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Original scientific paper

Anthropometrical Characteristics of the Population of the Island of Rab

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A B S T R A C T

The paper presents the results of the population structure research on the inhabitants of the Island of Rab by the analysis of anthropometric, continuous characteristics (morphological variables of head and body) on the representative sample of 601 adult persons (aged 18–75 years) from the settlements Banjol, Barbat, Lopar, Rab and Supetarska Draga (Figure 1). The aim was to investigate the possibility to confirm the existence of population groupings or divisions in one geographically limited area based on the analysis of continuous anthropometric variables. In other words, the purpose is to investigate the structure of the inhabitants in order to contribute to the explanation of its microevolution. The performed analysis shows partial anthropometric variability of the present day population that is confirmed by a series of biostatistics analyses. The analysis includes continuous (quantitative) characteristics, 36 anthropometric body variables and 14 anthropometric head variables. Heterogeneity among the groups of examinees is evaluated for separate phenotypic characteristics in order to obtain the data on the inhabitants' microevolution. The estimation performed on the total of 36 analyzed body variables showed the existence of statistically significant heterogeneities for 13 variables in men and for women in 8. By descriptive statistic procedures and by the estimation of heterogeneity, in space of the head related phenotypic characteristics, heterogeneity was found for 7 characteristics in men and for 5 in women. Discrimination analyses show that certain heterogeneity exists in some investigated continuous characteristics among individual populations. The results of the biological distances evaluation among the populations of the Island of Rab point to the separation of some populations, primarily of the inhabitants of Lopar.

Key words: *anthropometry, population structure, Rab*

Introduction

The investigations of the population structure are important in the current day anthropology, population genetics and demography. We can nowadays define population structure 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. Also, population structure is an attempt to describe the model of population changes or evolution more realistically.

During evolution, through the process of hominization various human populations have developed in various parts of the world. Human populations, exposed to various pressures of the environmental factors, through the activity of evolutional forces of natural selection, genetic drift, gene flow and mutations have formed their distinctive characteristics. It is known that evolutional processes are best expressed in small, reproductively isolated communities[1–3]. Effective reproductive size of a population (N_{ef}) substantially affects the changes in gene frequencies, because in small local communities the inbreeding phenomena and gene drift become evident[4–8]. It is today practically impossible to find populations that still remain in reproductive isolation, particularly in Europe, having in mind many migration pressures to which they were exposed during the 20th century. As the so-called island populations isolates are among the best for investigating theoretical hypotheses (microevolution) by

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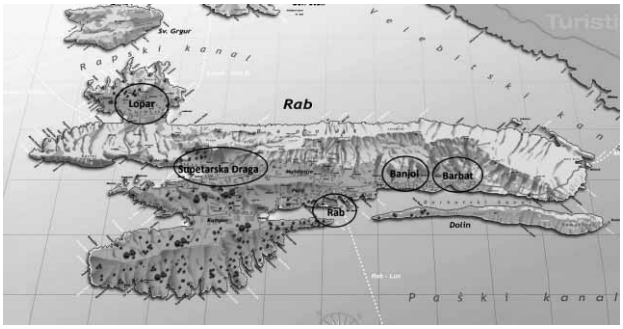

Fig. 1. Island of Rab with location of the town Rab and other settlements where researches were carried out

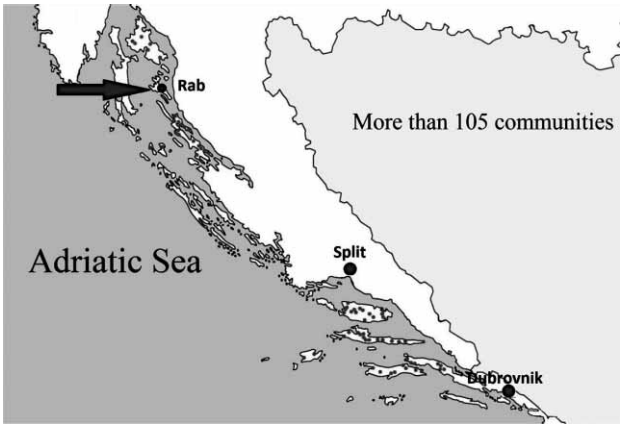

Fig. 2. Adriatic's islands where researches were carried out.

applying holistic approach, it must be stressed that they still exist in our country[9]. As rare ones among the existing in Europe, the Adriatic islands isolates have been the subjects of many anthropological and genetic research projects during the last 30 years[10–11]. Rudan started them already in 1972, with the investigations of the inhabitants in the whole region of the Middle Dalmatia[12], but also of particular island populations of, for example, islands of Hvar, Korčula, Pelješac, Brač, Pag, Silba, Krk and Vis[13–18] (Figure 2). Within the so far anthropological investigations of population structure in the Middle Dalmatia, morphological (anthropometric) characteristics of individual populations are also analyzed in order to examine the degree and type of morphological variations among populations, on the level of E-W division (on larger islands) and on the level of populations of separate locations (one settlement on the island: Silba and Olib). Along that, 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 today. This shows that morphological characteristics yield valuable data on biological structure of the Middle Dalmatian population, as well as of other Adriatic isolates. The collected information open the possibility to draw conclusions on the course of their biological microevolution, along with the knowledge of their social and cultural features[19–22].

Sample and Methods

The performed research project used data collected in 2002 on the inhabitants of the Island of Rab. The sample encompassed 601 persons, aged from 18 to 75 years[23]. Anthropometric complex (continuous) characteristics were selected according to the guidelines of the International Biological Program (IBP – Weiner and Lourie, 1969) that are worldwide accepted for investigations with similar purposes. All performed investigations were done by the techniques and instruments from the Institute of Anthropology, according to the guidelines of the »Practicum of Biological Anthropology« as follows: »Anthropometry«[24] and »Morphological and functional anthropometry«[25]. The selection of examinees and applied methods were performed according to the protocol of the Institute of Anthropology in Zagreb and of the International Biological Program (IBP; 1982). The analysis included 35 anthropometric variables of the body and MBI, as well as 14 anthropometric variables of the head. Biostatistic analyses were done on original data. The basic analysis of divisions and measures of the central tendency was done on individual variables and by separate groups of examinees. Homogeneity and heterogeneity of characteristics were subsequently evaluated, while with distance statistics were evaluated biological distances among individual groups of examinees. Dendograms presented phylogenetic relation among individual groups of inhabitants determined on the basis of the Malahanobis distances[26]. By the analysis in latent space (PC), the identity and/or variety among individual groups and among sets of the analyzed phenotypic continuous variables were assessed. The canonical discrimination analysis presented the relation of individual groups in two dimensional discrimination space and evaluated the significance of particular discrimination functions, as well as the percentage of variables explained by them.

Results

Descriptive statistics and evaluation of heterogeneity

Statistical analyses were performed separately for the groups of body and head variables.

a) Body anthropometric variables

Out of the total of 36 body variables, we found the existence of statistically significant heterogeneity in 13 for the following characteristics: the thorax width (THW, $p=0.020$), the left wrist width (LWRW, $p=0.049$), the right wrist width (RWRW, $p=0.041$), the left knee width (LKNW, $p=0.002$), the right knee width (RKNW, $p=0.001$), the left ankle width (LANW, $p=0.016$), the right ankle width (RANW, $p=0.025$), the thigh circumference (THC, $p=0.047$), the biceps skinfold (BSKF, $p<0.001$), the triceps skinfold (TSKF, $p<0.001$), suprailiac skinfold 1 (SISKF1, $p<0.001$), abdomi nal skinfold (ABDSKF, $p=0.015$), the calf skinfold (CASKF, $p=0.001$).

In female examines, out of 36 body variables, in 8 the existence of statistically significant heterogeneities was found as follows: the arm length (ARL. p=0.011), the forearm length (FAL, p=0.003), the thorax width (THW, p=0.002), the right wrist width (RWRW, p=0.018), the left knee width (LKNW, p<0.0001), the right knee width (RKNW, p<0.001), the biceps skinfold (BSKF, p=0,003), the calf skinfold (CASKF, p=0.012).

b) Head anthropometric variables

In male examinees, out of 14 anthropometric head variables, the existence of statistically significant heterogeneities was found in the following 7: the cheek width (CHW, p=0.009), the morphological cheek height (MORCHH, p=0.0010), the nose width (NOW, p=0.008), the mouth width (MOW, p=0.010), the ear length (EAL, p=0.001), the ear width (EAW, p<0.001), interorbital width (INTORBW, p=0.078).

In female examinees, from 14 anthropometric head variables, statistically significant homogeneities were recorded in 5: morphological cheek height (MORCHH, p=0.007), mouth width (MOW, p<0.001), the ear length (EAL, p=0.025), the ear width (EAW, p<0.001), interorbital width (INTORBW, p<0.001).

Discrimination analyses

Discrimination analyses were performed separately in the space of the body and head variables for the group of women and for the group of men. For the investigation of the male population in the space of body variables, the first function is significant at the level of 0.1%. To it also belongs the largest percentage of the total differentiation of even 56.9%. The impact upon discrimination has the second function as well, with 18.7% of participation. The effect of these two functions is visible in Figure 3. where the centroids of individual tested populations are put in the space defined with the first (abscise) and second (ordinate) discrimination function. These figures obviously indicate that the characteristic of the first function is the finding of the biceps skinfold, the triceps skinfold, bicondylar width of the right thigh-bone, bicondylar width of the left thigh-bone as positive correlations, and as the negative ones the arm length, the forearm length and the upper-arm length. For the second function significant variable is the calf skinfold.

In the space of these two discrimination functions is seen that, consequently to positive correlations, in the space of body variables the group of men from Barbat characterizes the larger biceps skinfold, triceps skinfold, the left knee width, the left upper-arm length. Contrary to that, the inhabitants of Lopar, situated on the North--East, yielded the reverse findings.

In the space of body variables in men, 61.3% of the examinees were correctly classified by individual settlements. The most stable population is from Lopar with correctly classified 72.5% of the examinees.

For the tested male population in the space of head variables, the first function is significant at the level of 0.1%. To it belongs the highest percentage of the total

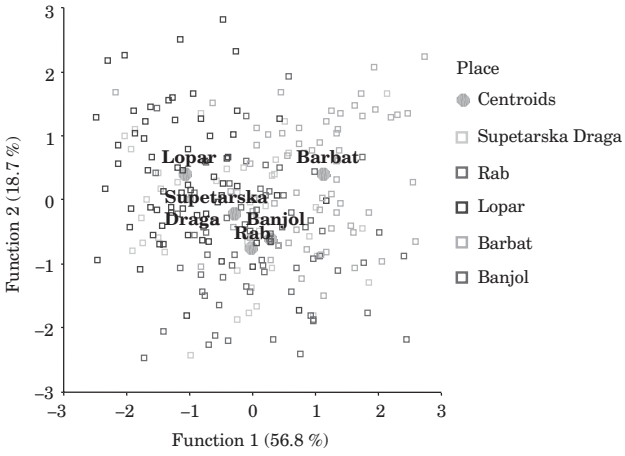

Fig. 3. Diagram defined by first two discriminant functions for body variables (men).

differentiation of even 63.1%. The first function positively correlates with the width and length of the ear and with the nose width, and negatively with the mouth width. The position of the corresponding centroid shows that male populations from Banjol, Barbat, Rab and Supetarska Draga have broader and longer ears and larger nose width, while the male population of Lopar is characterized by wider mouths, smaller ears and narrower nose. In the space of head variables, 51.7% of the examinees were classified correctly, again the most stable being Lopar with 73.2% of correctly classified persons.

In the performed discrimination analyses for female populations from the Island of Rab, the first function is significant at the level of 0.1%. To it also belongs the highest percentage of the total discrimination differentiation of women of 56.9%. The effect has the second function as well, with 15.5% of the explained variability. The first function positively correlates with the following variables: the left and right knee width and negatively with the abdominal circumference and the upper-arm length. This results with the explanation suggesting that the female inhabitants of Barbat and Banjol have wider knees, smaller abdominal circumference and shorter thighs, while women from Lopar have longer upper-arms, narrower knees but larger abdominal circumference.

In the space of the two discrimination functions in the space of body variables among female examinees, the first discrimination function divides the tested populations of Lopar and Barbat. In Barbat the results are higher for the transverse variable values of the knee width right and left, while for the thigh length and abdominal circumference the values are higher in Lopar.

In regard of the evaluated presence for body variables in separate groups, the highest stability is in Lopar, with 70.4% of correctly classified female examinees.

The analysis of discrimination functions for women in the space of head variables is significant at the level of 0.1%, representing the highest percentage of the total differentiation of 56.1%. The effect in discrimination also

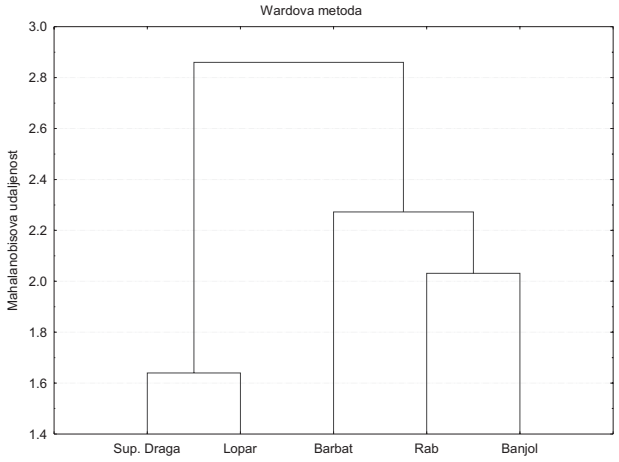

Fig. 4. Dendogram based on Mahalanobis distance for body variables (men, N=259).

shows the second function with 25.4% of the explained variability. The first function positively correlates with only one variable, the mouth width, and the second one with interorbital width, the ear length, ear width and cheek width (Figure 4). The corresponding centroids reveal that women from Lopar have wider mouths. From the impact of the second discrimination function is concluded that women in Barbat have larger interorbital width, wider and longer ears and larger cheek width.

In the space of the two discrimination functions for the group of women in the space of head variables, the first function for the variable of mouth width separates Lopar in the positive part of the scale.

The estimation of presence within the group in the space of head variables again shows that the female inhabitants of Lopar are the most stable, with 57.4% correctly classified persons.

Assessment of biological distances

We performed the analysis of the Mahalanobis D2, which is the space of continuous characteristic the most suitable measurement for the evaluation of biological distances. Mutual distance was evaluated for five populations of the Island of Rab, separately for men and for women for the body and head variables. The results show that the population of Lopar is the most distant island population, in men and women alike, both for the variables of body and head.

In order to establish which locations constitute separate groups in individual spaces of the body and head variables, we applied the cluster analysis using Ward's method and the Mahalanobis distances. In the space of the body variables for men two clusters were formed, where the pair with the lowest values of the Mahalanobis distance comprises the inhabitants of Lopar and Supetarska Draga. Those in the space of the body variables show the highest mutual similarity. This fact can be connected with geographic location of settlements and with the supposed more pronounced reproduction of the population (Figure 4). In the space of body variables in women, the female inhabitants of Lopar are a separate population group (Figure 5).

In the space of head variables in men, the population pair Lopar-Supetarska Draga is formed, while the pair of the inhabitants of Rab and Banjol is joined by the inhabitants of Barbat. In female examinees in the space of head variables is observed that the female examinees of the southern and eastern, as well as of southeastern part of the island make a cluster (Banjol, Supetarska Draga, Rab and Barbat), while women from the northwesterly located settlement of Lopar are distinctly separated (Figure 6).

Discussion and Conclusions

The investigations in the space of morphological dimensions performed on the inhabitants of the Island of

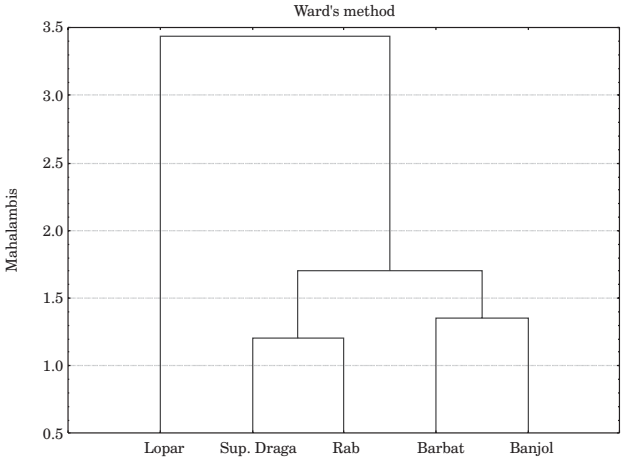

Fig. 5. Dendogram based on Mahalanobis distance for body variables (women, N=342). Female inhabitants of Lopar from a separate cluster.

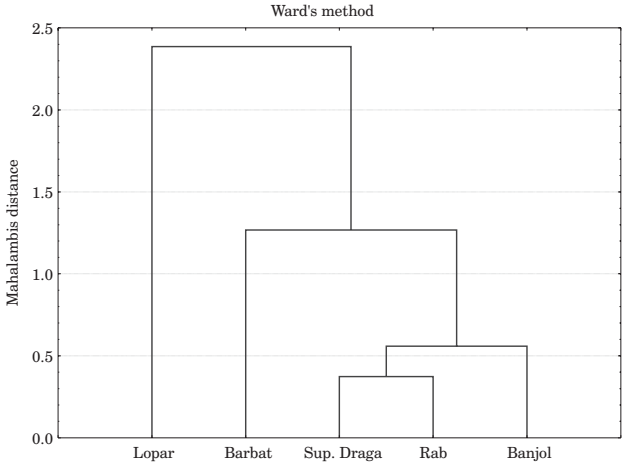

Fig. 6. Dendogram based on Mahalanobis distance for head variables (women, N=342). Female inhabitans of Lopar form a separate cluster

Rab yielded the data with which we can explain micro-evolutional processes that shaped the present population of the island.

Variance analysis performed on the level of examinees from five locations on the Island of Rab demonstrated that the tested population is heterogeneous in the space of the investigated body and head variables for both sexes.

Heterogeneity of body variables in men is more pronounced in eco-labile characteristics as are torso and extremities circumferences, and in diameters of extremities. Their phenotype is during growth and development more prone to the impact of external factors. The performed research stresses the possibility that the observed differences are presumably expressed at the level of phenotypic plasticity or short lasting adaptation. As regards the heterogeneity investigated in women, it occurs in more eco-labile, but also in eco-stable morphological characteristics, for example for linear parts of the body (the length of the arm and forearm). The possible explanation of this finding might be that with the aim of as successful reproduction as possible the female phenotype, in contrast to the male, is less susceptible to the influence of ecological factors. From this can be concluded that women in a population present genetic structure of the population better than men.

The performed discrimination analyses showed the existence of differences in anthropometric variables of the body and head in both men and women. Differences are primarily seen in more eco-labile variables, as are torso and extremities circumference and skinfolds. Such result points to the fact that the observed phenotypic body variations are primarily the outcome of phenotypic plasticity and adaptation. In two dimensional discrimination space, the tendency of separation of the first function in the space of body variables is present for the settlements Barbat and Lopar, where heterogeneity is prominent for the skinfold thickness and transversal body dimensions that are larger in Barbat, and longitudinal body dimensions and abdominal circumference that are larger in Lopar. This shows that the inhabitants of Barbat are somewhat more corpulent, and the inhabitants of Lopar more gracile. More eco-stable characteristics (head) lead to the conclusion that, due to different dynamics of settling of the island's population in various periods of time and as the consequence of mutual reproductional isolation, phenotypic morphological peculiarity was created.

The results of the biological distances assessment among populations of the Island of Rab evinced that the most distant is, for both sexes, the population of Lopar, while other investigated populations more or less comprise more homogenous groups. We conclude that the inhabitants of Lopar are genetically the most isolated population group on the Island of Rab, in which we can expect a high degree of linkage disequilibrium. Precisely the inhabitants of Lopar should receive most attention in further research if we want to explicate possible effects of uneven gene distribution of a certain population group on the island.

Historical course of settling on the Island of Rab and historical events that partly conditioned the emergence of population groups on the island have in a longer period brought to complete biological and socio-cultural isolation. This shows that even partial isolation, thanks to evolution processes, can sometimes result in clear phenotypic and biological (morphological) differentiation of a group. Our results lead to the conclusion that the grouping of current population communities from the Island of Rab, based on the analysis of morphological characteristics, corresponds to the known historical data on the settling of the island and on the dynamics within the migrations of its inhabitants on the island.

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ANTROPOMETRIJSKE KARAKTERISTIKE POPULACIJE OTOKA RABA

S A Ž E T A K

U radu su prikazani rezultati istraživanja populacijske strukture stanovništva otoka Raba analizom antropometrijskih, kontinuiranih obilježja (morfoloških varijabli glave i tijela) i to na reprezentativnom uzorku od 601 odrasle osobe (u dobi između 18 i 75 godina života) iz mjesta Banjol, Barbat, Lopar, Rab i Supetarska Draga (slika 1). Ovim istraživanjem željela se proučiti mogućnost da se na temelju analize kontinuiranih antropometrijskih varijabli utvrdi postojanje populacijskih grupiranja ili podjela u jednom geografski ograničenom prostoru, odnosno da se prouči strukturu stanovništva otoka kako bi se dao prilog tumačenju njegove mikroevolucije. Provedena analiza pokazala je djelomičnu antropometrijsku varijabilnost današnjeg stanovništva koja je u tvrđena nizom biostatističkih analiza. U analizu su uključena kontinuirana (kvantitativna) svojstva i to 36 antropometrijskih varijabli tijela i 14 antropometrijskih varijabli glave. Procijenjena je heterogenost između skupina ispitanika za pojedina fenotipska svojstva kako bi se dobile informacije o mikroevoluciji stanovništva otoka. Procjena provedena nad ukupno 36 analiziranih varijabli tijela pokazala je postojanje statističkih značajnih heterogenosti u muškaraca u 13 varijabli a u žena kod 8. Deskriptivnim statističkim procedurama te procjenom heterogenosti u prostoru fenotipskih obilježja glave nađena je heterogenost među skupinom muškaraca za 7 svojstava, a kod žena kod 5. Diskriminacijske analize su pokazale kako kod nekih proučenih kontinuiranih svojstava među pojedinim populacijama postoji određena heterogenost. Rezultati procjene bioloških udaljenosti između populacija otoka Raba ukazuju na izdvajanje nekih populacija, prvenstveno populacije iz mjesta Lopar.