis de componentes principales del Análisis Factorial se extrajeron cuatro factores latentes que explican el 66,39% de la varianza total: Factor de capacidad intracraneal; Factor transversal de la cara; Factor longitudinal del rostro.

Conclusión: La composición de los factores extraídos fue compatible con la explicación científica de los antropólogos sobre el desarrollo de la cabeza.

Palabras clave: medidas cefalofaciales; estructura latente; antropología.