Coll. Antropol. **32** (2008) 2: 467–477
Original scientific paper

Sexual Dimorphism in the Chuvashian Population of Russia in Two Types of Dermatoglyphic Traits: Principal Component Analysis

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A B S T R A C T

With the aim of determining sexual dimorphism in the component structures among the Chuvashian population of Russia, finger and palmar dermatoglyphics of 547 individuals (293 males, 254 females) were analyzed. The sex differences in two categories of dermatoglyphic traits (22 quantitative traits and 38 asymmetry and diversity traits) are reflected differently and contradictory with other ethnic groups. However, a common feature of the factor 1 »digital pattern size factor« (finger ridge counts from the first category of traits) indicate its degree of universality when compared with other populations, which suggests that the variability of finger ridge counts is determined by the same genes that control the pattern types. The factors »intra-individual finger diversity factor«, and »bi-lateral asymmetry factor« extracted from the second category of dermatoglyphic traits are also similar in both sexes. However, these components are hardly described in the literature. The nature of variation of these components (from two categories of dermatoglyphic traits) appears with a good similarity between sexes, which suggests their common biological validity of the underlying component structures of the finger and palmar dermatoglyphic characters.

Key words: *dermatoglyphics, sexual dimorphism, factor analysis, Chuvashian population, Russia*

Introduction

Sex differences in dermatoglyphic characters, females almost universally differ from males[1,2]. Several studies on diverse populations have proved that females have higher correlations for various dimensions and developmental events than males[3–12]. According to Stinson[13] that males are biologically less buffered than females against environmental influences, especially in the prenatal period. Prenatal sex differences in environmental sensitivity would seem compatible with the effects of changed environmental factors on dermatoglyphic sexual dimorphism. One of the possible effects of environmental stress on dermatoglyphic structure is for example, an increase of the fluctuating asymmetry levels in males[14,15]. There are two categories of bi-lateral asymmetry namely-directional (signed difference) and fluctuating (random difference or irrespective of signed difference) asymmetry abbreviated as DAs and FLAs. Diversity of dermatoglyphic traits (abbreviated as Div) is used as inter-population, intra-population, and intra-individual levels. The first two phenomena are frequently used in Anthropological research, but is scare at the intra-individual level[14,16–18]. Therefore, study of sex differences of dermatoglyphic traits in diverse populations is still a subject of interest in Anthropology. Thus, two main categories of dermatoglyphic traits, namely-22 usually studied quantitative traits and 38 variables that represent the indices of diversity and asymmetry were considered for the present study. Further, we know that genetic or environmental factors are expected to affect developmental homeostasis on a systemic level. Dermatoglyphics have been used to investigate inter population structuring in a number of human populations[19–21]. Because, several studies had demonstrated that dermatoglyphics are phylogenetically more stable than other biological traits[22,23]. The fact that dermatoglyphic traits appear to be evolutionarily conservative renders them more reliable for studies of the historical relationships of population components. Dermatoglyphic characters has

Received for publication September 20, 2007

also been suggested the result of a biogenetic expression by Singh[24], rather than the physical environment. Because dermatoglyphic features are formed before the 19th week of gestation[25] and thereafter are not amenable to change due to age and/or environmental factors. Dermatoglyphic characteristics thus permanently preserve an earlier stage of fetal development, whereas most other biological characteristics are examined through postnatal development. In this context, the composite score of dermatoglyphic traits may be a more adequate measure of developmental homeostasis than any single trait. This measure can be obtained from factor scores by principal component analysis, which is based on correlations among a number of indices. From this standpoint, to get a clear picture of this phenomenon, our comparative examination of biological validity of the underlying component structure of dermatoglyphic character is appropriate in both sexes by principal component analysis. Furthermore, studies on sex variation in the Chuvashian population of Russia of dermatoglyphic characters are hardly available. In this article, we therefore, explore the nature of sex dimorphism with respect to principal component structures (PCA) in two different sets of dermatoglyphic traits in the Chuvashian population.

Materials and Methods

Subjects and historical background: The studied individuals of the Chuvashian population reside in several small villages along the Volga River region of Russia. They migrated to these regions during the 17th and 18th centuries. Ethnically, Chuvasha is considered Caucasian origin and was formed during the last quarter of the first millennium AD in the forested or hilly portions of the Volga riverside[26]. Their forefathers were most likely Bulgars from the Volga and Kama riversides and intermarried with the local Finno-Ugric tribes [27]. This population is characterized by a demographically stable familial structure with traditional relations between family members. Their principal source of livelihood is agriculture. Chuvashian families have lived under the same environmental conditions for several generations and thus were not exposed to any outside gene pool [28, 29]. The sample included 547 individuals; 293 males and 254 females with age constituting of 18 to 91 and 18 to 86 years and collected from the families those are without inter group marriages. However, according to age all individuals under age 18 were excluded. Additional number of individuals without of one more traits included in PCA was also excluded from the analysis according to the procedure accepted in PCA. In Table 1 all sample sizes for all different traits are indicated. Maximum number is indicated for age 686 males and 577 females. All studied individuals were randomly selected through direct contact with all households who agreed to participate in the study. The data were collected by the joint expedition of the Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel Aviv University, Israel, and the Anthropological Institute and Museum of Moscow State University, Russia (for details, see Kalichman et al.[30]).

Dermatoglyphic print analysis: Finger and palm prints were collected according to the rolled print (inked) method of Cummins and Midlo[1]. The variables used in the present study belonged into two main categories. The first category included the 22 usually studied quantitative traits (12 digital ridge counts, 2 palmar a-b ridge counts, 3 pattern intensity indices (PII), 4 palmar main line (A and D) endings, and MLI – main line index). The second category included the 38 variables that represent the indices of diversity and asymmetry (11 intra-individual diversity indices, 13 directional asymmetry traits, and 14 indices of fluctuating asymmetry). The dermatoglyphic traits for the most part were evaluated by the methods of Cummins and Midlo[1], Holt[31] and Penrose[32]. In spite of using traditional and widely used methods, ridge counting is an entirely the objective process and requires decisions what to include and exclude; thus print analysis needs a special attention. Therefore, in order to avoid any inter-observer error the first author alone analyzed the whole dermatoglyphic prints of 547 individuals. The indices of intra-individual diversity and asymmetry were calculated according to Jantz[33] and Kobyliansky et al.[34]. The dermatoglyphic variables are set out in Appendix 1 and the formulae for calculating various indices are presented in Appendix 2.

Statistical applications: One-way Analysis of Variance (ANOVA) was used for the assessment of the significance of the group differences between quantitative traits and directional asymmetry variables. It generates a set of transformed variables to test between and within subject effects (through the proportion of group-means) and obtained F-value indicates that the population means are probably unequal. For the assessment of the significance of differences in intra-individual diversity indices and fluctuating asymmetry variables, used the Kruskal-Wallis test of one-way ANOVA. It ranked all the variables from the original set of data in a single series and computed the Mean rank for each group, and finally computed the 'H' statistic, which represents approximately a distribution. For multiple comparisons Bonferroni correction test was used according to Sokal and Rohlf[35].

Principal component analysis (PCA): A principal component reduces numerous related variables and transforms them into a few linear functions that account for a large portion of the total variation. Thus, these components provide an insight into the underlying biological interpretations. PCA was performed using the matrices of phenotypic correlation between the studied traits (not shown in tables). The factors were constructed with varimax rotation of principal components to maximize the sum of squares of the loading for each factor. Then factor scores were computed and expressed quantitatively for each individual by the design of their construction. The data were processed at the Tel Aviv University Computer Center, Israel, according to the computer programs described by Nie et al.[36] and by Dixon[37].

Results

Characteristics of studied traits between sexes: Table 1 presents the sex differences of 22 dermatoglyphic variables by ANOVA test.

The ridge counts on individual fingers regarding sex differences are mostly uniform between the right and left sides. Finger I shows a markedly significant difference followed by IV and V, respectively. Significant sex differences appear for total (TRC) and absolute (ARC) finger ridge counts, main line index (MLI), exits of the main line A and D for the left palms, and pattern intensity index (PIIr). However, the results of palmar traits reveal extreme homogeneity. Table 2 provides the sex differences of 13 dermatoglyphic variables of directional asymmetry by ANOVA test.

Females have greater mean values on some variables (for 7 traits) compared with males (for 3 traits), but significant sex differences are very poor, only in case of DAs II (PII), which suggests homogeneous in nature.

The results of ANOVA test of 11 diversity and 14 fluctuating asymmetry indices are presented in Table 3. Females show relatively larger mean values compared to males for 11 indices of intra individual diversity and 14 indices of fluctuating asymmetry. Out of 11 traits, 8 are statistically significant between sexes indicate clearly the heterogeneous nature of sex dimorphism. However, sex differences are failed to show statistical significance in most of the 14 indices – only 5 differ significantly, that suggests homogeneous in nature.

Principal component analysis: The principal factors were obtained from the correlation matrices of the quantitative dermatoglyphic variables (not shown in Table). Four principal factors for 22 traits (Table 4) and ten principal factors for 38 traits (Tables 5–6) were extracted. The order of their extraction coincided with the decreasing order of the portion of the total variance accounted in by each factor. This was used in 71.75% of males and 72.68% of females for 38 traits, respectively.

22 traits

Factor I includes the ridge counts of individual fingers, total and absolute ridge counts, and the pattern intensity index in males and females. This factor may be called »digital pattern size factor« and has high loadings. In comparison with other factors, this factor is responsible for the greatest part of the total variance (34.90% in males and 34.56% in females). *Factor 2* describes mainly

TABLE 1
SEX COMPARISON OF 22 QUANTITATIVE TRAITS BY ANOVA METHOD

Traits	Males		Females		Sex differences	
	Mean	SD	Mean	SD	F ratio	Sign*(P)
Finger RC, I-r	18.67	6.55	16.56	5.32	15.85	0.00**
Finger RC, II-r	9.88	5.89	10.15	5.90	0.23	0.63
Finger RC, III-r	11.65	5.89	10.94	5.38	1.92	0.17
Finger RC, IV-r	16.23	6.93	15.34	6.87	2.17	0.14
Finger RC, V-r	13.04	5.64	12.10	5.37	3.75	0.05
Finger RC, I-l	14.04	5.57	12.65	5.30	8.30	0.00**
Finger RC, II-l	11.15	6.50	10.29	6.28	2.11	0.15
Finger RC, III-l	11.48	5.55	10.57	5.40	3.34	0.07
Finger RC, IV-l	12.91	5.95	11.70	5.88	5.41	0.02
Finger RC, V-l	11.03	4.75	9.88	4.78	7.63	0.01
Total TRC	121.62	46.20	112.82	44.01	5.11	0.02
Absolute ARC	173.27	88.91	152.03	80.10	8.30	0.00**
PII, lh	6.35	1.92	6.22	1.93	0.64	0.42
PII, rh	6.76	1.92	6.38	1.91	5.23	0.02
PII, both h	13.14	3.66	12.56	3.73	3.25	0.07
a-b RC, rh	41.85	5.75	41.15	5.67	1.98	0.16
a-b RC, lh	42.28	6.26	41.38	5.19	3.19	0.07
A-line exit l	2.93	0.85	2.68	0.84	12.05	0.00**
A-line exit r	3.80	1.11	3.61	1.20	3.66	0.06
D-line exit l	4.16	1.26	3.83	1.39	8.29	0.00**
D-line exit r	4.88	1.37	4.62	1.40	4.53	0.03
Main line index	7.89	1.60	7.38	1.76	12.18	0.00**

* The differences are statistically significant when $P < 0.05$.
**According to Bonferroni correction for multiple comparison, the differences are statistically significant when $P < 0.002$.

TABLE 2
SEX COMPARISON OF 13 DAS TRAITS BY ANOVA METHOD

	Males		Females		Sex differences	
Trait	Mean	SD	Mean	SD	F ratio	Sign. (P)
DAs I	16.23	51.28	8.51	50.21	2.19	0.14
DAs II	7.87	19.49	3.78	19.10	5.71	0.02
DAs III	–0.75	12.01	–0.68	12.25	0.00	0.95
DAs IV	15.62	21.01	18.77	21.85	2.07	0.15
DAs V	26.60	85.17	13.89	89.89	2.03	0.15
DAs VI	0.55	3.41	0.37	4.12	0.19	0.67
DAs VII	2.36	9.70	4.21	10.86	3.89	0.05
DAs X	16.77	41.49	20.00	47.53	0.67	0.41
DAs XI	26.65	43.72	27.69	52.25	0.06	0.81
DAs XII	0.62	49.78	8.70	53.29	2.77	0.10
DAs XIII	–10.55	71.10	1.30	63.29	3.26	0.07
DAs XIV	30.42	43.60	30.58	34.91	0.00	0.96
DAs XV	18.56	24.10	22.81	26.36	3.72	0.05

TABLE 3
SEX COMPARISION OF 11 DIV AND 14 FLAS TRAITS BY KRUSKAL-WALLIS METHOD

	Mean values		Mean ranks		Sex differences	
Trait	Males	Females	Males	Females	χ^2	Signif.*(P)
Div I	11.24	10.57	223.05	202.92	2.83	0.09
Div II	13.48	11.63	237.42	190.59	15.08	0.00**
Div III	16.38	14.74	209.97	168.71	13.25	0.00**
Div IV	91.05	75.53	220.79	189.50	7.00	0.01
Div V	124.83	91.80	229.22	178.07	18.76	0.00**
Div VI	259.44	216.42	209.08	165.29	15.01	0.00
Div VII	4.11	3.86	224.34	201.34	3.67	0.06
Div VIII	4.87	4.22	237.17	190.90	14.67	0.00**
Div IX	4.96	4.50	210.93	167.53	14.60	0.00**
Div X	16.58	14.81	206.51	172.78	8.81	0.00**
Div XI	0.59	0.56	279.89	262.68	1.65	0.20
FlAs I	39.59	38.72	194.23	186.95	0.41	0.52
FlAs II	14.31	14.35	265.13	233.14	6.23	0.01
FlAs III	9.25	9.73	254.40	266.41	0.83	0.36
FlAs IV	14.85	15.15	187.34	188.82	0.02	0.90
FlAs V	69.24	73.65	190.74	197.99	0.40	0.53
FlAs VI	4.57	5.49	167.17	201.83	9.75	0.00**
FlAs VII	6.58	8.02	220.81	248.69	4.97	0.03
FlAs X	30.91	35.87	238.94	267.90	4.96	0.03
FlAs XI	32.88	38.22	234.99	259.29	3.58	0.06
FlAs XII	35.60	36.86	219.76	229.05	0.57	0.45
FlAs XIII	55.30	47.61	223.74	203.03	2.97	0.09
arFlAs XIV	31.70	25.51	256.20	231.65	3.66	0.06
FlAs XV	19.49	20.38	247.54	275.39	4.50	0.03
FlAs XVI	13.14	13.08	190.50	192.71	0.04	0.85

* The differences are statistically significant when $P < 0.05$.
**According to the Bonferroni correction for multiple comparison, the differences are statistically significant when $P < 0.002$.

TABLE 4
ROTATED FACTOR LOADINGS OF 22 QUANTITATIVE TRAITS IN MALES AND FEMALES

	Males Factors					Females Factors			
Trait	1	2	3	4	Trait	1	2	3	4
Absolute ARC	0.98	–	–	–	Absolute ARC	0.98			
Total TRC	0.95	–	–	–	Total TRC	0.95	–	0.25	–
PII both h	0.84	–	–0.32	–0.31	PII both h	0.83	–	–0.40	0.31
PII rh	0.80	–	–0.29	–	PII rh	0.80	–	–0.31	–
PII lh	0.77	–	–0.30	–0.37	Finger RC, IVr	0.75	–	–	–
Finger RC, IIIr	0.76	–	–	–	PII lh	0.74	–	–0.43	0.38
Finger RC, IVr	0.74	–	–	–	Finger RC, IIIr	0.72	–	–	–
Finger RC, Vr	0.74	–	–	–	Finger RC, Vr	0.71	–	–	–
Finger RC, IIIl	0.72	–	–	–	Finger RC, IIl	0.68	–	–	–
Finger RC, IIl	0.71	–	–	–	Finger RC, IIIl	0.68	–	–	–
Finger RC, IIr	0.58	–	–	–	Finger RC, IIr	0.67	–	–	–
Finger RC, Ir	0.55	–0.27	–	0.34	Finger RC, IVl	0.57	–	–	–0.39
Finger RC, IVl	0.52	–	–	–	Finger RC, Vl	0.49	–	0.28	–0.43
MLI	–	0.92	0.38	–	MLI	–	0.98	–	–
D-line, r	–	0.69	0.43	–	A–line, r	–	0.80	–	–
A-line, r	–	0.66	–	–	D-line, r	–	0.80	–	–
D-line, l	–	0.59	0.33	–0.36	D-line, l	–	0.72	–	–
a-b RC, r	–	–0.42	0.62	–0.25	A-line, l	–	0.50	–	–
a-b RC, l	–	–0.51	0.58	–	a-b RC, l	–	–0.32	0.54	0.43
Finger-RC, Il	0.29	–	0.44	0.37	Finger RC, Ir	0.47	–	0.52	–
Finger-RC, Vl	0.41	–	–	0.53	a-b RC, r	–	–	0.48	0.63
A-line,-l	–	0.48	–	0.27	Finger RC, Il	0.31	–	0.55	–
V.P.	7.68	3.02	1.92	1.40	V.P.	7.60	3.26	1.80	1.41
Cum.var.	34.90	48.61	57.35	63.72	Cum.var.	34.56	49.39	57.57	63.95

1 Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

the terminations of palmar main lines A and D in both sexes. This factor may be called »palmar main lines factor« and explains 13.71% variance in males, and 14.83% in females. *Factor 3* includes the most dominating variable a-b ridge counts and may be called »a-b ridge count factor«. This factor also has in common high loadings for some of the variables (PII, finger ridge counts on I, IV, V, MLI, A and D lines endings, etc.) as in the first and second factors. This, factor explains 8.74% variance in males, and 8.18% in females. *Factor 4* has high loadings for almost the same variables as in factor 3, which accounts for the finger and palmar traits. This factor may be called »finger pattern intensity factor« and explains the variance of 6.37% in males and 6.38% in females. The cumulative proportion of variance explained by the aforementioned factors is 63.72% in males and 63.95% in females for 22 traits.

38 traits

In the second principal component analysis, 38 dermatoglyphic variables were used, including indices of intra-individual diversity and of directional and fluctuating asymmetry (Table 5 and Table 6). Ten principal component factors were extracted as indicated below. The first two principal factors (Factor 1 and Factor 2) represent »intra-individual diversity of finger ridge counts«.

This component has its weights fairly evenly distributed in both sexes, with high loadings for the ten indices of intra-individual diversity, four related to all ten fingers, the other six related only to the five fingers of the left or right hand. These factors explain 20.23% variance in males, 19.79% in females (Factor 1) while 15.21% in males and 14.29% in females (Factor 2). The third factor (Factor 3), which has significant weights for the directional asymmetry indices in males, and it is prominent in Factor 5, may be called »directional asymmetry factor«. Some differences in the two sexes occur in the extraction order of the remaining factors. Thus, the third factor in males partially corresponds to the females' fifth factor. This factor is responsible for 6.79% and 6.45% of the total variance in males and in females, respectively. The

TABLE 5
ROTATED FACTOR LOADINGS OF 38 VARIABLES IN MALES

	Factors									
Trait	1	2	3	4	5	6	7	8	9	10
Div IX	0.94	0.27	–	–	–	–	–	–	–	–
Div VI	0.94	0.27	–	–	–	–	–	–	–	–
Div VII	0.89	–0.38	–	–	–	–	–	–	–	–
Div IV	0.88	–0.36	–	–	–	–	–	–	–	–
Div I	0.85	–0.42	–	–	–	–	–	–	–	–
Div III	0.84	0.30	0.25	–	–	–	–	–	–	–
Div X	0.78	–	–0.28	–	–	–	–	–	–	–
DAs I	–0.32	0.92	–	–	–	–	–	–	–	–
DAs V	–0.36	0.91	–	–	–	–	–	–	–	–
DAs VI	–0.39	0.78	–	–0.32	–	–	–	–	–	–
Div VIII	0.60	0.76	–	–	–	–	–	–	–	–
Div V	0.60	0.75	–	–	–	–	–	–	–	–
Div II	0.60	0.74	–	–	–	–	–	–	–	–
FlAs VI	–0.52	0.62	–	–	–	–	–	–	–	–
DAs XIII	–	–0.46	0.27	–	–	0.25	–	–	0.37	–
DAs IV	–	–	0.78	–	–	0.39	–	–	–	–
DAs XIV	–	–	0.59	–0.29	–	–	–	–	–	–
FlAs XVI	0.25	–	0.44	–	0.35	–0.33	–	–	–	–
FlAs I	–	–	0.34	0.79	–	–	–	–	–	–
FlAs V	–	–	0.41	0.75	–	–	–	–	–	–
DAs VII	–	–	–	–0.44	–	–	–	–0.35	–	–
FlAs XIII	0.27	–	–	–	0.61	–	0.25	–	–	–
DAs XI	–	0.29	0.30	–	0.58	–	–0.42	–	–	–
FlAs III	–	–	–	–	0.54	–	–	0.36	–	–
DAs XII	–	–0.29	0.25	–	–	0.54	–	–0.32	–	–
Div XI	–	–	–	0.26	–	0.47	–	–	–	–
FlAs XIV	–	–	0.40	–	–	–0.46	0.42	–	–	–
FlAs IV	–	–	–	–	0.30	–0.36	0.31	0.26	0.34	–
FlAs XII	–	–	–	–	–	–	0.50	–	–	0.40
DAs X	–	–	0.29	–	–	–	–0.45	0.31	–	–
FlAs II	–	–	–	–	–	0.26	0.33	0.58	–	–
DAs XV	–	–	–	–	–	–	–	–	0.55	0.31
FlAs XI	–	–	–	–	0.41	–	–	–	0.54	–0.35
FlAs XV	–	–	–0.33	–	–	–	–	0.29	–	–0.49
FlAs X	–	–	–	–	–	–0.44	–	–	–	0.43
DAs III	–	–	–0.28	–	–	–	–	–	–	0.32
DAs II	–	–	–	–	–	–	0.40	–	–	–0.38
FlAs VII	–	–	–	–	–	0.26	–	–	–0.31	–
V.P.	7.69	5.78	2.58	2.11	1.86	1.79	1.49	1.39	1.33	1.25
Cum. var.	20.23	35.44	42.23	47.78	52.66	57.38	61.30	64.97	68.47	71.75

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

TABLE 6
ROTATED FACTOR LOADINGS OF 38 VARIABLES IN FEMALES

	Factors									
Trait	1	2	3	4	5	6	7	8	9	10
Div VI	0.94	–	–	–	–	–	–	–	–	–
Div II	0.93	0.26	–	–	–	–	–	–	–	–
Div IX	0.93	–	–	–	–	–	–	–	–	–
Div VIII	0.93	0.30	–	–	–	–	–	–	–	–
Div V	0.92	0.27	–	–	–	–	–	–	–	–
Div X	0.92	–	–	–	–	–	–	–	–	–
Div III	0.86	–	–	–	–	–	–	–	–	–
Div IV	0.67	–0.66	–	–	–	–	–	–	–	–
DAs V	–	0.95	–	–	–	–	–	–	–	–
DAs I	–	0.93	–	–	–	–	–	–	–	–
DAs VI	–	0.89	–	–	–	–	–	–	–	–
FlAs VI	–	0.73	0.46	–	–	–	–	–	–	–
Div VII	0.63	–0.72	–0.26	–	–	–	–	–	–	–
Div I	0.65	–0.69	–	–	–	–	–	–	–	–
FlAs V	–	–	0.91	–	–	–	–	–	–	–
FlAs I	–	0.30	0.89	–	–	–	–	–	–	–
tblFlAs II	–	–	–	0.71	–	–	–	–	–	–0.29
DAs X	–	–	–	0.71	–	–	–	–	–	–
FlAs X	–	–	–	0.62	–	–	–	–	–	0.45
DAs II	–	–	–	–0.61	–	–	0.26	–	–	–
DAs IV	–	–	–	0.41	0.83	–	–	–	–	–
DAs XII	–	–	–	–	0.71	–	–0.34	–	–	–
DAs XI	–	–	–	–	0.60	–0.28	–	–	0.45	–
FlAs XII	–	–	–	–	–	0.81	–	–	–	–
FlAs III	–	–	–	–	–	–	0.75	–	–	–
Div XI	–	–	–	–	–	–	0.69	–	–	–
FlAs XIII	0.26	–	–	–	–	–	–	0.77	–	–
FlAs IV	–	–	–	–	–	0.46	–	0.59	0.25	0.27
FlAs XVI	–	–	–	–	0.40	–	–	0.45	–	–
FlAs XI	–	–	–	–	–	–	–	–	0.85	–
DAs XV	–	–	–	–	–	–	0.35	–	0.39	–
DAs III	–	–	–	–	–	–	–	–	–	0.67
DAs XIII	–	–	–	–	0.32	0.52	–	–	–	–0.53
DAs VII	–	–	–	–	–	–	–	–	–	–
FlAs VII	–	–	–	–	–	–	–	–0.26	–	–
FlAs XV	–	–	–	–	–	–	–	–	–	–
DAs XIV	–	–	–	–	0.41	–	0.29	–	–	–
FlAs XIV	–	–0.33	–	–	–	0.40	–	–	–	0.30
V.P.	7.52	5.43	2.45	2.32	2.26	1.63	1.62	1.50	1.48	1.40
Cum. var.	19.79	34.08	40.53	46.65	52.60	56.90	61.15	65.09	68.98	72.68

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

highest concentration of the fluctuating asymmetry indices are clear for factors 6 in males, factor 8 in females and may be called »fluctuating asymmetry factor«. The other indices in these factors carry little weight; only DAs and FLAs indices are dominating very clearly. The remaining factors displayed a great deal of variations, which have low loadings, and the weights are not similar in magnitude for the DAs and FLAs indices in both sexes. These factors mainly concentrated with DAs and FLAs indices. However, all appear in the same component or in adjacent components, or in other words, these indices are dispersed among the above factors. We made an attempted to interpret these remaining components but they are not clearly interpretable, none of these components reflects DAs, FLAs, or Div; these are mixed up with each other. In view of the lack of clarity of the latter components in both sexes, we have not presented them all in detail. From the above results, however, only two clearly defined factors may be observed based on 38 indices in the analysis namely – »finger ridge counts diversity factor« and »bilateral asymmetry factor«.

Discussion and Conclusion

The results were presented in the preceding pages will be discussed under the following headlines:

Analysis of variance:

22 traits

Out of 22 traits, only nine are appear significant sex differences for finger I, followed by IV and V, total (TRC) and absolute (ARC) finger ridge counts, main line index (MLI), exits of the main line A and D for the left palms, and pattern intensity index (PIIr). However, the results of palmar traits reveal extreme homogeneity that is similar to earlier studies in various populations[38–42,10,43]. This difference between palm and finger may be due to the possible role of environmental (prenatal) factors in the realization of dermatoglyphic sex differences. The development of palmar dermatoglyphics has a relatively longer growth period compared with fingers stated by Cummins[44]. Thus, the palmar dermatoglyphic pattern of affinities corresponds better than fingers to the ethno-historic background of the populations[45,46,10].

38 traits

The indices of intra-individual diversity are stronger in showing significant sex differences; out of 11 traits 8 are statistically significant. This result is very similar with Indian population[47, 17], but not with Jewish population [14] and Andean Indians[48]. Reddy and Reddy[49] suggest that the differences between sexes and population may be due to the micro-environmental variation in fetal growth. Sex differences in the indices of directional asymmetry (DAs) is very poor in the Chuvashian population (only 1 out of 13 indices), which is in perfect agreement with Karmakar et al.[17], while it is well expressed in Jewish population[14]. A low degree of sex dimorphism with regard to fluctuating asymmetry (FLAs) is observed. Only 5 out of 14 indices are significantly different. This finding is similar with Jewish population[14].

Another important observation that needs to be highlighted is that the present study has greater mean values in females compared to males; and this is exactly similar with Indian population[17]. However, most of the previous studies in different populations in India and abroad are characterized in showing greater asymmetry in males than in females[47,50,7,51,52]. Our present results contradict the above-mentioned studies and support the hypothesis of Livshits and Kobyliansky[53] that increased heterozygosity is often associated with a decreased phenotypic variability including a diminished fluctuating asymmetry. Micle and Kobyliansky[14] also explained in detail that possibly like dermatoglyphic traits do not follow the same behavior like other morphological traits, but male embryos with high level of FLAs are may be eliminated by selection. Thus, sometimes the reverse situation is also found, i.e. higher dermatoglyphic FLAs in females than in males.

Principal component analysis: The four factors on finger and palmar dermatoglyphic traits were identified for both sexes in the present study from 22 traits – digital pattern size, palmar main lines, a-b ridge count, and finger pattern intensity. The first three factors are comparable with the earlier studies in Melanesian population Froehlich and Gills[23]; in German population Chopra[54,55]; in English population Roberts and Coope[56]; in Taimir aborigine Galaktinov et al.[57]; in Indian population Das Chaudhuri and Chopra[58], Krishnan and Reddy[59], Karmakar et al.[10]; and in Jewish population Micle and Kobyliansky[60,14]. The fourth factor is similar with earlier studies[64,14,10]. Among factors describing the variability of 38 indices of diversity and asymmetry, mainly two factors namely of intra-individual diversity, and bilateral asymmetry, are revealed in both sexes. Therefore, in addition to the above four factors (from 22 traits), already described in the literature, these two (from 38 indices) clearly defined factors may be added to the above-mentioned list of factors on dermatoglyphic traits. These results are perfectly corroborated with Micle and Kobyliansky[60,14,] Karmakar et al.[10]. In view of hardly available such study in the literature on dermatoglyphic component structure; we can not compare in detail our results with other findings. However, we can explain that there is lack of universality in the order of components. However, the structure of components that exhibit a large inter-population difference is similar in both sexes. The overall variations among different studies may be due to different combinations of variables utilized, which are reflected by the principal components as different orders of arrangements in different populations or studies. Especially, factor 1 (digital pattern size factor) is remarkable, due to its degree of universality observed in different racial/geographical and sex groups, which supports the following hypothesis: (i) the general size of the finger pattern[55] indicates that no separate complexes are responsible for individual fingers. (ii) Each finger is a discrete part of a digital complex comprising ten fingers and not a separate

unit acted on independently by the genes involved Butler[61]. (iii) The theory of Butler[61] also supported by Roberts and Coope[56], Jantz and Owsley[62] in their studies of factor analysis on dermatoglyphic data.

Conclusion

The sex differences in two categories of dermatoglyphic traits in Chuvashian populations are reflected differently and contradictory with other ethnic groups. However, a degree of universality is observed in different ethnic/geographical and sex groups with respect to »digital pattern size factor« and »intra-individual diversity factor«, which possibly indicates that the genetic factor has more influence on these variables than environmental factors in male and female. Jantz [63] also arrived at a similar conclusion in his comparison of American and African Negro samples. The overall variations among the remaining factors of dermatoglyphic traits are different, just only for different orders of arrangements in different population studies, which indicate of a common biological validity perhaps exists of the underlying component structure between two categories of dermatoglyphic traits.

Acknowledgements

The cooperation and hospitality during the fieldwork of all the members of the families included in this analysis is gratefully appreciated.

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SEKSUALNI DIMORFIZAM KOD ČUVAŠKE POPULACIJE U RUSIJI U DVA TIPA DERMATOGLIFSKIH OSOBINA: ANALIZA GLAVNIH KOMPONENATA

S A Ž E T A K

Provedena je analiza glavnih komponenata, s ciljem određivanja seksualnog dimorfizma u sastavnim strukturama digito-palmarnih dermatoglifa 547 pojedinaca (293 muškaraca, 254 žene) kod čuvaške populacije u Rusiji. Razlike među spolovima u dvije kategorije (22 kvantitativna svojstva kao i 38 svojstva asimetrije i raznolikosti) dermatoglifskih osobina reflektiraju se različito i razlikuju ih od drugih etničkih grupa. Međutim, zajednička obilježja faktora 1, »faktora veličine uzorka prsta« (FRC – Finger ridge count – broj grebena na vrhu pojedinog prsta između triradiusa i središta crteža – iz prve kategorije osobina), kad se usporede s drugim populacijama, ukazuju na njihov stupanj univerzalnosti, što pak pokazuje da je varijabilnost FRC određena istim genima koji kontroliraju vrste crteža. Faktori – »faktor raznolikosti među prstima« i »faktor bi-lateralne asimetrije« – izlučeni iz druge kategorije dermatoglifskih osobina također su slični kod oba spola. Međutim, te komponente jedva da su opisane u literaturi. Priroda varijabilnosti ovih komponenti iz obje kategorije dermatoglifskih osobina vrlo je slična između spolova. Ovi rezultati ukazuju na zajedničku biološku vrijednost temeljnih sastavnih struktura osobina digito-palmarnih dermatoglifa.

Appendix 1: List of the utilized traits and indices

22 Quantitative Traits	13 Directional Asymmetry (DAs) traits
Finger RC, I r	DAs I = Div II – Div I
Finger RC, II r	DAs II = PII, r h – l h
Finger RC, III r	DAs III = a-b RC, r – l
Finger RC, IV r	DAs IV = h RC, r h – l h
Finger RC, V r	DAs V = S^2, r h – l h
Finger RC, I l	DAs VI = Div VIII – Div VII
Finger RC, II l	DAs VII = atd angle, r – l
Finger RC, III l	DAs X = fRC, V r – V l
Finger RC, IV 1	DAs XI = fRC, IV r – IV l
Finger RC, V 1	DAs XII = fRC, III r – III l
Total RC (TRC)	DAs XIII = fRC, II r – II l
Abs (ARC)	DAs XIV = fRC, I r – I l
PII, lh	DAs XV = MLI, r h – l h
PII, rh	14 Fluctuating Asymmetry (FLAs) traits
PII, both h	FlAs I = [Div I – Div II]
a-b RC, rh	FlAs II = PII, [rh – lh]
a-b RC, lh	FlAs III = a-b, RC, [rh – lh]
A-line exit, l	FlAs IV = hRC, [rh – lh]
A-line exit, r	FlAs V = [Div V – Div IV]
D-line exit, l	FlAs VI = [Div VIII – Div VII]
D-line exit, r	FlAs VII = atd angle, [r – l]
MLI	FlAs X = fRC, [Vr – Vl]
38 traits (diversity and asymmetry):	FlAs XI = fRC, [IVr – IVl]
11 Diversity traits (Div)	FlAs XII = fRC, [IIIr – IIIl]
Div I = max – min fRC (lh)	FlAs XIII = fRC, [IIr – IIl]
Div II = max – min fRC (rh)	FlAs XIV = fRC, [Ir – Il]
Div III = max – min fRC (both h)	FlAs XV = MLI, [rh – lh]
Div IV = S^2 for lh, (or S^2L)	FlAs XVI = A1, asymmetry index
Div V = S^2 for rh, (or S^2R)	
Div VI = S2 (both h)	DAs VIII – IX and FlAs VIII – IX, based on a-b dist,
Div VIII = IIDR (for rh)	a-b ridge breadth were excluded from the analysis.
Div IX = $S\sqrt{10}$, (both h)	Numbering of the traits remained as in our other publications
Div X = $S\sqrt{5}$, (both h)	for simplification of comparison with our previous data.
Div XI = Shannon's index	

Abbreviations: RC = ridge count; r = right; l = left; h = hand; PII – Pattern Intensity Index; MLI = main line index; Div I to Div XI = indices of intra-individual diversity of finger ridge counts; DAs I to Das XV = indices of directional asymmetry; FlAs I to FlAs XVI = indices of fluctuating asymmetry.

Appendix 2: Formulae for some indices of dermatoglyphic diversity and asymmetry:

The directional asymmetry (DAs) was computed by the following equation: $DAij = X_{iR} - X_{iL}$.

The fluctuating asymmetry (FLAs) was computed by using the absolute differences between the bilateral measurements. The distributions of the non-absolute differences for each individual were corrected (Livshits et al., 1988) to avoid additional influences (scaling effects) such as size of the trait or directional asymmetry, yielding the following equation for computing FA:

$$FA_{ij} = \left| (X_{iR} - X_{iL}) - 1 / n \sum_{i=1}^{n} [(X_{iR} - X_{iL}) \right|$$

Where, xi = trait (x) of individual (i), R, L = right and left, n = size of the sample, and FA_{ij} is the value of FA of trait (j) in the i th individual.

Div I, Div II, Div III. Maximal minus minimal finger ridge counts in the five left (Div I), five right (Div II), or in the ten finger ridge counts (Div III). Div IV, Div V = $\sum_{i=1}^{5} q_i^2 - Q^2 / 5$, for the left (Div IV, S^2L), or right fingers (Div V, S^2R); Div VI, $S^2 = \sum_{i=1}^{10} q_i^2 - Q^2 / 10$, Div VII, Div VIII $= \sqrt{\sum_{i=1}^{5} q_i^2 - Q^2 / 5}$, for the left (Div VII, IIDL), or right finger (Div VIII, IIDR); Div IX, $S\sqrt{10} = \sqrt{\sum_{i=1}^{10} (q_i^2 - Q^2 / 10) / 10}$; Div X, $S\sqrt{5} = \sqrt{\sum_{i=1}^{5} (k_i^2 - Q^2 / 5) / 5}$.

In these formulae, q_i is the ridge count for the ith finger, Q is the sum of the five finger ridge counts of a hand (Div IV, V, VII, VIII) or of all the ten fingers (Div VI, IX, X), and k is the sum of ridge counts of the ith pairs of homologous right and left fingers.

Div XI. Shannon's index, $D = -\sum_{i=1}^{4} P_i \log P_i$ where P_i is the frequency of each of the four basic finger pattern types on the ten fingers; Abs XVI, $AI = \sqrt{\sum_{i=1}^{5} (R_i - L_i)^2}$, where R_i and L_i are the ridge counts for the ith finger of the right and left hands.