Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta morphologica et anthropologica, 27 (3-4)
Sofia ● 2020

# Palmar and Finger Ridge Count in Two Isolated Slavic Muslim Populations (Zhupa and Gora) from Kosovo in Comparison with Kosovo Albanians

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In order to compare two geographically and culturally isolated ethnic groups of Slavic Muslims from Zhupa and Gora regions in Kosovo, we analyzed their quantitative dermatoglyphic traits, compared them with each other and with the majority, Albanian population. The dermatoglyphs were collected from a total of 263 Zhuplyani, 145 Gorani, and 213 Albanians of both sexes. The ANOVA analysis showed more differences between the Albanians and both minority populations, than between Zhupa and Gora regions populations themselves. We also detected selective inertia in Slavic Muslim women. The canonical discriminant analysis grouped the Gora and the Zhupa women together, and at the same time closer to the Gora men than to the Kosovo Plain women. The Gora and Zhupa men were much closer to each other than to the men from Kosovo Plain. To conclude, the Gora and Zhupa populations differ less from each other, than any of them differs from Kosovo Albanians.

*Key words*: quantitative dermatoglyphic traits, Slavic Muslim populations, Zhupa region, Gora region, Kosovo

## Introduction

Genetic structure of the population reflects not only the balance between gene flow and genetic drift within and among interbreeding populations; it also documents the genetic variability due to migrations, founder effects, the size and composition of these populations [5]. Consequently, from the aspect of population history, it is questionable whether the degree of similarity between populations is the result of exchanging mates or a common ancestry [16]. Hence, when interpreting the geographical pattern of genetic

variation, one should join the population structure and population history data, and combine structural and historical factors [45], as confirmed in several studies [21, 39, 40]. Biological variations between populations are directly related to geographical, migratory, linguistic and socio-cultural characteristics [18]. Dermatoglyphics have been used extensively to characterize human populations and to assess biological affinities between them [1, 9, 18, 19, 27, 43], and quantitative dermatoglyphic traits, when used as phenotypic markers, were shown to be conserved with respect to plastic environmental influences and stochastic processes of evolution [13, 25, 26, 29, 30, 32, 38].

Kosovo, one of the youngest European countries, has a population of more than 1.73 million [8], and most of the inhabitants are ethnically Albanians (>92%). Albanians are an ancient population that lives in the Southwest Balkan Peninsula: they speak Albanian, the only surviving Indo-European language, which is an extreme case of a relict language that has survived through thousands of years of continuous linguistic turnover in neighboring regions [14]. Since this area was inhabited by Dardans, an Illyrian tribe, from about 400 years BC [12], it is probable that Albanians are their descendants [6, 35]. In spite of the country`s turbulent history due to numerous invaders, Albanians managed to avoid the assimilation and to keep their identity and language intact. Beside the Albanians, the most numerous population in Kosovo, it is also inhabited by less numerous populations such as Serbs, Bosniaks, Romani, Ashkali, Gorani, etc. [8].

The inhabitants of Gora, the geographical region in Southern Kosovo surrounded by the tall Albanian Accursed Mountains in the west and by the high Šar Mountain (2,748 m) from two sides, have the only route in and out of the Gora region through hilly area with relatively slight slope via Prizren direction. Gorani, which means "people from the mountain", are a South Slavic ethnic group and despite still vivid debates about their collective identity and their ethnic origin, Gorani have since the 1990s been recognized as ethnic minority group in Kosovo [8]. It is believed that their ancestors came in this area in 6$^{th}$ and 7$^{th}$ century across the mountains, Christianized in Middle Ages, but later been converted from Christianity to Islam. This population is mentioned for the first time in 1348 in the edicts of Serbian Emperor Stefan Dushan. They speak the Gora dialect, known as "Našinski/Nashentski", meaning roughly "ours" - it is an Old Slavic dialect, part of a wider Torlakian dialect. They are adherents to Islam and have a rich and varied folk culture [46].

Zhupa (Župa) is the eastern periphery of the ethnographic region of Gora, but it seems that this area has rarely been counted as a part of the Gora [26]. Administratively Zhupa belongs to the district of Prizren and geographically is a part of Šar Mountain: some of Župa villages are in the basin of river Prizrenska Bistrica. This is a sparsely populated region whose residents call themselves Zhuplyani and Gorani, one group being contained within the other [26]. Most of them are also Muslim Slavs who speak "Nashentski", but elucidating the identity of Zhupa region residents is even more complex because this region is even more heterogenous than the Gora region since Zhuplyani were, over the time, subject to many national ideologies [3].

These two minority populations, residents of Zhupa (who will be further called Zhuplyani) and Gorani, could be regarded as two different groups according to their dialect, customs and tradition [36], plus marriages between them are rare [42]. In order to test this hypothesis, we compared the quantitative dermatoglyphic traits between the populations from Zhupa and Gora region, and since both regions are surrounded by the

Albanian villages, we also compared their digito-palmar patterns with the autochthonous Albanian population from the Kosovo plain.

## Materials and Methods

The analyses of dermatoglyphic patterns of digito-palmar complex were carried out in two minority populations and in the majority Albanian population, all from Kosovo. Their finger and palm prints on both hands were taken by the standard ink method and scored according to Cummins & Midlo [11] and Holt [17]. The prints which were not complete were excluded. The final sample consisted of 263 residents of Zhupa region (125 men and 138 women), 145 Gorani from Gora region (80 men and 65 women) and 213 Albanians from Kosovo Plain (103 men and 110 women) (**Fig. 1**). All of the participants participated in this study voluntarily and signed informed consent.

We analyzed the following quantitative digital dermatoglyphic traits: ridge count on each finger on right (FRCR 1-5) and left hand (FRCL 1-5) Of the palmar traits, we analyzed number of ridges between digital triradius a and b (a-b ridge count – a-b rc), b

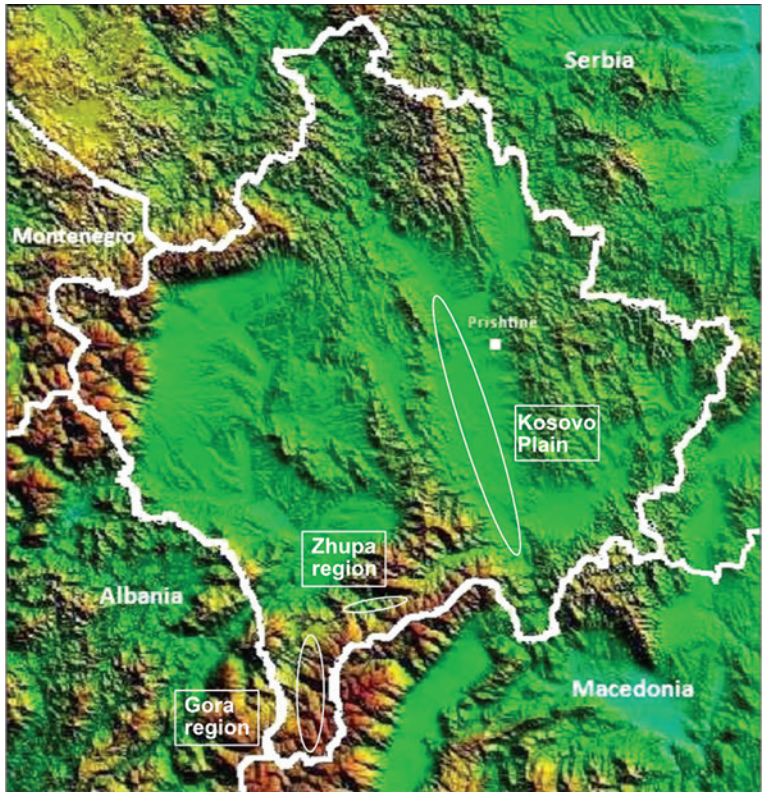


**Fig. 1.** The geographical map of Kosovo selected explicitly to display the natural barriers between Gora and Zhupa regions and the location of Kosovo Plain (taken and adapted from http://www.kosovo-mining.org/kosovoweb/en/kosovo/geography.html).

and c (b-c rc) and c and d (c-d rc), and the atd angle of both hands measured in degrees. The dermatoglyphic prints were analyzed by the single observer (G. Temaj).

The analyses of these quantitative dermatoglyphic traits included descriptive statistics, "One-way" ANalysis Of VAriance (ANOVA) and post-hoc Tukey HSD method, and Canonical Discriminant Analysis for the six (3 male and 3 female) groups of examinees. These statistical analyses were conducted using SPSS Statistical package 7.5.

## Results

The descriptive statistics results of the comparison of quantitative digito-palmar dermatoglyphic traits from two minority and one majority Kosovar populations are presented in **Table 1** for men and **Table 2** for women. The men from Gora (Gorani) differed from men from Zhupa (Zhuplyani) only in one trait, the fourth finger ridge count right (FRCR4, $p<0.05$) (**Table 3**). More differences, and only on palms, were found in comparison of Zhuplyani and Gorani with Albanians from Kosovo plain. The Gorani differed from the Albanian men on a-b rcR ($p<0.05$) and rcL ($p<0.001$), and on the b-c rcL ($p<0.001$) and atd angle right ($p<0.001$). Differences between Zhuplyani and the Albanians were found in three variables on the left palm; a-b rcL ($p<0.001$), b-c rcL ($p<0.001$) and c-d rcL ($p<0.001$); and only atd angle on the right palm ($p<0.001$).

A comparison of women from Gora with those from Zhupa revealed no differences in quantitative digito-palmar traits (**Table 4**). However, both these populations differed from the Albanian women population. The Gorani women significantly differed from the Albanian women on digital FRCL1 ($p<0.05$), on palmar variables b-c rcL ($p<0.01$), c-d rcR ($p<0.05$) and c-d rcL ($p<0.001$), and the differences were found also in atd angle right ($p<0.05$). The women from Zhupa differed from the Albanian women from Kosovo plain on the FRCL4 ($p<0.001$), and on palms in b-c rcL ($p<0.001$), c-d rcR ($p<0.001$) and c-d rcL ($p<0.001$). Differences were also found in atd angle right ($p<0.001$).

The results of discriminant analysis for the three examined groups and original variables revealed that out of five canonical discriminant functions, the first three were significant at $p<0.05$ level, and that cumulative percentage of variance explained by those three functions was high (94.9%). Structure matrix showing correlations among original variables and canonical discriminant functions, eigenvalues and chi-square tests for 5 canonical discriminant functions discriminating 6 groups is presented in **Table 5.** Three discriminant functions were statistically significant: function 1 (eigenvalue = 0.601, $\chi^2$ test = 491.968, $p<0.001$), function 2 (eigenvalue = 0.244, $\chi^2$ test = 205.802, $p<0.001$) and function 3 (eigenvalue = 0.074, $\chi^2$ test = 72.993, $p<0.012$). **Table 6** shows coordinates of group centroids in discriminant space for statistically significant functions. Discriminant function 1 clearly separated men from Kosovo Plain from all the other groups, discriminant function 2 separated the Kosovo Plain women from all the men and other female groups, whereas the discriminant function 3 separated men from Zhupa from the other examinees. When graphically presented in 3D (**Fig. 2**), the Gora and the Zhupa women were closer to each other and at the same time closer to the Gora men than any of them to the women from Kosovo plain. Besides finding a difference between the Gora and the Zhupa men only in one trait, discriminant functions grouped them closer than any of them to the men from Kosovo Plain, from whom both groups differed in several traits.

**Table 1.** Dermatoglyphic variables (mean ± standard deviations) of the digito-palmar complex in men from Gora and Zhupa regions, and in the Albanians from Kosovo Plain.

| | Men from Gora region (N = 80) | | Men from Zhupa region (N = 125) | | Albanian men from Kosovo Plain (N = 103) | |
|---|---|---|---|---|---|---|
| **Variables *** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| RIGHT HAND | | | | | | |
| FRCR1 | 14.79 | 5.88 | 15.56 | 5.21 | 14.48 | 5.17 |
| FRCR2 | 8.73 | 6.05 | 8.64 | 6.05 | 7.81 | 5.48 |
| FRCR3 | 9.79 | 5.41 | 9.75 | 5.11 | 8.95 | 5.23 |
| FRCR4 | 10.99 | 4.84 | 12.77 | 4.99 | 11.52 | 5.49 |
| FRCR5 | 9.21 | 4.66 | 10.51 | 4.51 | 10.32 | 4.42 |
| a-b rcR | 32.90 | 5.92 | 33.79 | 6.23 | 35.27 | 5.89 |
| b-c rcR | 21.83 | 6.16 | 23.58 | 5.21 | 22.24 | 5.36 |
| c-d rcR | 28.71 | 5.86 | 29.42 | 6.84 | 29.63 | 6.03 |
| atd R | 43.86 | 7.78 | 44.02 | 6.52 | 36.65 | 8.58 |
| LEFT HAND | | | | | | |
| FRCL1 | 12.91 | 5.08 | 13.35 | 4.84 | 13.17 | 5.03 |
| FRCL2 | 7.99 | 5.46 | 7.51 | 5.90 | 6.49 | 5.46 |
| FRCL3 | 9.16 | 5.21 | 9.90 | 5.49 | 8.80 | 5.48 |
| FRCL4 | 10.98 | 3.94 | 11.91 | 4.77 | 11.39 | 5.28 |
| FRCL5 | 9.00 | 4.14 | 10.09 | 4.12 | 10.16 | 4.75 |
| a-b rcL | 32.71 | 6.43 | 34.46 | 6.67 | 40.01 | 7.37 |
| b-c rcL | 21.54 | 5.95 | 21.98 | 5.10 | 27.75 | 8.00 |
| c-d rcL | 27.51 | 6.29 | 29.03 | 6.09 | 25.77 | 6.28 |
| atd L | 45.09 | 8.52 | 46.66 | 5.74 | 43.84 | 5.27 |

*Abbreviations: FRCR – finger ridge count right; FRCL – finger ridge count left; a-b rcR, b-c rcR, and c-d rcR – palmar ridge count right; a-b rcL, b-c rcL, and c-d rcL – palmar ridge count left; atd R – right angle; and atd L – left angle.

**Table 2.** Dermatoglyphic variables (mean ± standard deviations) of the digito-palmar complex in women from Gora and Zhupa regions, and in the Albanian women from Kosovo Plain.

| | Women from Gora region (N = 65) | | Women from Zhupa region (N = 138) | | Albanian women from Kosovo plain (N = 110) | |
|---|---|---|---|---|---|---|
| **Variables *** | **mean** | **SD** | **mean** | **SD** | **mean** | **SD** |
| RIGHT HAND | | | | | | |
| FRCR1 | 15.68 | 4.35 | 15.01 | 4.72 | 14.08 | 5.90 |
| FRCR2 | 8.82 | 6.28 | 9.43 | 6.26 | 10.51 | 5.99 |
| FRCR3 | 9.98 | 4.57 | 10.06 | 5.11 | 9.55 | 4.30 |
| FRCR4 | 12.18 | 4.46 | 11.38 | 5.07 | 13.75 | 5.27 |
| FRCR5 | 9.38 | 3.72 | 9.69 | 4.20 | 10.41 | 4.18 |
| a-b rcR | 35.62 | 4.81 | 34.76 | 5.02 | 34.53 | 5.89 |

| | | | | | | |
|---|---|---|---|---|---|---|
| b-c rcR | 23.17 | 4.19 | 22.83 | 4.42 | 23.56 | 5.75 |
| c-d rcR | 28.95 | 5.64 | 27.46 | 4.70 | 31.37 | 7.41 |
| atd R | 46.82 | 8.01 | 47.44 | 8.53 | 43.16 | 7.95 |
| LEFT HAND | | | | | | |
| FRCL1 | 13.86 | 4.63 | 13.16 | 5.00 | 11.83 | 5.17 |
| FRCL2 | 8.48 | 5.94 | 7.96 | 5.84 | 9.56 | 6.12 |
| FRCL3 | 8.66 | 5.05 | 8.90 | 5.84 | 10.44 | 5.24 |
| FRCL4 | 11.22 | 4.48 | 10.97 | 5.00 | 12.34 | 5.32 |
| FRCL5 | 9.74 | 4.48 | 9.73 | 4.62 | 10.25 | 4.22 |
| a-b rcL | 33.86 | 5.58 | 32.95 | 5.03 | 32.06 | 7.52 |
| b-c rcL | 21.94 | 4.86 | 21.26 | 4.38 | 24.66 | 7.08 |
| c-d rcL | 29.57 | 5.89 | 28.49 | 4.95 | 33.65 | 9.46 |
| atd L | 46.40 | 7.05 | 46.72 | 8.41 | 45.62 | 6.99 |

*Abbreviations: FRCR – finger ridge count right; FRCL – finger ridge count left; a-b rcR, b-c rcR, and c-d rcR – palmar ridge count right; a-b rcL, b-c rcL, and c-d rcL – palmar ridge count left; atd R – right angle; and atd L – left angle.

**Table 3.** Results of comparison between the three groups of men from different geographic regions of Kosovo (Zhupa, Gora and Kosovo Plain) using One-way ANOVA test.

| | **Gora men/ Zhupa men** | | **Gora men/ Albanian men from Kosovo Plain** | | **Zhupa men/ Albanian men from Kosovo Plain** | |
|---|---|---|---|---|---|---|
| **Variables *** | **F** | **p** | **F** | **p** | **F** | **p** |
| RIGHT HAND | | | | | | |
| FRCR1 | 0.77 | 0.575 | 0.30 | 0.925 | 1.07 | 0.290 |
| FRCR2 | 0.09 | 0.994 | 0.92 | 0.544 | 0.83 | 0.534 |
| FRCR3 | 0.03 | 0.999 | 0.84 | 0.531 | 0.80 | 0.483 |
| FRCR4 | **1.78** | **0.040** | 0.54 | 0.762 | 1.24 | 0.162 |
| FRCR5 | 1.30 | 0.110 | 1.11 | 0.227 | 0.19 | 0.946 |
| a-b rcR | 0.89 | 0.557 | **2.37** | **0.023** | 1.48 | 0.156 |
| b-c rcR | 1.76 | 0.067 | 0.42 | 0.867 | 1.34 | 0.161 |
| c-d rcR | 0.70 | 0.718 | 0.92 | 0.594 | 0.22 | 0.965 |
| atd R | 0.15 | 0.989 | **7.21** | **0.001** | **7.37** | **0.001** |
| LEFT HAND | | | | | | |
| FRCL1 | 0.44 | 0.810 | 0.26 | 0.933 | 0.18 | 0.961 |
| FRCL2 | 0.48 | 0.826 | 1.50 | 0.174 | 1.03 | 0.359 |
| FRCL3 | 0.74 | 0.605 | 0.37 | 0.893 | 1.11 | 0.274 |
| FRCL4 | 0.94 | 0.353 | 0.41 | 0.829 | 0.52 | 0.686 |
| FRCL5 | 1.09 | 0.187 | 1.16 | 0.175 | 0.07 | 0.993 |
| a-b rcL | 1.74 | 0.177 | **7.30** | **0.001** | **5.55** | **0.001** |
| b-c rcL | 0.44 | 0.882 | **6.21** | **0.001** | **5.77** | **0.001** |
| c-d rcL | 1.52 | 0.201 | 1.75 | 0.142 | **3.27** | **0.001** |
| atd L | 1.42 | 0.270 | 1.25 | 0.392 | 0.17 | 0.978 |

*Abbreviations: FRCR – finger ridge count right; FRCL – finger ridge count left; a-b rcR, b-c rcR, and c-d rcR – palmar ridge count right; a-b rcL, b-c rcL, and c-d rcL – palmar ridge count left; atd R – right angle; and atd L – left angle.

**Table 4.** Results of comparison between the three groups of women from different geographic regions of Kosovo (Zhupa, Gora and Kosovo Plain) using One-way ANOVA test.

| | Zhupa women/ Zhupa women | | Gora women/ Albanian women from Kosovo Plain | | Zhupa women/ Albanian women from Kosovo Plain | |
|---|---|---|---|---|---|---|
| **Variables *** | **F** | **p** | **F** | **p** | **F** | **p** |
| RIGHT HAND | | | | | | |
| FRCR1 | 0.67 | 0.657 | 1.60 | 0.112 | 0.93 | 0.330 |
| FRCR2 | 0.61 | 0.787 | 1.69 | 0.185 | 1.08 | 0.356 |
| FRCR3 | 0.07 | 0.994 | 0.44 | 0.823 | 0.51 | 0.673 |
| FRCR4 | 0.80 | 0.539 | 1.157 | 0.403 | **2.37** | **0.001** |
| FRCR5 | 0.30 | 0.875 | 1.03 | 0.240 | 0.73 | 0.344 |
| a-b rcR | 0.85 | 0.532 | 1.09 | 0.388 | 0.23 | 0.937 |
| b-c rcR | 0.34 | 0.887 | 0.39 | 0.864 | 0.74 | 0.465 |
| c-d rcR | 1.49 | 0.221 | **2.42** | **0.026** | **3.91** | **0.001** |
| atd R | 0.63 | 0.868 | **3.65** | **0.013** | **4.28** | **0.001** |
| LEFT HAND | | | | | | |
| FRCL1 | 0.70 | 0.617 | **2.03** | **0.025** | 1.32 | 0.095 |
| FRCL2 | 0.52 | 0.831 | 1.09 | 0.685 | 1.61 | 0.088 |
| FRCL3 | 0.28 | 0.955 | 1.77 | 0.096 | 1.54 | 0.072 |
| FRCL4 | 0.24 | 0.944 | 1.12 | 0.326 | 1.37 | 0.084 |
| FRCL5 | 0.01 | 0.999 | 0.51 | 0.747 | 0.51 | 0.639 |
| a-b rcL | 0.91 | 0.583 | 1.80 | 0.145 | 0.89 | 0.494 |
| b-c rcL | 0.68 | 0.697 | **2.73** | **0.005** | **3.40** | **0.001** |
| c-d rcL | 1.08 | 0.566 | **4.09** | **0.001** | **5.16** | **0.001** |
| atd L | 0.32 | 0.959 | 0.78 | 0.791 | 1.10 | 0.500 |

*Abbreviations: FRCR – finger ridge count right; FRCL – finger ridge count left; a-b rcR, b-c rcR, and c-d rcR – palmar ridge count right; a-b rcL, b-c rcL, and c-d rcL – palmar ridge count left; atd R – right angle; and atd L – left angle.

**Table 5.** Discriminant analysis: structure matrix showing correlations among original variables and canonical discriminant functions (upper part of the table), and eigenvalues and chi-square tests for 5 canonical discriminant functions discriminating 6 examined groups (lower part of the table). First three discriminant functions were significant, explaining 94.9% of variance. Discriminant function 1 strongly correlated with atd angle of the right hand and c-d ridge count of the left hand, discriminant function 2 with c-d ridge counts of both hands, b-c ridge count of the left hand and FRCR4, whereas discriminant function 3 had the highest correlation with atd L.

| | Discriminant function | | | | |
|---|---|---|---|---|---|
| **Variable *** | **1** | **2** | **3** | **4** | **5** |
| atd R | 0.553 | -0.241 | 0.110 | 0.239 | -0.100 |
| c-d rcL | 0.278 | 0.596 | -0.049 | 0.286 | 0.134 |
| atd L | 0.151 | -0.022 | 0.460 | 0.097 | -0.057 |
| FRCL2 | 0.150 | 0.215 | 0.114 | -0.046 | 0.189 |
| FRCR2 | 0.126 | 0.187 | 0.117 | 0.009 | -0.244 |
| FRCR3 | 0.089 | -0.054 | 0.002 | 0.008 | -0.007 |

| | Discriminant function | | | | |
|---|---|---|---|---|---|
| **Variable *** | **1** | **2** | **3** | **4** | **5** |
| b-c rcR | 0.071 | 0.115 | -0.203 | 0.410 | -0.040 |
| FRCR4 | 0.052 | 0.316 | -0.260 | 0.354 | 0.119 |
| FRCR1 | 0.044 | -0.149 | -0.181 | 0.186 | 0.242 |
| FRCL3 | 0.039 | 0.194 | -0.228 | -0.050 | -0.146 |
| FRCL4 | -0.003 | 0.182 | -0.189 | 0.126 | -0.003 |
| FRCL1 | -0.014 | -0.214 | -0.069 | 0.208 | 0.283 |
| FRCL5 | -0.036 | 0.099 | -0.073 | 0.344 | -0.155 |
| a-b rcR | -0.047 | 0.009 | 0.291 | 0.627 | 0.130 |
| FRCR5 | -0.056 | 0.126 | -0.224 | 0.252 | -0.306 |
| c-d rdR | -0.067 | 0.378 | -0.172 | 0.016 | 0.397 |
| b-c rcL | -0.437 | 0.354 | 0.264 | 0.293 | 0.013 |
| a-b rcL | -0.502 | -0.180 | -0.023 | 0.521 | 0.096 |
| Eigenvalues | 0.601 | 0.244 | 0.074 | 0.034 | 0.016 |
| Cumulative % of variance | 62.1 | 87.3 | 94.9 | 98.3 | 100 |
| chi-square tests when preceding roots were removed | 491.968 | 205.802 | 72.993 | 29.755 | 9.686 |
| p (chi-square test) | **<0.001** | **<0.001** | **0.012** | 0.478 | 0.785 |

* Variables are ordered by absolute size of correlation within first function (largest absolute correlation between each variable and any discriminant function). Abbreviations: FRCR – finger ridge count right; FRCL – finger ridge count left; a-b rcR, b-c rcR, and c-d rcR – palmar ridge count right; a-b rcL, b-c rcL, and c-d rcL – palmar ridge count left; atd R – right angle; and atd L – left angle.

**Table 6.** Discriminant functions at group centroids but only for the statistically significant functions: discriminant function 1 separates Kosovo Plain men, discriminant function 2 separates Kosovo Plain women, whereas discriminant function 3 separates Zhupa men.

| | Discriminant function | | |
|---|---|---|---|
| **Group** | **1** | **2** | **3** |
| Gora women | 0.522 | -0.273 | 0.179 |
| Zhupa women | 0.590 | -0.393 | 0.226 |
| Kosovo Plain women | 0.315 | 1.030 | 0.076 |
| Gora men | 0.137 | -0.254 | 0.018 |
| Zhupa men | 0.096 | -0.120 | -0.522 |
| Kosovo Plain men | -1.679 | -0.057 | 0.122 |

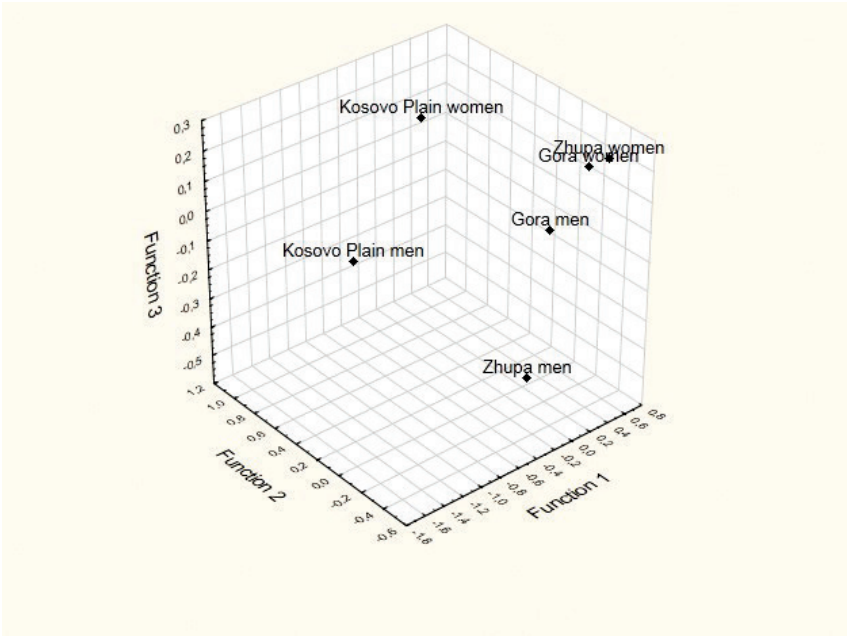


**Fig. 2.** Graphical presentation of group centroids in discriminant functions 1, 2 and 3. Women from Gora and Zhupa are closer to each other than any of them are to women from Kosovo plain. Additionally, the Gora and Zhupa women are closer to Gora men than to Kosovo plain women. Gora and Zhupa men are closer than any of these two groups to men from Kosovo Plain.

## Discussion

The variability in dermatoglyphic patterns reflects the existence of differences dating from the fetal period [11]. The development of palmar dermatoglyphics has a relatively longer growth period when compared with fingers [10], and the palmar patterns are found to correspond better to the ethno-historical background of the populations than characteristics of fingers [24]. Also, genetic and linguistic evolutions are found to correspond closely [7, 34], although not in every study [41].

Quantitative dermatoglyphic traits change slower than qualitative ones, but are at the same time very sensitive to the events which took place during microevolution of the contemporary populations [20, 40]. Geographic isolation and small relative size of the populations, the optimal conditions for the operation of the genetic drift, have almost certainly been present in the Zhupa and Gora regions. Still, our findings indicate the relative lack of genetic differences between these two investigated populations, although at the same time they support the expectation that in environmentally stressful areas, where all local populations are subjected to the same pressures, male and female measures of differentiation should be smaller than in other areas [37]. As we already mentioned, several studies demonstrated that quantitative dermatoglyphic traits are conservative with respect to plastic environmental influences and stochastic processes of evolution, showing selective inertia on changes mostly in females, as is the case in populations living in Zhupa and Gora regions [13, 21, 31, 32, 33].

The men of Gora and Zhupa differed from the Albanians in a-c and b-c ridge counts, and the men from Zhupa additionally differed from the Albanians in c-d ridge counts. In women, both the Gora and Zhupa groups differed from the Albanian group in one digital trait and in three palmar traits (b-c rcL, c-d rcR and c-d rcL). Arrieta et al. [2] investigated influence of genetic and environmental factors on a-b, b-c and c-d interdigital areas, and found that the genetic influence in palmar variables in men was stronger for b-c interdigital area, while a-b ridge count seemed to be more influenced by environmental factors. In women they found stronger genetic than environmental influence for all three counts in the interdigital area, but lowest was for b-c ridge count.

So, in the context of Arrieta`s finding, the differences between the Zhupa and Gora male groups and the Albanian male group might be the result of the influence of both genetic and environmental factors, while the differences between the Zhupa and Gora females on one side, and Albanian women on the other side, might be caused by their genetic differences. The prenatal sex differences in environmental sensitivity should also be taken into account when discussing dermatoglyphic sexual dimorphism [23, 28]. The 3D graphical presentation of the results of the canonical discriminant analysis showed that the Zhupa and Gora women differed from women from the Kosovo plain, and at the same time they were closer to the Gora men than to the Kosovo plain women. The Gora and Zhupa men were grouped closer than any of them to the men from Kosovo Plain.

## Conclusion

In conclusion, the Zhupa and Gora populations from Kosovo showed less difference in quantitative dermatoglyphic variables than any of these population groups alone when compared to the Albanians. This indicates that the admixture between these two minorities and Albanian population living in Kosovo has been very small, and that Zhuplyani and Gorani have retained their genetic identity for several centuries. Most probable factors responsible for the detected dermatoglyphic variations might be geographic isolation, stressful environment, and turbulent history of this area, linguistic specificity and socio-cultural differences between the investigated populations. The forces of random genetic drift and local gene flow adequately describe the observed microgeographic variations [4].

*Acknowledgements:* We are grateful to all volunteers for their kind participation in this study. This study was supported by the Ministry of Science, Education and Sports, of the Republic of Croatia (projects 196-1962766-2736 and 196-1962766-2747) and the Ministry of Sciences of Kosovo.

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