Structures of morphological characteristics of the population of the island of Rab

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Abstract
The focus of this article is the part of a holistic anthropological interdisciplinary study of the population structure of the inhabitants of the Island of Rab, focused on multivariate analyses of latent morphological variables, to contribute to the explanation of its micro-evolution. The goals of the study were directed to determine population differences in a geographically limited area of Rab, based on the latent morphological variables of the head and body. A representative sample of 601 adult persons (aged 18–75 years) from the settlements of Banjol, Barbat, Lopar, Rab and Supetarska Draga was examined. The analysis included 30 anthropometric variables of the body, as well as 14 anthropometric variables of the head. Principal Component Analysis with Varimax rotation revealed five latent variables of the body and five latent variables of the head (in both sexes), while quasi-confirmatory factor analysis proved that there are no significant differences in component structures among men and women. Analysing the latent morphological variables enabled the clear insight that the examined population is heterogeneous, in the space of the investigated body and head variables for both sexes in certain sets of variables.

KEYWORDS: anthropometry, population structure, Rab

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Introduction

The concept of population structure is an attempt to describe the model of population changes or evolution more realistically. The scope of this study is to explore complex phenotypic morphological traits, as well as to determine the differences among people who live in a quite small geographic area of the northern Adriatic island of Rab. Exploring the population structure can be also viewed as the study of genetic differentiation within the network of small or limited populations, including small deviations from the Hardy-Weinberg balance caused by size, non-random recruitment or subdivision (Pribačić Ambrožić et al. 2009).

Over the course of evolution, various human populations have developed in various parts of the world, exposed to the various pressures of environmental factors. Through the activity of the evolutionary forces of natural selection, genetic drift, gene flow and mutations, these populations have formed their distinctive characteristics (Pribačić Ambrožić et al. 2009). Having in mind the widespread migration pressures to which European populations were exposed during the 20th century, it is hardly impossible to find populations that already remain in reproductive isolation. Therefore, evolutional processes are the best studied in small, reproductively isolated communities (Wright 1931, 1943, 1951). In small local communities, the inbreeding phenomena and gene drift become evident (Rudan et al. 1987a, 1987b, 1987c, 1990a, 1990b), so the effective reproductive size of a population substantially affects the changes in gene frequencies. These island populations' isolates are very convenient for investigating theoretical hypotheses about microevolution (Rudan et al. 1998). Because of their features, the Adriatic islands' isolates have been the issues of numerous anthropological and genetic research projects over the previous 40 years (Rudan 1978; Rudan et al. 1979). The investigations of the inhabitants in the whole region of Middle Dalmatia started in 1972, with special emphasis on the particular populations of the islands of Hvar, Korčula, Pelješac, Brač, Pag, Silba, Krk, and Vis (Rudan 1980, 1982; Rudan et al. 1982, 1986, 1988, 1999; Pavičić, 2004).

The research focused mainly on morphological characteristics gave valuable data on the biological structure of the Middle Dalmatian population, as well as of other Adriatic isolates, and are providing information on the course of their biological microevolution and their social and cultural features (Rudan et al. 1992, 1994; Smolej-Narančić et al. 1987, 1994). Morphological variations are confirmed in accordance with currently known ethnological and demographic data on migration movements of the inhabitants on this territory in the past and present (Pribačić Ambrožić et al. 2009).

The studies of morphological (anthropometric) characteristics of certain populations in Middle Dalmatia are also useful in order to examine the degree and type of morphological variations among populations, for example on the principle of geographical division among the western and eastern parts of the island (on larger islands). The second principle of the analysis of differences is given on the level of populations placed on separate locations (one settlement on the island: Silba and Olib) (Pribačić Ambrožić et al. 2009). Previous research conducted using the same data was performed using univariate analysis on certain morphological variables of the body and head among populations on

the island Rab, separately for two sexes. After analysing 36 body variables, the results revealed the existence of statistically significant heterogeneities in 13 morphological variables in men and in 8 variables in women. Among the variables of head-related phenotypic characteristics, heterogeneity was statistically significant in 7 morphological variables in men and 5 morphological variables in women. Furthermore, the results of discrimination analyses showed that heterogeneity exists in some investigated continuous characteristics among certain populations (Pribačić Ambrožić et al. 2009).

The scope of this study is to explore the population structure, by anthropometric analysis of complex phenotypic traits, of a representative sample of the population in the northern Adriatic island of Rab, separately for men and women. The homogeneity or heterogeneity in morphologic characteristics, as well as the degree of differentiation among subpopulations of Rab, which correspond to the population of certain settlements (Banjol, Barbat, Lopar, Rab, and Supetar Draga) will be determined. For this purpose, the research objectives are defined. The first objective of the study is to identify the latent dimensions of the body and head for anthropometric variables, separately for men and separately for women. The second objective of the study is to determine the factors of differences among the populations on the island of Rab in the latent dimensions of the anthropometric variables and the body in the latent dimensions of the anthropometric variables of the head, separately for men and separately for women.

Sample and methods

The sample of participants included 601 persons, aged from 18 to 75 years (Državni zavod za statistiku 2003). All anthropometric complex characteristics were selected according to the guidelines of the International Biological Program (Weiner & Louri, 1969). All data collection was performed using the techniques and instruments from the Institute of Anthropology, according to the guidelines of the 'Practicum of Biological Anthropology' as follows: 'Anthropometry' (Buzina et al. 1975) and 'Morphological and functional anthropometry' (Buzina et al. 1984). The principle of the selection of the methods applied to participant were performed according to the protocol of the Institute of Anthropology in Zagreb and of the International Biological Program (IBP; 1982, according to Pribačić Ambrožić et al. 2009). The analysis included 30 anthropometric variables of the body, as well as 14 anthropometric variables of the head.

Biostatistical analyses were carried out with methods of univariate and multivariate statistics, separately for subsamples of men and women. The influence of the variable age on the variables of the body and head has been eliminated by linear regression. A large number of manifest variables of the body and the head is reduced by using the principal components analysis (PCA) with Varimax rotation (hereinafter, the expressions factor analysis and PCA, factors and principal components are used as the synonyms). Comparisons among factor structures for the variables of body and head in males and females were performed using the simple robust method for quasi-confirmatory factor analysis (QCFA) (Sindik 2013). Further analysis of the differentiation among subpopulations of Rab, which correspond to the populations of some villages, were carried out

using appropriate regression factor scores for each latent anthropometric variable. Canonical discriminant analysis (DA) was used for determining the differences among the studied settlements, separately in the latent space of anthropometric variables of the body, and separately in the area of anthropometric variables of the head. ANOVA was used in testing the differences among the populations in the studied villages, for each latent anthropometric variable of the body or head. Statistical analysis was performed using the software package IBM SPSS Statistics 19.0.

Results

Descriptive statistics was performed separately for the subsets of body and head anthropometric variables. In previous research (Pribačić Ambrožić et al. 2009), among the total of 36 body variables in male participants, the existence of statistically significant heterogeneity was found in 13 anthropometric characteristics. In female participants, among 36 body variables, the existence of statistically significant heterogeneities was found in 8 anthropometric characteristics. With anthropometric variables of the head, in male participants, the existence of statistically significant heterogeneities was found in the following 7 (out of 14) anthropometric head variables in total. Among female participants, of 14 anthropometric head variables, statistically significant heterogeneities were found in 5 characteristics (Pribačić Ambrožić et al. 2009).

In this research, factor analysis is conducted separately on all samples of men and women, separate sets of variables for the body and head. In the analyses are used only simple anthropologic variables (excluding complex, or derived morphological variables, such as BMI), in other words a lower number of body variables (30, instead of 35) than in the previous study (Pribačić Ambrožić et al. 2009). All the variables used in this and previous study were standardised by age, which is important for considering real differences in morphological characteristics (Buffa et al. 2011).

Table 1 shows the matrix of the factor loadings after Varimax rotation, for standardised variables of the *body* by age, separately for men and women subsamples. With both men and women, the application of PCA revealed the five principal components of the body morphological characteristics. Based on the variables that largely saturated each principal component, the factors in men are as follows: the transversal dimensions of the body, circumferences and body weight (factor 1), the longitudinal dimensions of the body and hip circumference (factor 2), the transversal dimensions of the extremities (factor 3), skin folds (factor 4), and the circumference of the knee (factor 5). Based on the variables that largely saturated each principal component, the factors in women are as follows: circumferences of the body and extremities, skin folds and body weight (factor 1), the longitudinal dimensions of the body and hip circumference (factor 2), the transversal dimensions of the extremities (factor 3), the circumference of the knee (factor 4), and the transversal dimensions of the body (factor 5). When applying the simple robust method for quasi-confirmatory factor analysis (QCFA), it was shown that no statistical significant differences are found among comparable factor structures at the morphological variables of the body, in males and females (when testing the differences among factor structures using the McNemar test).

Table 1: Matrix of the factors' loadings after Varimax rotation of the standardised anthropometric variables of the body by age

	Males (N=259)					**Females** (N=342)				
Variable	F 1	F 2	F 3	F 4	F 5	F 1	F 2	F 3	F 4	F 5
body height		**0.894**					**0.889**			
sitting height		**0.531**					**0.535**			
leg length		**0.916**					**0.883**			
upper leg length		**0.800**					**0.740**			
lower leg length		**0.785**					**0.776**			
arm length		**0.865**					**0.862**			
forearm length		**0.803**					**0.743**			
upper arm length		**0.724**					**0.672**			
biacromial length	**0.521**	0.406			0.395	0.425	0.379			**0.568**
thorax width	**0.616**				0.487	0.428				**0.679**
thorax depth	**0.760**					**0.664**		0.309		
pelvis width		**0.524**				0.346	**0.466**	0.371		
bicondiar with upper arm left	0.364		**0.697**			0.320		**0.744**		
bicondiar with upper arm right	0.405		**0.700**			0.325		**0.754**		
left knee width			**0.815**					**0.794**		0.303
right knee width			**0.803**					**0.798**		
bicondilar width femur left	0.378		0.401	0.307	**0.627**				**0.792**	
bicondilar width femur right	0.397		0.403	0.309	**0.633**				**0.815**	
left ankle width		0.351	**0.699**				0.397	**0.636**		
right ankle width		0.370	**0.716**				0.438	**0.682**		
thorax circumferen.	**0.885**					**0.867**				
abdominal circumferen.	**0.829**					**0.857**				
ledge circumferen.	**0.794**			0.321		**0.725**			0.445	
arm circumferen.	**0.820**					**0.844**				
forearm circumfere.	**0.769**		0.468			**0.738**		0.310		
upper thigh circumferen.	**0.776**			0.363		**0.687**			0.515	
lower thigh circumferen.	**0.656**		0.331	0.303		**0.568**			0.511	
biceps skinfold	0.417			**0.741**		**0.748**				
triceps skinfold	0.354			**0.803**		**0.670**			0.414	
suprailiac skinfold				**0.816**		0.455			**0.663**	
body mass	**0.848**	0.312				**0.854**	0.318			
Eigenvalue	7.697	6.367	4.594	2.643	1.885	7.465	5.939	4.234	3.177	1.439
Variance explained (%)	24.8	20.5	14.8	8.5	6.1	24.1	19.2	13.7	10.2	4.6
Cumulative % variance	24.8	45.4	60.2	68.7	74.8	24.1	43.2	56.9	67.1	71.8

Legend:

Males: *Factor 1- transversal dimensions of the body, circumferences and body weight; Factor 2-longitudinal dimensions of the body and pelvis width; Factor 3-transversal dimensions of the extremities; Factor 4-skinfolds; Factor 5- knee width*

Females: *Factor 1- body circumferences and the extremities, skinfolds and body weight; Factor 2-longitudinal dimensions of the body and pelvis width; Factor 3-transversal dimensions of the extremities; Factor 4- knee width; Factor 5- transversal dimensions of the body*

However, all correlations among comparable factor structures are positive and significant: the contingency coefficient among first factors in males and females equals 0.595 (p<.01), between second factors 0.707 (p<.01), among third factors 0.475 (p<.01), among fourth factors 0.675 (p<.01) and among fifth factors 0.465 (p<.01).

Table 2: Matrix of the factors' loadings after Varimax rotation of the standardised anthropometric variables of the head by age

	Males (N=259)					**Females** (N=342)				
Variable	F 1	F 2	F 3	F 4	F 5	F 1	F 2	F 3	F 4	F 5
head length	0.301	0.424	**0.517**		0.315			**0.907**		
head width	**0.786**					**0.709**				
forehead width	**0.839**					**0.849**				
face width	**0.828**					**0.853**				
lower jaw width	**0.610**					**0.594**				
morphological cheek height		**0.799**					**0.822**			
nose height		**0.811**					**0.753**			
nose width			**0.641**	0.457						**0.786**
mouth width			**0.749**							**0.803**
lip thickness					**0.696**		**0.656**			
ear length				**0.659**					**0.699**	
ear width				**0.780**					**0.757**	
interorbital width					0.627			0.333		
head circumference	**0.630**		0.393			0.463		**0.739**		
Eigenvalue	2.996	1.763	1.600	1.424	1.275	2.737	1.834	1.680	1.398	1.339
Variance explained (%)	21.4	12.6	11.4	10.2	9.1	19.6	13.1	12.0	10.0	9.6
Cumulative % variance	21.4	34.0	45.4	55.6	64.7	19.6	32.6	44.6	54.6	64.2

Legend:

Males: *Factor 1- transversal dimensions of the head and head circumference; Factor 2-longitudinal dimensions of the face; Factor 3-transversal dimensions of the face and head length; Factor 4-length and width of the ear; Factor 5- lip thickness and interorbital width*

Females: *Factor 1- transversal dimensions of the head; Factor 2-l longitudinal dimensions of the face and lip thickness; Factor 3-head length, interorbital width and head circumference; Factor 4- length and width of the ear; Factor 5- transversal dimensions of the face*

Table 2 shows the matrix of the factor loadings after Varimax rotation, for standardised variables of the *head* by age, separately for male and female subsamples. Both with men and women, the application of PCA revealed the five principal components of the head morphological characteristics. Based on the variables that largely saturated each principal component, the factors in men are named as follows: the transversal dimensions of the head and head circumference (factor 1), the longitudinal dimensions of the face (factor 2), the transversal dimensions of the face and head length (factor 3), length and width of the ear (factor 4), and thick lips and inter-orbital width (factor 5). Based on the variables that largely saturated each principal component, factors in women are as follows: the transversal dimensions of the head (factor 1), the longitudinal dimension of the face and thick lips (factor 2), head length, inter-orbital width and head circumference (factor 3), length and width

of the ear (factor 4), and the transversal dimensions of the face (factor 5). When QCFA was applied, it was shown that no statistically significant differences are found among comparable factor structures at the variables of the head, in males and females (when testing differences among factor structures using the McNemar test). However, all correlations among comparable factor structures are positive and significant: the contingency coefficient among first factors in males and females equals 0.652 ($p<.01$), among second factors 0.499 ($p<.05$), among third factor in males and fifth factor in females 0.542 ($p<.05$), among fourth factors 0.616 ($p<.01$) and among fifth factor in males and third factor in females 0.499 ($p<.05$).

Box's M tests for all sets of variables met the assumption of homogeneity of variance-covariance matrix, which allowed further step discriminant analysis.

Table 3: Discrimination analysis in a space of latent anthropometric variables of the body in males among certain settlements on the island Rab

Discrimination function	**Eigen-value**	**Variance explained**	**Canonical correlation**	**Test dis.fun.**	**Wilks's lambda**	**χ^2-test**	**df**	**p**
1	0.243	71.7	0.442	1 – 4	0.733	78.552	20	**<0.001**
2	0.067	19.8	0.250	2 – 4	0.911	23.612	12	**<0.050**
Latent variables	**Places on Rab**	**N**	**Mean**	**SD**	**SE of Mean**	**F (df1/df2= 4/254)**	**Corr. with 1st discr. funct.**	**Corr. with 2nd discr. funct.**
transversal dimensions of the body, circumferences and body weight	Banjol	33	0.229	1.017	0.177	1.615	**0.757**	0.210
	Barbat	73	-0.051	0.941	0.110			
	Lopar	71	0.026	0.931	0.111			
	Rab	40	0.158	1.183	0.187			
	Sup.Draga	42	-0.286	0.982	0.152			
longitudinal dimensions of the body and pelvis width	Banjol	33	0.076	0.915	0.159	0.814	-0.129	**0.786**
	Barbat	73	-0.146	0.911	0.107			
	Lopar	71	0.136	1.022	0.121			
	Rab	40	0.028	1.007	0.159			
	Sup.Draga	42	-0.062	1.165	0.180			
transversal dimensions of the extremities	Banjol	33	0.042	0.838	0.146	**3.182***	**0.522**	-0.149
	Barbat	73	-0.076	1.075	0.126			
	Lopar	71	0.104	0.958	0.114			
	Rab	40	-0.413	0.876	0.139			
	Sup.Draga	42	0.318	1.058	0.163			
skinfolds	Banjol	33	0.006	1.034	0.180	**9.364****	-0.014	**-0.532**
	Barbat	73	0.551	1.154	0.135			
	Lopar	71	-0.298	0.775	0.092			
	Rab	40	-0.278	0.747	0.118			
	Sup.Draga	42	-0.195	0.869	0.134			
knee width	Banjol	33	0.266	0.837	0.146	**4.969****	-0.195	-0.121
	Barbat	73	0.284	0.971	0.114			
	Lopar	71	-0.382	0.975	0.116			
	Rab	40	0.003	0.934	0.148			
	Sup.Draga	42	-0.061	1.088	0.168			

*Legend: ** F statistically significant at p<.01; *F statistically significant at p<.05; bold – highest statistically significant differences*

In Table 3, which refers to the differences in the latent anthropometric variables of the body in men, it is evident that the two discriminant functions statistically significantly differ among male residents of five different settlements on the island of Rab. The first discriminant function is the best described by latent variables of the transversal dimensions of the extremities and transversal dimensions of the body, circumferences and body weight. The second discriminant function is the best described by the latent variables of the longitudinal dimensions of the body and pelvis width and the negative projection of skinfolds. Based on the results of the ANOVA with respect to the discriminant function, it was showed that in a total of five factors of anthropometric variables of the body, three statistically significant indices of heterogeneity among male subpopulations in Rab are found in the transversal dimensions of the extremities; skinfolds; the width of the knee. Based on the discrimination functions, 40.5% of the participants are correctly classified. The most stable group is the subpopulation of males from Lopar with 67.6% of the participants correctly classified, followed by the population of the village Barbat with 67.1% of the participants correctly classified.

Table 4: Discrimination analysis in a space of latent anthropometric variables of the body in females among certain settlements on the island Rab

Discrimination function	**Eigen-value**	**Variance explained**	**Canonical correlation**	**Test dis.fun.**	**Wilks's lambda**	**χ^2-test**	**df**	**p**
1	0.332	88.0	0.499	1 – 4	0.718	**111.30**	20	**<0.001**
Latent variables	**Places on Rab**	**N**	**Mean**	**SD**	**SE of Mean**	**F (df1/df2= 4/254)**	**Corr. with 1st discr. funct.**	
circumferences of the body and extremities, skinfolds and body weight	Banjol	63	0.045	1.023	0.129	**2.425***	**0.682**	
	Barbat	84	-0.104	1.017	0.111			
	Lopar	68	0.306	0.956	0.116			
	Rab	69	-0.068	1.041	0.125			
	Sup.Draga	58	**-0.176**	0.897	0.118			
longitudinal dimensions of the body and pelvis width	Banjol	63	0.030	0.947	0.119	1.209	**0.533**	
	Barbat	84	-0.144	0.973	0.106			
	Lopar	68	0.204	0.998	0.121			
	Rab	69	-0.053	0.950	0.114			
	Sup.Draga	58	0.001	1.139	0.150			
transversal dimensions of the extremities	Banjol	63	-0.150	0.979	0.123	2.263	-0.091	
	Barbat	84	0.140	0.948	0.104			
	Lopar	68	0.214	1.097	0.133			
	Rab	69	-0.191	0.937	0.113			
	Sup.Draga	58	-0.063	1.006	0.132			
knee width	Banjol	63	0.284	0.962	0.121	**13.158****	-0.219	
	Barbat	84	**0.382**	0.898	0.098			
	Lopar	68	**-0.636**	0.844	0.102			
	Rab	69	0.025	0.987	0.119			
	Sup.Draga	58	-0.145	0.997	0.131			
transversal dimensions of the body	Banjol	63	0.138	0.935	0.118	**8.326****	-0.190	
	Barbat	84	**0.409**	1.023	0.112			
	Lopar	68	**-0.457**	0.982	0.119			
	Rab	69	-0.065	0.845	0.102			
	Sup.Draga	58	-0.128	0.993	0.130			

*Legend: ** F statistically significant at p<.01; *F statistically significant at p<.05; bold – highest statistically significant differences*

In Table 4, which refers to the differences in anthropometric variables latent body of women, it is evident that one discriminant function was significantly different among the residents of five different settlements on the island of Rab. The first discriminant function is the best described by latent variables: circumferences of the body and extremities, skinfolds and body weight and longitudinal dimensions of the body and pelvis width. Based on the results of the ANOVA with respect to the discriminant function, it was shown that in five factors of anthropometric variables of the body, statistically significant indices of heterogeneity among female subpopulations in Rab are found: circumferences of the body and extremities, skinfolds and body weight; knee width; transversal dimensions of the body. Based on the discriminant function, 37.4% of the participants are correctly classified. The most stable group is the subpopulation of females from Lopar, with 67.6% of the participants are correctly classified.

Table 5: Discrimination analysis in a space of latent anthropometric variables of the head in males among certain settlements on the island Rab

Discrimination function	**Eigen-value**	**Variance explained**	**Canonical correlation**	**Test dis.fun.**	**Wilks's lambda**	**χ^2-test**	**df**	**p**
1	0.318	76.4	0.491		1 – 4	0.690	94.00	20
2	0.072	17.2	0.258		2 – 4	0.909	24.19	12
Latent variables	**Places on Rab**	**N**	**Mean**	**SD**	**SE of Mean**	**F (df1/df2= 4/254)**	**Corr. with 1st discr. funct.**	**Corr. with 2nd discr. funct.**
transversal dimensions of the head and head circumference	Banjol	33	-0.066		1.067			
	Barbat	73	0.088		1.006			
	Lopar	71	**0.263**		0.869	**3.125***	**0.918**	0.343
	Rab	40	-0.244		1.039			
	Sup.Draga	42	**-0.313**		1.008			
longitudinal dimensions of the face	Banjol	33	0.167		0.974			
	Barbat	73	-0.060		1.163			
	Lopar	71	0.002		0.990	1.095	-0.194	**0.671**
	Rab	40	0.186		0.715			
	Sup.Draga	42	-0.208		0.953			
transversal dimensions of the face and head length	Banjol	33	-0.008		1.137			
	Barbat	73	-0.088		0.967			
	Lopar	71	0.172		1.015	0.763	0.016	0.151
	Rab	40	-0.080		1.070			
	Sup.Draga	42	-0.055		0.849			
length and width of the ear	Banjol	33	0.427		0.943			
	Barbat	73	**0.497**		0.909			
	Lopar	71	**-0.660**		0.853	**17.530****	-0.182	0.633
	Rab	40	0.052		0.895			
	Sup.Draga	42	-0.134		0.884			
lip thickness and interorbital width	Banjol	33	-0.226		1.029	**2.794***	-0.177	0.082
	Barbat	73	0.070		0.973			
	Lopar	71	**0.214**		1.053			
	Rab	40	0.056		0.888			
	Sup.Draga	42	-0.360		0.946			

*Legend: ** F statistically significant at p<.01; *F statistically significant at p<.05; bold – highest statistically significant differences*

In Table 5, which refers to the differences in the latent anthropometric variables of the head in men, it is evident that the two discriminant functions significantly differ among the residents of five different settlements on the island of Rab. The first discriminant function is the best described by the latent variable transversal dimensions of the head and head circumference. The second discriminant function is the best described by the latent variables: longitudinal dimensions of the face; length and width of the ear. Based on the results of the ANOVA, with respect to the discriminant functions, it is showed that in a total of five factors of the anthropometric variables of the head, three statistically significant indices of heterogeneity among male subpopulations in Rab are found: in the transversal dimensions of the head and head circumference; length and width of the ear; lip thickness and interorbital width. Based on the discrimination functions, 42.1% of participants are correctly classified. The most stable group is the subpopulation of males from Lopar, with 70.4% of participants correctly classified.

Table 6: Discrimination analysis in a space of latent anthropometric variables of the head in females among certain settlements on the island Rab

Discrimination function	**Eigen-value**	**Variance explained**	**Canonical correlation**	**Test dis.fun.**	**Wilks's lambda**	**χ^2-test**	**df**	**p**
1	0.141	65.1	0.352	1 – 4	0.813	69.409	20	**<0.001**
2	0.052	23.7	0.221	2 – 4	0.928	24.962	12	**0.015**
Latent variables	**Places on Rab**	**N**	**Mean**	**SD**	**SE of Mean**	**F (df1/df2= 4/254)**	**Corr. with 1st discr. funct.**	**Corr. with 2nd discr. funct.**
transversal dimensions of the head	Banjol	63	-0.031	1.168	0.147			
	Barbat	84	0.090	1.062	0.116			
	Lopar	68	0.122	0.878	0.107	1.030	**0.828**	0.213
	Rab	69	-0.184	0.803	0.097			
	Sup.Draga	58	-0.020	1.053	0.138			
longitudinal dimensions of the face and lip thickness	Banjol	63	0.272	1.057	0.133			
	Barbat	84	0.063	0.961	0.105			
	Lopar	68	-0.156	1.006	0.122	2.077	-0.128	**0.858**
	Rab	69	-0.037	1.011	0.122			
	Sup.Draga	58	-0.159	0.933	0.123			
transversal dimensions of the face	Banjol	63	-0.049	0.983	0.124			
	Barbat	84	0.102	1.019	0.111			
	Lopar	68	**0.313**	1.041	0.126	**3.523****	0.228	-0.025
	Rab	69	-0.159	0.954	0.115			
	Sup.Draga	58	**-0.271**	0.906	0.119			
length and width of the ear	Banjol	63	-0.049	0.992	0.125			
	Barbat	84	**0.482**	0.972	0.106			
	Lopar	68	**-0.395**	0.929	0.113	**8.537****	0.003	**0.437**
	Rab	69	-0.120	0.973	0.117			
	Sup.Draga	58	-0.039	0.917	0.120			
head length, interorbital width and head circumference	Banjol	63	-0.049	1.070	0.135			
	Barbat	84	**-0.207**	1.010	0.110			
	Lopar	68	**0.287**	1.024	0.124	**2.469***	**-0.440**	0.119
	Rab	69	-0.043	0.900	0.108			
	Sup.Draga	58	0.067	0.939	0.123			

*Legend: ** F statistically significant at p<.01; *F statistically significant at p<.05; bold – highest statistically significant differences*

In Table 6, which refers to the differences in the latent anthropometric variables of the head in women, it is evident that the two discriminant functions significantly differ among residents of five different settlements on the island of Rab. The first discriminant function is the best described by the latent variables: transversal dimensions of the head; negative projection on head length, interorbital width and head circumference. The second discriminant function is the best described by the latent variables: longitudinal dimensions of the face and lip thickness; length and width of the ear. Based on the results of the ANOVA with respect to the discriminant functions, it showed that in a total of five factors of anthropometric variables of the head, three statistically significant indices of heterogeneity among female subpopulations in Rab are found in: transversal dimensions of the face; length and width of the ear; head length, interorbital width and head circumference. On the basis of the discrimination functions, 31.3% of the participants are correctly classified. The most stable group is the subpopulation of females from Barbat (58.3% correctly classified participants), followed by Lopar with 45.6% correctly classified participants.

Discussion and conclusions

The factors revealed in this research followed the logic of morphological factors (cumulative environmental-genetic factor, longitudinal factor and transversal factors) obtained in the research about morphometric variables, measured on six metacarpal bones (Šimić et al. 1992). These factors can be discussed within the context of their biological meaning affecting the phenotypic formation of the body and head (as well as of the metacarpal skeleton) in a given population (Smolej et al. 1987; Šimić et al. 1992; Smolej-Narančić et al. 1994).

Based on the analysis of complex phenotypic traits in subpopulations of Rab, it is possible to present the following general findings. First, by using the regression procedures, when we analysed the impact of age on anthropometric characteristics, it is found that age has a significant proportion of variability in these variables and in both sexes. Specifically, with aging, there is an increase in transversal variables and in circumferences, with a reduction of longitudinal variables. Among the variables of the head, there is an increase in the size of the face and ear. The impact of the factors of age, height and weight, on the investigated properties (variables) is eliminated by their standardisation, enabling an analysis of phenotypic variations in the subpopulations with a large age range.

The estimation of the heterogeneity among the subpopulations of the island, using latent variables, showed that in both sexes, population settlements differ in three of the five factors, among anthropometric variables of the body. Heterogeneity among subpopulations exist for eco-labile properties (circumferences of the body and extremities, diameters of the extremities and skinfolds). This fact suggests that the observed phenotypic variations of the body are primarily the results of the interaction among phenotypic plasticity and adaptation. Results of the assessment of the heterogeneity among the subpopulations of Rab using the latent dimensions of the head in both men and women showed significant differences in three factors. Heterogeneity in eco-stabile properties of the head indicates that due to differing population settlement in different periods and due to reproductive isolation, the population from the examined settlements retain their

original properties. Discriminant analysis, conducted in the space of anthropometric variables of the body, separate men from Lopar and Barbat according to their skinfolds. Men from Rab and Supetar Draga can be discriminated by their transverse dimensions of the extremities. Women from Lopar and Barbat can be differed by the transverse dimensions of the body and the width of the knee. Discriminant analyses, conducted in the space of the variables of the head, showed that in both sexes, people from Lopar have smaller ears and a larger head circumference.

Therefore, the investigations in the space of morphological dimensions performed on the populations of inhabitants of the Island of Rab provided data useful for explaining micro-evolutional processes that shaped the present population of the island (Pribačić Ambrožić et al. 2009). Analysing the latent morphological variables enabled clearer insight that the examined population is heterogeneous in the space of the investigated body and head variables for both sexes. The heterogeneity of body variables in men from five locations on the Island of Rab is more emphasised in the torso and extremities circumferences, as well as in the diameters of extremities (eco-labile characteristics). In other words, their phenotype is more prone to the impact of external factors during the periods of growth and development (Rudan et al. 1994). The heterogeneity in women is more emphasised in eco-labile, but also in eco-stable morphological characteristics, which can be explained in terms of the female phenotype, in contrast to the male, less susceptible to the influence of ecological factors, as well as in terms of univariate analyses (Pribačić Ambrožić et al. 2009).

The performed discrimination analyses showed the existence of differences in latent morphological variables of the body and head in both men and women. These differences are more clearly seen in more eco-labile variables; the greatest differences can be seen among the settlements of Barbat and Lopar, both in head and body latent variables. In terms of historical course of settling on the Island of Rab, it has to be mentioned that the emergence of population groups on the island was followed by long periods of complete biological and socio-cultural isolation. This partial isolation, together with the interactive evolution processes, can have a result in phenotypic and biological (morphological) differentiation of a group (Rudan et al. 1988; Rudan et al. 1999). These results clearly reflect the grouping of current population communities on the Island of Rab, in terms of their morphological characteristics, which can be correlated with the historical facts on the settling of the island, together with the dynamics of the migrations of the inhabitants on the island. In the future studies, whether this biological variation in morphology variables is related to geographic, linguistic and migration differences could be examined.

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Povzetek

Glavni predmet pričujočega članka je del holistične antropološke interdisciplinarne študije populacijske strukture prebivalstva otoka Raba, ki temelji na multivariatnih analizah latentnih morfoloških spremenljivk, z namenom obrazložitve mikroevolucije prebivalstva. Cilji raziskovanja so usmerjeni v proučevanje razlik med prebivalstvom v geografsko zamejenem področju Raba na osnovi latentnih morfoloških spremenljivk glave in telesa. Predstavljena je analiza reprezentativnega vzorca 601 odraslih oseb (v starosti od 18 do 75 let) iz naselij Banjol, Barbat, Lopar, Rab in Supetarska Draga. V analizo je vključenih 30 antropometrijskih spremenljivk telesa ter 14 antropometrijskih spremenljivk glave. Analiza glavnih komponent z varimax rotacijo je izolirala pet latentnih spremenljivk telesa in pet latentnih spremenljivk glave (pri obeh spolih), medtem ko je kvazi-konfirmatorna faktorska analiza pokazala, da ni statistično značilnih spolnih razlik v latentni strukturi morfoloških spremenljivk. Analizira razlik v latentnih morfoloških spremenljivkah je omogočila jasen vpogled v heterogenost proučevane populacije v prostoru proučevanih spremenljivk telesa in glave pri obeh spolih.

KLJUČNE BESEDE: antropometrija, struktura prebivalstva, Rab

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