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Morpho-Physiological Features of Human Populations in the Context of Climatic – Geographical Conditions

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A B S T R A C T

This paper is based on the data obtained in the course of population studies conducted in 33 geographical regions of the former USSR territory by the faculty of the Anuchin Research Institute and Museum of Anthropology, Lomonosov Moscow State University, between 1961 and 1991. The data resulting from study of 4386 male and 4626 female subjects aged 17 to 99 include head and body morphology, bone mineral density, blood oxygen saturation and blood biochemistry. We aimed at studying the link between the traits of a population and the climatic conditions of the area inhabited by this population. Individual characteristics of the subjects were normalized by age and sex, and factor analysis was used to reduce the number of cross-correlating features. As a result, several integral characteristics (factors) were identified: five body morphology-related factors, two head morphology-related factors, one bone mineral density-related factor, one blood oxygen saturation-related factor and three blood biochemistry-related factors. These factors explained 79.3%, 78.38%, 63.51%, 74.4% and 66.77% of the trait groups' variability, respectively. The correlation analysis between these factors and climatic indicators demonstrated that chest dimensions were the least tolerant to the climatic conditions among the morphological characteristics studied. Hemoglobin-protein ratios, as well as the factor that includes total cholesterol, were the most climate-dependent among the biochemical parameters. As far as our data show, blood serum oxygen saturation – the key factor determining the performance of the cardiovascular and respiratory systems – is also climate-dependent.

***Key words**: anthropoecology, body morphology, metabolic and biochemical traits, climatic factors*

Introduction

The anthropological and ecological literature offers a wealth of data on the variation of morphological and physiological characteristics of subjects populating different climatic regions[1–4]. Different standard values of functional and metabolic parameters have been determined for high altitude communities[5–8], for hot and cold climate populations[9–20]. The study discusses a wide range of factors that determine the morphological and physiological differences in populations. These factors included nutrition patterns, duration of residence in the area, and other cultural and social factors. Nevertheless, most authors emphasize that the peculiarities of the way a human body functions are determined by the specific meteorological factors which characterize a climatic zone.

The study attempts to determine the strength of evidence linking anthropometric and metabolic traits of certain populations, on the one hand, with climatic and geographical characteristics of their habitats – different locations in the vast territory of the former USSR, on the other. Individual characteristics were normalized to the total sample for age, separately for male and female subjects. The need to account for the age-gender structure was caused by a significant dependence of the distribution of the analyzed characteristics upon age and gender.

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However, this component of sample variability was not among the targets of the study, hence its possible effect upon the results had to be minimized. Consequently, this simplified the analysis of the climatic component in the entire complex of factors determining the differences between populations. It is noteworthy that weeding this component out of the total variability picture does not affect the other components of individual and group trait variability.

Material and Methods

A detailed list of the groups included in the study, their geographical locations, as well as the size of the samples distributed by their morphological and metabolic characteristics are presented in Tables 1a and 1b. The sample includes 4386 male (aged 17 to 95) and 4626 female subjects (aged 17 to 99). The complete list of traits and the number of subjects studied for each of these traits appear in Tables 2a and 2b). This list includes 22 anthropometric and 14 metabolic characteristics. We used the data on head and body morphology, on the rate of hand bones ageing (OSSEO), and on the biochemical and physiological indicators of metabolic rate; the data were obtained during field expeditions by the faculty of the Anuchin Research Institute and Museum of Anthropology, Lomonosov Moscow State University, in 1961–1991. All the subjects were permanent residents of the territories included in the study[21]. The results of these expeditions had been previously analyzed in the research studies conducted by the faculty of the Anuchin Research Institute and Museum of Anthropology, Lomonosov Moscow State University – in particular, in Pavlovsky and Kobyliansky 1997[21] and Gudkova 2008, 2009[3,4].

Anthropometric parameters

The anthropometric body characteristics were divided into two groups of independently analyzed traits:

1) Body morphology – 18 traits
2) Head morphology – 4 traits.

A detailed description of the methodologies used for anthropometric measurements, as well as for estimating the biological age (OSSEO), appears in Kobyliansky et al. 1995[22] and Pavlovsky and Kobyliansky 1997[21].

Metabolic parameters

The metabolic parameters were divided into three groups of independently analyzed traits:

1) Oxygen consumption.

Blood oxygen saturation parameters obtained by oximetry included three characteristics:

a) the period after the subject started holding his/her breath, when no reduction of arterial blood oxygen saturation was noted (AB phase,);
b) stable saturation time to body weight ratio (AB phase to Weight ratio,).;
c) pulmonary blood flow time.

2) Blood biochemistry

Eight biochemical parameters were tested:

- Serum hemoglobin was determined using a photoelectric electro-hemometer.
- The total protein value was determined using a refractometer.
- The levels of five different protein fractions were determined by electrophoresis.
- The concentration of total serum cholesterol was estimated using the Ilca's method[23] (1964).

3) Bone mineral density (BMD)

Bone mineral density was determined based on the characteristics of the middle finger of the right hand: BMD of the compacts of the distal and middle phalanges, and the average BMD of both compact and spongious bone of the phalanges.

BMD indices were derived from the X-ray analysis by photodensitometry.

The methods used for determining the metabolic characteristics are described in the manual[24], Methods of morphological and physiological studies in anthropology. Publ. MSU, Moscow, ed. Alexeeva T.I., 1981.

Climate data

The geographical coordinates (LATID and LONGT) and ten climatic characteristics corresponding to each population were collected using World Climate Data and Monitoring Program[25] (2009).

Climatological data included:

1) mean monthly temperature (°C) in January (TMPJN) and in July (TMPJL)
2) mean monthly atmospheric pressure (hPa) in January (PRSJN) and in July (PRSJL)
3) mean annual precipitation (mm) (PRCPT)
4) altitude (ALTTD)
5) day duration (hours) in January (DAYJN) and July (DAYJL)
6) mean monthly humidity (partial vapor parcel pressure; hPa) in January (VPJN) and July (VPJL).

In addition, the bioclimatic index of severity of climatic regime (BISCR) was determined.

This index had originally been introduced by Belkin (1992)[26] and Belkin et al. (1998)[27] as an empirical »comfort assessment value« reflecting the severity of climatic conditions«.

In this study, the BISCR index in January (BISCR1) and in July (BISCR2), as well as the difference between July and January (B2-B1= BISCR2 – BISCR1), were included in the analysis.

Statistics methods

All statistical calculations were run on the STATISTICA-2005[28] and MAN-2009 software packages[29].

Age dependency of the traits in the total sample was investigated separately for male and female subjects us-

TABLE 1A
STUDIED POPULATIONS AND NUMBER OF THE INDIVIDUAL'S MORPHOMETRIC MEASUREMENTS

Population	Location*	OSSEO			Body morphology			Head morphology		
		male	female	total	male	female	total	male	female	total
Abkhazian_1	Ochamirsky district of Georgia: Chlou, Jgerda, Atara	324	294	618	354	293	647			
Abkhazian_2	Gudauta district of Georgia: Kaldakhvar, Aatsy	234	183	417	293	211	504			
Azerbaijanian	Kazakh district of Azerbaijan: Askipar	131	162	293	183	201	384			
Beduin	South Sinai Egypt	107		107						
Buryat	Buryatia: Argoda, Kurumkan, Ulyuian	125	179	304	137	189	326	136	189	325
Byelorus	Mogilev region of Byelorussia: Veremeiki	75	96	171	51	72	123			
Chukchi	Chukchi National Circuit: Uelen, Lorino	71	99	170	69	79	148			
Eskimos	Chukchi National Circuit: Uelen, Cireniki, Chaplino	48	56	104						
Georgian	Terzholi district of Georgia: Alisubani	89	182	271	85	179	264			
Indian	Delhi area of India	185		185	157		157			
Jew	Israel	158	134	292						
Karakalpak	Takhtakupyr district of Uzbekistan: Karuzyak	93	111	204	85	98	183	79	81	160
Karyak	Kariat Circuit in Kamchatka	52	40	92						
Kazakh	Jambul region of Kazakhstan: Akkol	115	109	224	100	105	205	98	105	203
Lithuanian	Lithuania: Klaipeda, Palanga, Vilinus	195	133	328						
Mongol Khalkha	Mongoliia: Bat-Ulzii	97	96	193						
Nents	Yamalo-Nenets National Circuit: Tarko-Sale	73	37	110	59	28	87	43	12	55
Russian_01	Buryatia: Argoda, Burguzin, Chitkan, Kurumkan, Uro	265	273	538	276	287	563	273	287	560
Russian_02	Ismailinsky district of Azerbaijan: Ivanovka	207	224	431	236	263	499			
Russian_03	Lithuania: Klaipeda, Palanga, Vilnus	81	107	188						
Russian_04	Kursk region: Rozhdestvenka	60	46	106	84	104	188	82	99	181
Russian_05	Povorinsky district of Voronezh region: Peski	118	242	360	104	217	321			
Russian_06	Lipetsk region:Puttytino	34	52	86	37	57	94			
Russian_07	Crimea of Ukraina: Voshod	75	159	234						
Russian_08	Komi republic: Ukhta	78	201	279						
Russian_09	Moscow	4	76	80						
Russian_10	Komi republic: Syktyvkar	24	23	47						
Russian_11	Yaroslavl region: Porechye	219	266	485						
Russian_12	Voronezh region: Rossosh	93	84	177	91	80	171			
Saamy	Murmansk region: Lovozer	23	20	43	22	18	40			
Tadjik_1	Leninabad region of Tajikistan: Chorku	108	89	197	119	99	218	109	99	208
Tadjik_2	Leninabad region of Tajikistan: Unji	54	88	142	56	88	144	49	76	125
Teke Turkmen	Bukharden distinct of Turkmenia: Kelyata	92	100	192	96	107	203	90	64	154
Tuvinchi	Tuva: Chadan, Erzin, Toora-Jem	173	130	303						
Ukrainia	Crimea of Ukraina: Voshod	58	90	148						
Yomut Turkmen	Kazanjik distinct of Turkmenia: Kulmach and Uzun-Sun	81	78	159	71	78	149			

* The places are named as it was for the moment of the study

ing polynomial regression models. The choice of the best model was based on the likelihood ratio test (LRT). Age dependency models were then used to level the data variability reflecting the age- and gender-related sample structure. All further analyses were performed on adjusted traits independently for each of the five groups of traits: two groups of anthropometric characteristics and three groups of metabolic characteristics. Trait correlation analysis was performed separately for male and female subjects in each of the five groups. Due to lack of statistically significant differences between the two correlation matrices, the subsequent factor analysis was

TABLE 1B
STUDIED POPULATIONS AND NUMBER OF THE INDIVIDUAL'S METABOLIC MEASUREMENTS

Population	Location*	Blood biochemistry			BMD			Oxygen consumption		
		male	female	total	male	female	total	male	female	total
Abkhazian_1	Ochamirsky district of Georgia: Chlou, Jgerda, Atara				236	164	400			
Abkhazian_2	Gudauta district of Georgia: Kaldakhvar, Aatsy				219	162	381			
Azerbaijanian	Kazakh district of Azerbaijan: Askipar				117	149	266			
Beduin	South Sinai Egypt									
Buryat	Buryatia: Argoda, Kurumkan, Ulyuian	123	164	287	127	178	305	135	172	307
Byelorus	Mogilev region of Byelorussia: Veremeiki				48	69	117			
Chukchi	Chukchi National Circuit: Uelen, Lorino	65	77	142	63	73	136	58	68	126
Eskimos	Chukchi National Circuit: Uelen, Cireniki, Chaplino									
Georgian	Terzholi district of Georgia: Alisubani				79	173	252			
Indian	Delhi area of India				129		129	130		130
Jew	Israel									
Karakalpak	Takhtakupyr district of Uzbekistan: Karuzyak	36	18	54	80	80	160	80	80	160
Karyak	Kariat Circuit in Kamchatka									
Kazakh	Jambul region of Kazakhstan: Akkol	82	93	175	99	105	204	100	102	202
Lithuanian	Lithuania: Klaipeda, Palanga, Vilinus									
Mongol Khalkha	Mongoliia: Bat-Ulzii									
Nents	Yamalo-Nenets National Circuit: Tarko-Sale				40	12	52	39	10	49
Russian_01	Buryatia: Argoda, Burguzin, Chitkan, Kurumkan, Uro	237	235	472	263	278	541	265	257	522
Russian_02	Ismailinsky district of Azerbaijan: Ivanovka									
Russian_03	Lithuania: Klaipeda, Palanga, Vilnus									
Russian_04	Kursk region: Rozhdestvenka	65	98	163	46	36	82	79	94	173
Russian_05	Povorinsky district of Voronezh region: Peski									
Russian_06	Lipetsk region:Puttytino				30	45	75			
Russian_07	Crimea of Ukraina: Voshod									
Russian_08	Komi republic: Ukhta									
Russian_09	Moscow									
Russian_10	Komi republic: Syktyvkar									
Russian_11	Yaroslavl region: Porechye									
Russian_12	Voronezh region: Rossosh				55	5	60			
Saamy	Murmansk region: Lovozer				20	16	36	20	16	36
Tadjik_1	Leninabad region of Tajikistan: Chorku	81	71	152	87	81	168	100	82	182
Tadjik_2	Leninabad region of Tajikistan: Unji				41	73	114	42	70	112
Teke Turkmen	Bukharden distinct of Turkmenia: Kelyata									
Tuvinchi	Tuva: Chadan, Erzin, Toora-Jem									
Ukrainia	Crimea of Ukraina: Voshod	83	80	163	81	66	147	90	79	169
Yomut Turkmen	Kazanjik distinct of Turkmenia: Kulmach and Uzun-Sun	27	34	61	53	53	106	67	69	136

* The places are named as it was for the moment of the study

conducted on the combined evidence sample that included both male and female subjects. The resulting aggregate characteristics (factors) were used to assess the effect of climatic conditions on the human body. This approach allowed us to reduce the number of individual characteristics and to avoid the problem of trait cross-correlation within groups. Climatic factors being common for all the individuals from a specific population studied, we were essentially studying the effect of climatic conditions on population-average values, rather than on individual values of anthropometric and metabolic characteristics. The significance of the effect was determined by the reliability level of the correlation coefficient ($p<0.05$). Along with individual climate parameters two aggregate climatic characteristics were also included in the analysis. The number of allocated aggregate characteristics in each trait group was determined by the standard ([eigen value]>1) restriction.

Results

The preliminary stage of data analysis included the study the results of the descriptive statistics of the total sample (N; $\overline{X}$; Min; Max; SD; Skewness; Kurtosis).

These results are presented in Tables S1-S4 for all traits, separately for male and female subjects, supplementary tables in Appendix.

Analysis of trait dependence on subjects' age

The majority of morphometric characteristics (Table 2a) correlate with age for both male and female subject groups, while for the metabolic characteristics (Table 2b), the number of significant correlations identified in male subjects is small. It should be noted that the existing literature data on the relationship of metabolic signs with age and gender are quite contradictory[3,11,30–32]. Be it as it may, our results clearly indicate the need for age and gender normalization of individual data prior to conducting the analysis of their possible dependence on climatic characteristics. This preliminary normalization of all the traits studied was conducted using the method described in the Statistical methods section.

Factor analysis of morphological and metabolic traits

Morphological traits were initially divided into two groups: body characteristics and craniofacial features. A detailed description of the results of factor analysis in each of these groups is presented in the Appendix (Tables S5–S6). Factor analysis identified five integral factors that characterize the parameters of the human body (Table S5), explaining 79.3% of the total trait variability in this group. The factors mostly represented features characterizing:

- the first factor (M1) – the body fat components (Body Fat Factor)

TABLE 2A
CORRELATION BETWEEN AGE AND THE MORPHOMETRIC TRAITS

Trait	Male			Female		
	N	corr	p *	N	corr	p
OSSEO	4386	0.780	0.000	4626	0.790	0.000
Body height (cm)	4386	–0.180	0.000	4626	–0.267	0.000
Weight (kg)	2765	0.138	0.000	2853	0.235	0.000
Chest circumference mesosternal (cm)	2757	0.317	0.000	2820	0.356	0.000
Biacromial diameter (cm)	2739	–0.088	0.000	2828	–0.053	0.005
Biiliac diameter (cm)	2731	0.272	0.000	2829	0.308	0.000
Chest breadth (cm)	2686	0.125	0.000	2781	0.181	0.000
Chest depth (cm)	2692	0.479	0.000	2785	0.618	0.000
Index chest (%)	2696	0.447	0.000	2783	0.576	0.000
Skeletal mass index**	2686	0.074	0.000	2783	0.183	0.000
Fat mass index (%)	2510	0.188	0.000	2724	0.172	0.000
Average skinfold (mm)	2507	0.183	0.000	2717	0.225	0.000
Sitting height to Leg length ratio (%)	2649	–0.010	0.634	2751	–0.056	0.005
Leg length to Bogy height ratio (%)	2439	0.022	0.278	2524	0.057	0.004
Upper arm length (cm)	2435	–0.076	0.000	2517	–0.032	0.113
Lower arm length (cm)	2547	0.041	0.041	2522	0.026	0.200
Hip length (cm)	2542	–0.081	0.000	2521	–0.215	0.000
Tibial length (cm)	2431	–0.051	0.014	2505	–0.057	0.004
Head length (mm)	2286	0.042	0.193	2502	0.126	0.000
Head breadth (mm)	958	–0.002	0.964	927	–0.038	0.251
Bizygomatic diameter (mm)	959	0.059	0.068	928	0.045	0.157
Morphological facial height (mm)	959	–0.021	0.520	1012	–0.051	0.105

* Correlation values deviated significantly (p]0.05) from zero are marked in bold
** Computation formula published by Pavlovsky and Kobyliansky, 1997

TABLE 2B
CORRELATION BETWEEN AGE AND THE METABOLIC TRAITS*

Trait	Male			Female		
	N	corr	p*	N	corr	p
Hemoglobin (g/dL)	799	–0.074	0.037	871	0.109	0.001
Cholesterol (mg/dL)	762	0.209	0.000	810	0.251	0.000
Protein (g/dL)	790	–0.051	0.151	852	0.052	0.132
Albumin (g/dL)	750	–0.030	0.410	809	0.114	0.001
α1 globulin (g/dL)	726	–0.028	0.450	795	–0.112	0.002
α2 globulin (g/dL)	754	–0.047	0.195	797	–0.115	0.001
β globulin (g/dL)	754	–0.019	0.594	799	–0.125	0.000
γ globulin (g/dL)	758	0.021	0.562	799	0.034	0.331
BMD_distal phalanx (mg/mm^3)	1906	0.014	0.533	1817	–0.132	0.000
BMD_middle phalanx (mg/mm^3)	1912	–0.209	0.000	1818	–0.318	0.000
BMD averaged (mg/mm^3)	1912	–0.088	0.000	1816	–0.197	0.000
AB phase (sec)	1199	0.020	0.483	1097	0.069	0.023
AB phase to Weight ratio (sec/kg)	1200	–0.044	0.127	1092	–0.076	0.013
Blood flow time (sec)	1204	0.064	0.027	1099	–0.091	0.003

* Correlation values deviated significantly (p≤0.05) from zero are marked in bold

- the second factor (M2) – the longitudinal dimensions of the body (Vertical Body Score Factor)
- the third factor (M3) – the proportions of the body (Trunk/Leg Length Ratio Factor)
- the fourth factor (M4) – the dimensions of the chest (Chest Form Factor)
- the fifth factor (M5) – the degradation of the hand bone (Bone Ageing Score Factor)

Two factors explaining 74.4% of the head and face characteristics variability (Table S6) were singled out; these factors represent features characterizing:

- the first factor (H1) – the shape of the face
- the second factor (H2) – the shape of the head.

A detailed description of the factor analysis results for each of the three groups of metabolic traits is presented in the Appendix (Tables S7–S9).

The group of eight biochemical characteristics (Table S7) was split into three factors:

- the first factor (B1) represents the albumin-globulin characteristics (Albumin-Globulin Factor);
- the second factor (B2) represents hemoglobin-protein characteristics (Hemoglobin-Protein Factor):
- the third factor (B3) links cholesterol and gamma globulin (Cholesterol-γ-Globulin Factor)

These selected factors explain 66.77% of trait variability.

Factor analysis of the remaining two groups on the mineral composition of bone tissue (Table S8) and on blood oxygen saturation (Table S9) indicated that the symptoms included in each of these two groups are closely related and can essentially be combined.

The two factors explained 78.38% and 63.51% of trait variability, respectively.

Taking into account the cross-correlation of climatic parameters, the two integral characteristics of the climate were also included in this analysis.

These integral factors, which we called Temperature-Humidity Factor and Altitude-Barometric Pressure Factor, were derived in the course of factor analysis of seven climatic parameters (TMPJN, TMPJL, PRSJN, PRSJL, ALTTD, DAYJN, DAYJL) and explained 74.923% of their variation in the sample (Table S10).

The final stage involved the analysis of correlations between the selected integrated morphometric and metabolic factors, on the one hand, and climatic characteristics of the residence areas of the populations studied, on the other (Tables 3, 4 and 5).

The correlations between climatic factors and morpho-metabolic characteristics of population variability that were found are discussed in the next section.

Discussion

The materials used in this study were collected in several regions of the USSR located between 28° and 68° northern latitude. To some extent, this material has already been presented and analyzed previously in a number of published papers[2–4,21,27,33–35]. In this paper, we revisit these data for analysis, taking into account the complex structure of cross-correlating features and differences between population samples by gender and age. These differences have been leveled, and the number of cross-correlating features was significantly reduced by grouping and by the introduction of integral characteris-

TABLE 3
CORRELATIONS BETWEEN CLIMATIC CHARACTERISTICS AND THE POPULATION AVERAGE OF INDIVIDUAL'S LOADING FACTORS: BODY, HEAD AND FACE MEASUREMENTS*

Climatic characteristics	M1		M2		M3		M4		M5		H1		H2	
	m	f	m	f	m	f	m	f	m	f	m	f	m	f
LATITUDE	–0.35	–0.04	–0.22	–0.02	–0.19	–0.40	0.45	0.25	0.23	0.27	0.28	0.45	–0.04	0.23
LONGITUD	–0.42	–0.25	–0.30	–0.40	–0.18	–0.39	0.08	0.01	0.05	0.08	0.53	0.52	–0.05	–0.01
DAYJN	0.46	0.19	0.27	0.11	0.25	0.53	–0.48	–0.34	–0.13	–0.23	–0.34	–0.49	0.08	–0.25
DAYJL	–0.37	–0.11	–0.26	–0.06	–0.18	–0.51	0.53	0.38	0.20	0.28	0.20	0.37	–0.05	0.28
TMPJN	0.42	0.08	0.31	0.19	0.19	0.28	0.07	0.31	–0.38	–0.32	–0.40	–0.48	0.09	0.00
TMPJL	0.19	–0.10	0.05	–0.15	0.03	0.22	–0.47	–0.23	–0.16	–0.10	–0.25	–0.44	–0.10	–0.22
PRSJN	–0.07	–0.05	–0.14	–0.13	–0.13	0.04	–0.65	–0.68	0.24	0.13	0.42	0.38	0.07	–0.14
PRSJL	0.14	0.20	0.04	0.02	0.18	–0.01	0.39	0.44	0.06	0.09	–0.52	–0.52	0.15	0.30
PRCPT	–0.23	–0.09	0.46	0.45	–0.07	–0.04	0.34	0.34	–0.46	–0.43	0.30	0.37	0.04	0.12
ALTTD	0.16	0.03	0.11	0.04	0.26	0.16	0.03	0.06	–0.12	–0.17	0.03	0.02	–0.36	–0.35
BISCR1	0.12	0.09	0.00	0.14	–0.04	–0.04	0.09	0.16	0.11	0.18	–0.31	–0.31	0.23	0.22
BISCR2	–0.06	0.14	–0.04	0.21	–0.17	–0.18	0.14	0.06	0.26	0.28	0.10	0.21	0.16	0.26
B2–B1	–0.23	0.13	–0.06	0.19	–0.22	–0.25	0.13	–0.08	0.31	0.27	0.38	0.53	0.02	0.14
VPJN	0.17	0.08	–0.27	–0.45	0.04	0.31	–0.35	–0.40	0.16	0.16	–0.48	–0.64	–0.07	–0.19
VPJL	0.32	0.42	0.16	0.21	0.14	0.48	–0.12	–0.24	0.23	–0.05	–0.44	–0.39	0.48	0.37
F1	0.40	0.08	0.26	0.08	0.17	0.40	–0.30	–0.08	–0.27	–0.27	–0.39	–0.54	0.07	–0.14
F2	0.01	0.04	0.05	0.08	–0.04	–0.11	0.42	0.46	–0.09	0.01	–0.33	–0.30	0.19	0.31

* The number of the pair values (climatic – morphologic) used for the correlation computation was the number of populations studied for the trait group (for M1–M5: 21 populations, for H1–H2: 9 populations). F1 and F2 are two first factors of climatic characteristics. Male and female samples are designated with m and f respectively. Correlation values that were deviated significantly ($p<0.05$) from zero are marked in bold

TABLE 4
CORRELATIONS BETWEEN CLIMATIC CHARACTERISTICS AND THE POPULATION AVERAGE OF INDIVIDUAL'S LOADING FACTORS: BLOOD BIOCHEMISTRY, BONE MINERAL DENSITY AND OXYGEN CONSUMPTION MEASUREMENTS

Climatic characteristics	B1		B2		B3		BMD		OX	
	m	f	m	f	m	f	m	f	m	f
LATITUDE	–0.56	–0.62	–0.94	–0.78	0.76	0.79	–0.25	–0.63	–0.62	–0.28
LONGITUD	–0.32	–0.41	–0.85	–0.62	0.84	0.77	0.16	–0.16	–0.66	–0.10
DAYJN	0.46	0.51	0.97	0.79	–0.82	–0.82	0.28	0.57	0.47	0.27
DAYJL	–0.57	–0.62	–0.93	–0.70	0.76	0.71	–0.35	–0.62	–0.50	–0.30
TMPJN	0.60	0.68	0.60	0.45	–0.62	–0.65	0.11	0.45	0.72	0.34
TMPJL	0.36	0.43	0.92	0.79	–0.79	–0.77	0.32	0.71	0.50	0.34
PRSJN	0.06	–0.06	0.33	0.28	0.00	0.04	0.26	0.30	–0.10	–0.07
PRSJL	–0.51	–0.36	–0.23	–0.08	–0.14	–0.18	–0.12	–0.32	0.08	0.37
PRCPT	0.00	–0.04	–0.65	–0.89	0.35	0.71	0.14	–0.02	0.29	0.21
ALTTD	0.27	0.16	0.18	0.29	0.24	–0.01	–0.13	0.29	–0.08	–0.47
BISCR1	0.09	0.20	0.12	–0.07	–0.49	–0.29	–0.06	–0.11	0.71	0.65
BISCR2	–0.49	–0.48	–0.57	–0.69	0.20	0.49	–0.10	–0.42	–0.11	0.30
B2–B1	–0.51	–0.60	–0.59	–0.52	0.58	0.66	–0.21	–0.53	–0.23	–0.22
VPJN	0.23	0.26	0.52	0.42	–0.72	–0.59	0.02	0.35	0.75	0.20
VPJL	–0.44	–0.43	0.58	0.60	–0.58	–0.58	–0.01	0.02	0.75	0.17
F1	0.51	0.60	0.85	0.66	–0.80	–0.78	0.28	0.61	0.64	0.41
F2	–0.12	0.01	–0.25	–0.24	–0.12	–0.09	–0.10	–0.34	0.20	0.30

* The number of the pair values (climatic – methabolic) used for the correlation computation was the number of populations studied for the trait group (for B1–B3: 8 populations, for BMD: 20 populations, OX: 12 populations). F1 and F2 are two first factors of climatic characteristics. Male and female samples are designated with m and f respectively. Correlation values that were deviated significantly ($p<0.05$) from zero are marked in bold

TABLE 5
CORRELATIONS BETWEEN CLIMATIC CHARACTERISTICS AND THE POPULATION AVERAGE OF BIOCHEMICAL BLOOD MEASUREMENTS*

Traits	Hemoglobin		Cholesterol		Protein		Albumin		α1 globulin		α2 globulin		β globulin		γ globulin	
	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f
LATITUDE	–0.43	0.25	0.92	0.93	–0.14	–0.17	0.07	0.16	–0.47	–0.65	–0.36	–0.58	–0.44	–0.66	0.22	0.23
LONGITUD	–0.49	0.33	0.35	0.66	–0.12	–0.03	–0.15	–0.13	–0.47	–0.32	–0.46	–0.30	–0.11	–0.19	0.52	0.60
DAYJN	0.46	–0.30	–0.91	–0.88	0.13	0.20	–0.02	–0.08	0.40	0.57	0.28	0.49	0.37	0.58	–0.25	–0.22
DAYJL	–0.37	0.18	0.93	0.88	–0.17	–0.23	0.05	0.14	–0.45	–0.65	–0.38	–0.56	–0.46	–0.66	0.21	0.15
TMPJN	0.50	–0.42	–0.66	–0.76	0.18	0.17	–0.11	–0.25	0.65	0.68	0.59	0.62	0.51	0.72	–0.20	–0.17
TMPJL	0.23	–0.14	–0.93	–0.95	0.10	0.12	0.04	–0.05	0.36	0.55	0.28	0.48	0.28	0.52	–0.37	–0.42
PRSJN	0.02	0.10	–0.42	–0.26	0.17	0.24	0.04	0.08	0.07	0.19	–0.10	0.07	0.15	0.11	0.04	0.15
PRSJL	–0.12	0.01	0.15	0.16	–0.07	0.01	0.39	0.35	–0.35	–0.50	–0.25	–0.26	–0.56	–0.33	–0.39	–0.39
PRCPT	–0.47	–0.74	0.31	0.50	0.04	0.14	–0.04	–0.07	–0.07	–0.08	0.27	–0.14	0.02	–0.01	0.15	0.46
ALTTD	0.07	–0.11	0.20	0.05	–0.64	–0.73	–0.73	–0.58	–0.12	0.26	–0.20	0.00	0.34	0.12	0.54	0.06
BISCR1	0.08	–0.32	–0.43	–0.37	0.38	0.50	0.42	0.27	0.28	0.08	0.41	0.20	–0.07	0.23	–0.50	–0.15
BISCR2	–0.23	–0.22	0.32	0.52	0.32	0.46	0.51	0.49	–0.20	–0.47	–0.03	–0.31	–0.42	–0.36	–0.26	0.15
B2–B1	–0.32	0.08	0.64	0.76	0.00	0.05	0.18	0.31	–0.48	–0.61	–0.44	–0.57	–0.42	–0.65	0.18	0.31
VPJN	0.07	0.30	–0.73	–0.70	–0.17	–0.11	–0.08	–0.11	0.29	0.46	0.26	0.22	0.14	0.42	–0.35	–0.48
VPJL	0.38	–0.11	–0.46	–0.40	0.20	0.35	0.55	0.66	–0.08	–0.24	–0.33	–0.21	–0.41	–0.28	–0.55	–0.46
F1	0.41	–0.29	–0.90	–0.93	0.19	0.23	0.02	–0.11	0.52	0.64	0.46	0.60	0.40	0.68	–0.35	–0.30
F2	0.00	–0.06	0.23	0.15	0.17	0.18	0.32	0.21	0.02	–0.24	0.16	–0.03	–0.26	–0.10	–0.30	–0.16

* Eight pair values (climatic – biochemical) was used for the correlation computation, since the biochemical data were available only for in 8 of 36 studied populations. Correlation values that were deviated significantly ($p<0.05$) from zero are marked in bold

tics (factors) that account for the majority of the variation characteristics within each group.

There is no consensus in the literature concerning the relationship between body proportions and height/weight parameters, and climate[36–41].

In particular, while a number of authors[36,42,43] believe that body length and proportions, as well as the topography of the subcutaneous adipose tissue, are too stable to change under the influence of climatic factors, Kozlov and Vershubsky (1998) do not exclude the influence of climatic conditions on these parameters[38].

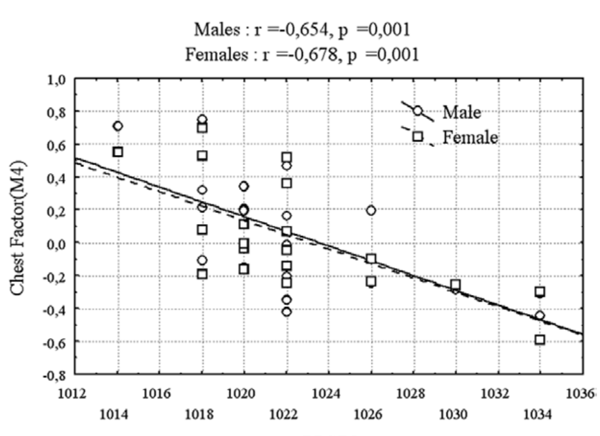

Fig. 1. The correlation between the factor (M4) that characterizes the dimensions of the chest and the level of barometric pressure (PRSJN).

In our research, we did not obtain clear-cut results regarding the connection between Body Fat, Vertical Body Score and Trunk / Leg Length Ratio factors (M1-M3), and the climate. Only a few significant correlations between these morphological factors and climatic parameters have been discovered.

At the same time, our data (Table 3, M4 – Chest factor, Figure 1) demonstrate significant correlations between climatic characteristics and chest parameters. The presence of a reliable negative correlation has been determined with the level of barometric pressure in winter ($r=-0.65$ for male and $r=-0.68$ for female subjects) and in summer ($r=-0.47$ and $r=-0.23$, respectively). This is consistent with the data reported by other authors who note the chest dimensions change in the high altitude areas[5,7,42,44]. These barometric pressure fluctuations, combined with low temperature in the North, are the cause of the so-called circumpolar hypoxic syndrome often resulting in the polar dyspnea syndrome[45]. Similar correlations, in terms of their prognostic value for hypoxia, are observed between climatic factors and oxygen saturation of arterial blood (Table 4, OX). In our sample, this parameter increased with the temperature and humidity factor ($r=0.64$ in men and $r=0.41$ in women) and with the index of severity of the climate during the winter ($r=0.71$ in male and $r=0.65$ in female subjects). It should be noted, however, that this result is not consistent with the data obtained in a sample of patients suffering from congestive heart failure, which reported a negative correlation between the arterial blood oxygen saturation, on the one hand, and the maximum temperature and relative air humidity, on the other[46,47]. Morphological factor (M5) Bone Ageing Factor (Table 3) in our sample reveals a link only with annual precipitation (i.e., air humidity).

This link needs to be interpreted in conjunction with our results (Table 4) suggesting a link of temperature and humidity with bone mineral density.

Other authors[27,48,49] also point at the presence of these links.

The link between the climate (and other environmental characteristics) and craniometric parameters is noted in many studies[50–58]. While reviewing our data on the link between the morphological parameters of the face and head and climatic parameters (Table 3), one should take into account the relatively small number of populations for which these parameters were studied (Table 1a). The absence of significant correlations that we encountered may have resulted from this limitation.

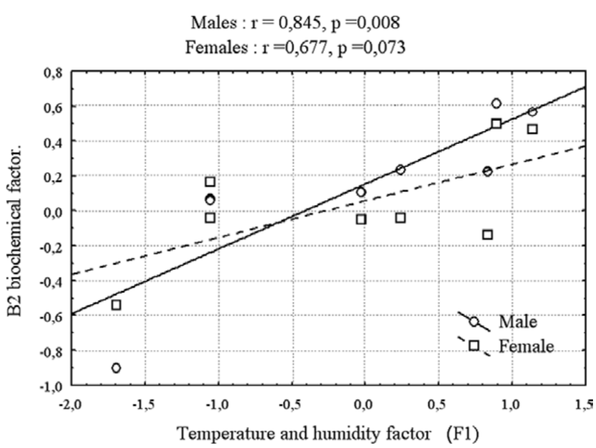

Fig. 2. Correlation between the F1 temperature and humidity factor, and the B2 biochemical factor.

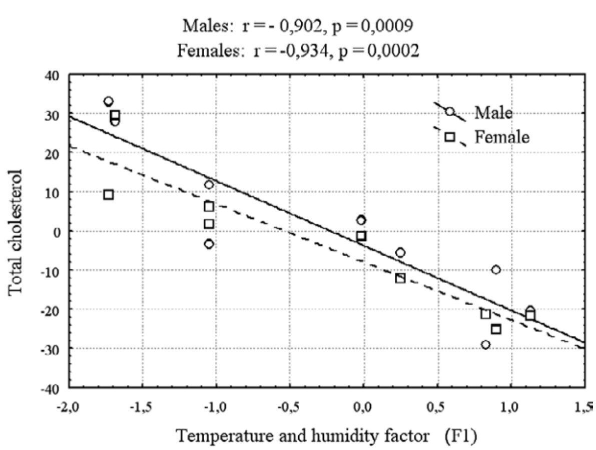

Fig. 3. Correlation between the F1 temperature and humidity factor and the level of total cholesterol.

Biochemical characteristics exhibit multiple correlations with climate (Table 4, 5). The correlations with the B2 factor that characterizes hemoglobin-protein parameters (Hemoglobin-Protein Factor, B2, Figure 2) are especially noteworthy. A significant negative correlation of the B2 factor (r=-0.94 in male and r=-78 in female subjects) with the latitude of habitat of the population was found. There is ample information regarding the variation in demand for proteins and amino acids among residents of different latitudes[10,59,15,60,61] and different metabolic rates among the indigenous inhabitants of high and low latitudes[18,35].

This is apparently related to different levels of basal energy expenditure required.

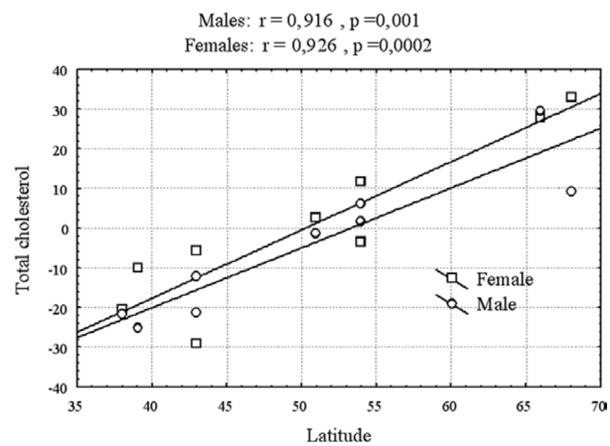

Fig. 4. Correlation between latitude and the level of total cholesterol.

The third biochemical factor (Cholesterol-γ-globulin Factor) displays a negative correlation with temperature and humidity factor (r=–0.90 for male and r=–0.93 for female subjects; $p<0.05$) (Table 5, Figure 3). This is consistent with the data reported by other authors[62–65,19]. The total cholesterol (Table 5) is also significantly correlated with latitude (r=0.902 for male and r=0.934 for female subjects; $p<0.05$). Grimes et al.[66] (1996) bring up an analysis of the data presented in the Keys (1980) monograph[67] demonstrating a clear regression of the serum cholesterol level with the increase of the distance from the equator (r=0.936; df=8; $p<0.001$). These authors consider the level of serum cholesterol to be a heart disease predictor. Boyko[15] (2005) regards the increase of total cholesterol in the α- and β-lipoproteins in individuals living in northern areas of Russia as an indirect mechanism of activation of lipoprotein metabolism triggered by low temperatures, which can be regarded as a positive physiological response.

Gudkova[4] (2009) showed that total cholesterol and the level of gamma globulin may serve as body typology distribution discriminators for study subjects in different climatic zones.

Conclusion

Discussions on global climate change have prompted the approach to health indicator analysis that takes the impact of seasonal and regional climatic conditions into account[32,68–72,20].

On the other hand, the majority of these studies contains no analysis of the influence of individual climatic characteristics.

However, the analysis of influence of each of the major environmental factors is a prerequisite for the scientific approach to the problem of prognosis, conservation and development of public health.

Preliminary data normalization for age within each gender group allows defining the influence of certain environmental factors on the status of the human body with greater clarity.

In particular, we have shown that among the morphological characteristics studied, chest dimensions are the least tolerant to the climatic conditions.

Among the biochemical parameters, hemoglobin-protein ratios and the factor that includes total cholesterol appear to be the most climate-dependent.

Blood serum oxygen saturation – the key factor determining the performance of the cardiovascular and respiratory systems – also appears to be climate-dependent.

REFERENCES

1. ALEKSEEVA TI, Geographical environment and human biology (Moscow, Mysl Publ, 1977). — 2. ALEKSEEVA TI, Humans' adaptation to different ecological niches of the Earth: Biological aspects (Moscow, MNEPU Publ, 1998). — 3. GUDKOVA LK, Human Population Physiology. Anthropological aspects. (Moscow: LKI Publ, 2008). — 4. GUDKOVA LK, On the role of physiological characters in constitution typology (Population approach) (The Moscow University Herald, Series XXIII, Anthropology, 11 (2009) 45. — 5. BAKER P, Adaptive capabilities of high-altitude populations. BAKER P (Eds) Biology of the inhabitants of highlands (Moscow, Mir, 1981). — 6. AGHAJANIAN NA, MARACHEV AG, BOBKOV AG, Ecological physiology of humans (Moscow, KRUK, 1998). — 7. MAXIMOV AL, BELKIN VSH, Human Physiology, 28 (2002) 6. — 8. MAXIMOV AL, BELKIN VS, KOBYLIANSKY ED, Bull SVNC RAS, 3 (2009) 91. — 9. BAGIROV BG, Man and hot climate (Ashkhabad: Ylim, 1977). — 10. PANIN L.E, Energy-related aspects of adaptation (Leningrad: Medicine, 1978). — 11. FORREST RD, JACKSON CA, YUDKIN JS, Postgra Med J, 63 (1987) 625. DOI: 10.1136/pgmj.63.742.625. — 12. BRUCE N, ELFORD J, WANNAMETHEE G, SHAPER AG, J Hypertens, 9 (1991) 851. DOI: 10.1097/00004872-199109000-00013. — 13. BRUNS I, LIETH H, Int J Biom, 36 (1992) 136. DOI: 10.1007/BF01224815. — 14. EL-BAKRY AK, CHANNA AB, BAKHAMEES H, TURKISTANI A, SERAJ MA, Resuscitation, 31 (1996) 121. DOI: 10.1016/0300-9572(95) 00918-3. — 15. BOYKO ER, Physiological and biochemical basis of human life and activity in the North (Yekaterinburg: RAS Ural Branch, 2005). — 16. BEALL CM, STEEGMANN AT, Human adaptation to climate: temperature, ultraviolet radiation, and altitude. STINSON S, BOGIN B, HUSS--ASHMORE R, O'ROURKE D (Eds) Human biology: An evolutionary and biocultural perspective (New York: Wiley-Liss, 2000). — 17. GALLOWAY VA, LEONARD WR, IVAKINE E, Am J Hum Biol, 12 (2000) 75. DOI: 10.1002/(SICI)1520-6300(200001/02)12:1<75::AID-AJHB9>3.0.CO;2-G. — 18. LEONARD WR, SNODGRASS JJ, SORENSEN MV, Ann Rev Anthropol, 34 (2005) 451. DOI: 10.1146/annurev.anthro.34.081804.120558. — 19. RÜHLIA FJ, HENNEBERG M, SCHAERC DJ, IMHOFC A, SCHLEIFFENBAUMD B, WOITEKE U, Swiss Med Weekly, 138 (2008) 286. — 20. GLEIBERMEN L, Am J Hum Biol, 21 (2009) 679. DOI: 10.1002/ajhb.20921 — 21. PAVLOVSKY OM, KOBYLIANSKY E, Population biology of human aging (Florence, Italy, Angelo Pontecorboli Editore, 1997). — 22. KOBYLIANSKY E, LIVSHITS G, PAVLOVSKY O, Human Biology, 67 (1995) 87. — 23. ILCA S, DODICA C, IOANOVICI Z, Z Gesamte Inn Med, 1 (1964) 323. — 24. ALEXEEVA TI (Ed) Methods of Morphological and Physiological Studies in Anthropology (Moscow: Moscow State U. Publ., 1981). — 25. WORLD CLIMATE DATA AND MONITORING PROGRAMME (WCDMP), Monthly Climatic Data for the World National Climatic Data. Center, Asheville, N.C., Available from: URL: http://www.wmo.int/pages/prog/wcp/wcdmp/monthly.html — 26. BELKIN V, Mountain Research and Development, 12 (1992) 63. DOI: 10.2307/3673748. — 27. BELKIN V, LIVSHITZ G, OTREMSKY I, KOBYLIANSKY E, Am Journal of Physical Anthropology, 106 (1998) 349. DOI: 10.1002/(SICI)1096-8644(199807)106:3<349::AID-AJPA7>3.0.CO; 2-H. — 28. StatSoft, Inc. STATISTICA (data analysis software system), version 7.1: on-line (2005). — 29. MALKIN I, GINSBURG E, Program package for pedigree analysis: version MAN-2009 (Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel Aviv University; Technical Report. 2009). — 30. COOPER JK, AND GARDNER C, J Am Geriatr Soc, 37(1989) 1039. — 31. WOODHOUSE PR KHAW KT, PLUMMER M, Age Ageing, 22 (1993) 273. DOI: 10.1093/ageing/22.4.273. — 32. NEID PJ, SYNDERCOMBE-COURT D, KEATINGE WR, DONALDSON GC, MATTOCK M, CAUNCE M, Clin Sci (Lond), 86 (1994) 43. — 33. AIZENSHTAT BA, Humans' heat balance and their health. In: Climate and human health. International Symposium WMO / WHO / UNEP. (Leningrad, 22-26 Sept. 1986. Vol. 1.). — 34. PAVLOVSKY OM, Biological age of humans (Moscow: Moscow State U Publ, 1987). — 35. BELKIN VS, KOROSTYSHEVSKY MA, BATSEVICH VA, KOBYLIANSKY ED, Correlation of morphological characteristics of human populations with climatic and geographical factors (The Moscow University Herald. Series XXIII. Anthropology, 1 (2012) 63). — 36. PURUNDZHAN AL, DERYABIN VE, The USSR population: the geographical peculiarities of the body build (Moscow: Moscow State U Publ, 1990). — 37. BEALL CM, GOLDSTEIN MÑ, Am J of Human Biology, 4 (1992) 747. DOI: 10.1002/ajhb.1310040606. — 38. KOZLOV AI, VERSHUBSKY GG, Anthropological Sciences (Tokyo), 106 (1998) 245. DOI: 10.1537/ase.106.245. — 39. KOZLOV AI, Intern J Circumpol Health, 63 (2004) 235. DOI: 10.3402/ijch.v63i3.17717. — 40. STEEGMANN AT Jr, Am J Hum Biol, 7 (2005) 393. DOI: 10.1002/ajhb.20401. — 41. WELLS JCK, Am J of Physical Anthropology, 147 (2012) 169. DOI: 10.1002/ajpa.21591. — 42. BEALL CM, Hum. Biol, 54 (1981) 145. — 43. KATZMARZYK PT, LEONARD WR, Am J Phys Anthropol, 106 (1998) 483. DOI: 10.1002/(SICI)1096-8644(199808)106:4<483::AID-AJPA4>3.3.CO;2-K. — 44. MAXIMOV AL, BELKIN VS, Bull SVNC RAS, 3 (2005) 28. — 45. AVTSIN AP, ZHAVORONKOV AA, MARACHEV AG, MILOVANOV AP, Human pathology in the North (Moscow, Medicine, 1985). — 46. GOLDBERG MS, GIANNETTI N, BURNETT RT, MAYO NE, VALOIS M-F, BROPHY JM, Occup Environ Med, 65 (2008) 659. DOI: 10.1136/oem.2007.034934. — 47. FROEHLE AW, Am J Hum Biol, 20 (2008) 510. DOI: 10.1002/ajhb.20769. — 48. VANDERSCHUEREN D, GEVERS G, DEQUEKER J, GEUSENS P, NIJS J, DEVOS P, DE ROO M, BOUILLON R, Calcif Tissue Int, 49 (1991) 84. — 49. KALICHMAN L, MALKIN I, BELKIN V, BATSEVICH V, KOBYLIANSKY E, Homo 61 (2010) 117. — 50. BOAS F, American Anthropologist, 42(2) (1940) 183. — 51. BEALS KL, Am J Phys Anthropol, 37 (1972) 85. DOI: 10.1002/ajpa.1330370111. — 52. BEALS KL, SMITH CL, DODD SM, Am J Phys Anthropol, 62 (1983) 425. DOI: 10.1002/ajpa.1330620407. — 53. BEALS KL, SMITH CL, DODD SM, Curr Anthropol, 25 (1984) 301. — 54. BHARATI S, SOM S, BHARATI P, VASULU TS, Am J Hum Biol, 13 (2001) 626. DOI: 10.1002/ajhb.1101. — 55. FRANKLIN D, CARDINI A, OXNARD CE, Am J Hum Biol, 22 (2009) 23. DOI: 10.1002/ajhb.20908. — 56. HARVATI K, WEAVER TD, Anat Rec A Discov Mol Cell Evol Biol, 288 (2006) 1225. — 57. SMITH HF, TERHUNE CE, LOCKWOOD CA, Am J Phys Anthropol, 134 (2007) 312. DOI: 10.1002/ajpa.20671. — 58. NOBACK ML, HARVATI K, SPOOR F, Am J Phys Anthropol, 145 (2011) 599. DOI: 10.1002/ajpa.21523. — 59. SRIVASTAVA KK, KUMAR R, Int J Biometeorol, 36(1) (1992) 10. DOI: 10.1007/BF01208728. — 60. RAND WM, PELLETT PL, YOUNG VR, Am J Clin Nutr, 77 (2003) 109. — 61. WHO PROTEIN AND AMINO ACID REQUIREMENTS IN HUMAN NUTRITION Report of a Joint WHO/FAO/UNU Expert Consultation WHO Technical Report Series 935 World Health Organization (2007). — 62. ROBINSON D, BEVANA EA, HINOHARAB SH, TAKAHASH T, Atherosclerosis, 5 (1992) 15. DOI: 1016/0021-9150(92)90171-C. — 63. CHENG TO, Int J of Cardiology, 104 (2005)

101. DOI: 10.1016/j.ijcard.2004.12.035. — 64. DONAHOO WT, ECKEL RH, Arch Intern Med, 164(13/27) (2004) 2506. DOI: 10.1001/archinte.164.22.2506-a. — 65. OCKENE IS, CHIRIBOGA DE, STANEK EJ, Arch Intern Med, 164 (2004) 863. DOI: 10.1001/archinte.164.8.863. — 66. GRIMES DS, HINDLE E, AND DYER T, Q J Med, 89 (1996) 579. DOI: 10.1093/qjmed/89.8.579. — 67. KEYS A, Seven Countries – a multivariate analysis of death and coronary heart disease (Cambridge MA and London, Harvard University Press, 1980). — 68. STOUT RW, CRAWFORD VL, MCDERMOTT MJ, ROCKS MJ, MORRIS TC, Age Ageing, 25 (1996) 256. DOI: 10.1093/ageing/25.3.256. — 69. HANNA JM, Hum Biol, 71(4) (1999) 553. — 70. KJELLSTROM T, SHAHI G, Technological and environmental change and health. Background discussion paper for WHO meeting in Kobe 11-13 August (World Health Organization Centre for Health Development/, Kobe Japan. 2004). — 71. YOUNG JH, Curr Hypertens Rep, 9 (2007) 13. DOI: 10.1016/B978-0-323-03961-1.50091-X. — 72. COSTELLO A, ABBAS M, ALLEN A, BALL S, et al, Lancet, 373 (2009) 1693. DOI: 10.1016/S0140-6736(09)60935-1.

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MORFOFIZIOLOŠKE ZNAČAJKE LJUDSKIH POPULACIJA U KONTEKSTU KLIMATSKO-GEOGRAFSKIH UVJETA

S A Ž E T A K

Ovaj rad temelji se na podacima prikupljenim u okviru populacijske studije u 33 zemljopisne regije bivšeg SSSR-a, organizirane od strane Znanstveno-istraživačkog instituta i Antropološkog muzeja Sveučilišta u Moskvi, u periodu 1961. – 1991. godina. Podaci dobiveni na uzorku od 4386 muškaraca i 4626 žena u dobi između 17 i 99 godina uključuju rezultate morfologije glave i tijela, mineralne gustoće kostiju, zasićenosti krvi kisikom te biokemijske nalaze krvi. Cilj je bio istražiti povezanost između značajki pojedine populacije i klimatskih uvjeta u kojima ta populacija živi. Individualne karakteristike ispitanika su normalizirane s obzirom na spol i dob, a faktorskom analizom je smanjen broj korelirajućih značajki. Rezultati su ukazali na nekoliko integralnih faktora: pet faktora povezanih s morfologijom tijela, dva s morfologijom glave, jednog s mineralnom gustoćom kostiju, jednog sa zasićenosti krvi kisikom te tri s biokemijskim nalazima krvi. Ovi faktori objasnili su 79,3%, 78,38%, 63,51%, 74,4% i 66,77% varijabilnosti značajki u uzorku. Korelacijska analiza između navedenih faktora i klimatskih uvjeta pokazala je najnižu korelaciju s dimenzijama prsa. Najveća povezanost s klimatskim uvjetima utvrđena je za omjer hemoglobina i proteina te ukupni kolesterol. Osim toga, naši rezultati su također pokazali povezanost zasićenosti krvi kisikom (ključni faktor pri procjeni funkcioniranja rada kardiovaskularnog i respiratornog sustava) s klimatskim uvjetima.

Supplements

Appendix. Supplementary tables S1–S10.

TABLE S1
DESCRIPTIVE STATISTICS OF THE MORPHOMETRIC MEASURMENTS (MALE)

Trait	N	$\overline{X}$	Min	Max	SD	Skewness	Kurtosis
Age	4386	40.15	17.00	95.00	14.75	0.76	0.25
OSSEO	4386	5.38	0.00	40.00	6.82	1.70	3.00
Body height	2765	167.44	143.00	197.50	6.63	0.04	0.27
Weight	2757	66.25	34.60	118.50	11.29	0.70	0.86
Chest circumference mesosternal	2739	92.04	69.00	123.00	7.40	0.43	0.58
Biacromial_diameter	2731	38.65	29.80	46.40	2.03	–0.06	0.18
Biiliac diameter	2686	28.86	23.40	36.00	1.84	0.31	0.24
Chest breadth	2692	27.84	19.60	34.80	2.04	0.23	0.10
Chest depth	2696	21.03	11.90	29.50	2.12	0.24	0.47
Index chest	2686	75.50	54.60	102.60	6.56	0.33	0.36
Skeletal mass index	2510	1227.83	300.00	3598.00	461.79	0.89	1.38
Fat mass index*	2507	16.80	5.60	42.10	5.34	0.88	0.55
Average skinfold	2649	9.94	2.80	28.60	3.70	1.11	1.27
Sitting height to Leg length ratio	2439	87.70	74.40	101.00	4.16	0.02	0.07
Leg length to Bogy height ratio	2435	53.29	48.40	57.50	1.20	0.06	0.41
Upper arm length	2547	31.62	25.70	38.00	1.82	–0.04	0.07
Lower arm length	2542	24.64	18.10	30.40	1.61	0.00	0.16
Hip length	2431	44.30	34.70	54.80	2.61	0.03	0.10
Tibial length	2286	38.12	28.50	45.70	2.46	–0.04	0.11
Head Length	958	188.90	168.00	211.00	7.17	0.11	0.06
Head Breadth	959	156.99	134.00	178.00	6.55	0.09	0.07
Bizygomatic diameter	959	144.85	126.00	164.00	6.31	0.14	–0.26
Morphological Facial Height	954	130.53	104.00	154.00	7.24	–0.03	0.36

*=Total fat to Body weight ratio

TABLE S2
DESCRIPTIVE STATISTICS OF THE MORPHOMETRIC TRAITS (FEMALE)

Trait	N	$\overline{X}$	Min	Max	SD	Skewness	Kurtosis
Age	4626	43.28	17.00	99.00	14.73	0.58	–0.05
OSSEO	4626	6.62	0.00	40.00	7.56	1.39	1.64
Body height	2853	155.12	131.80	180.00	5.91	–0.02	0.24
Weight	2820	61.36	34.50	122.00	12.64	0.76	0.59
Chest circumference mesosternal	2828	88.77	69.00	126.30	8.26	0.65	0.28
Biacromial_diameter	2829	35.25	28.40	41.20	1.84	0.02	–0.01
Biiliac diameter	2781	29.30	21.30	37.40	2.07	0.29	0.23
Chest breadth	2785	25.65	17.90	33.40	2.00	0.33	0.41
Chest depth	2783	19.31	13.00	28.90	2.29	0.52	0.23
Index chest	2783	75.33	51.20	104.80	7.76	0.55	0.51
Skeletal mass index	2724	614.28	47.00	1969.00	286.77	0.96	1.11
Fat mass index*	2717	26.99	5.70	51.10	6.87	0.07	–0.37
Average skinfold	2751	15.56	2.60	34.80	4.97	0.35	–0.27
Sitting height to Leg length ratio	2524	89.13	74.10	105.70	4.30	0.04	0.12
Leg length to Bogy height ratio	2517	52.88	48.60	57.90	1.20	0.06	0.11
Upper arm length	2522	28.97	22.90	34.20	1.66	0.05	0.12
Lower arm length	2521	22.76	18.20	29.30	1.39	0.12	0.62
Hip length	2505	41.15	30.20	50.60	2.48	0.04	0.11
Tibial length	2502	35.10	24.70	43.80	2.18	–0.21	1.01
Head Length	927	179.76	160.00	199.00	6.54	0.00	–0.25
Head Breadth	928	150.71	131.00	171.00	6.33	0.01	0.03
Bizygomatic diameter	1012	136.27	117.00	154.00	6.21	–0.03	0.00
Morphological Facial Height	1014	121.64	96.00	148.00	7.39	0.13	–0.15

TABLE S3
DESCRIPTIVE STATISTICS OF THE METABOLIC TRAITS (MALE)

Trait	N	$\overline{X}$	Min	Max	SD	Skewness	Kurtosis
Hemoglobin	799	153.07	90.00	200.00	16.69	–0.05	–0.13
Cholesterol	762	176.49	53.00	322.00	43.25	0.41	–0.07
Protein	790	78.08	55.40	98.40	5.93	–0.07	0.59
Albumin	750	51.87	30.90	71.10	7.52	–0.31	–0.31
α1 globulin	726	3.30	0.90	7.80	1.30	0.81	0.45
α2 globulin	754	4.93	1.50	12.20	1.74	0.91	1.17
β globulin	754	7.30	3.10	20.90	2.49	1.52	3.89
γ globulin	758	10.80	1.80	30.20	3.64	1.20	2.61
BMD_distal phalanx	1907	0.85	0.12	1.80	0.25	0.41	0.54
BMD_middle phalanx	1913	0.97	0.23	1.79	0.22	0.29	0.38
BMD averaged	1913	0.63	0.20	1.20	0.13	0.31	0.58
AB phase	1200	17.61	8.00	34.60	4.35	0.72	1.18
AB phase to Weight ratio	1201	0.29	0.09	0.74	0.10	1.40	2.86
Blood flow time	1205	6.95	3.00	13.40	1.71	0.70	0.63

TABLE S4
DESCRIPTIVE STATISTICS OF THE METABOLIC TRAITS (FEMALE)

Trait	N	$\overline{X}$	Min	Max	SD	Skewness	Kurtosis
[1]Hemoglobin	871	128.93	51.00	199.00	17.48	–0.35	2.34
Cholesterol	810	174.79	70.00	335.00	38.52	0.65	0.80
[1]Protein	852	78.57	54.20	99.10	6.56	–0.05	0.49
Albumin	809	50.65	30.20	77.80	7.34	–0.16	0.11
[1]α1 globulin	795	3.37	0.80	9.70	1.41	1.11	1.60
α2 globulin	797	5.13	1.40	11.70	1.78	0.88	0.53
β globulin	799	7.56	3.20	19.30	2.46	1.15	1.75
γ globulin	799	12.19	4.80	30.80	3.61	0.90	1.63
*BMD_distal phalanx	1817	0.82	0.23	1.73	0.26	0.45	0.03
[1]*BMD_middle phalanx	1818	0.96	0.25	1.88	0.24	0.39	0.49
**BMD averaged	1816	0.61	0.05	1.12	0.14	0.23	0.06
AB phase	1097	18.34	9.00	30.40	3.89	0.31	0.05
AB phase to Weight ratio	1092	0.33	0.14	0.66	0.09	0.54	0.16
Blood flow time	1099	6.62	2.00	13.80	1.75	0.99	1.39

*Compact measurements on third finger
**Averaged by compact and spongia measurements on third finger
[1]Difference between males and females were not detected ($p>0.05$)

TABLE S5
FACTOR ANALYSIS OF ANTHROPOMETRIC TRAITS

Trait	M1	M2	M3	M4	M5
OSSEO	0.116	–0.011	–0.041	0.017	0.946
Body height	0.070	0.893	0.163	–0.022	0.113
Weight	0.829	0.473	–0.036	0.135	0.028
Chest circumference mesosternal	0.849	0.342	–0.043	0.129	0.037
Biacromial_diameter	0.355	0.704	–0.069	–0.091	–0.155
Biiliac diameter	0.381	0.639	–0.048	0.175	–0.203
Chest breadth	0.676	0.419	–0.078	–0.315	0.018
Chest depth	0.607	0.319	0.007	0.616	0.028
Index chest	0.052	–0.024	0.082	0.982	0.007
Skeletal mass index	0.397	0.831	–0.001	0.078	–0.071
Fat mass index	0.869	–0.084	0.045	–0.012	0.072
Average skinfold	0.917	0.006	0.037	0.017	0.066
Sitting height to Leg length ratio	0.045	–0.185	–0.947	–0.054	0.039
Leg length to Bogy height ratio	–0.052	0.202	0.943	0.053	–0.045
Upper arm length	0.040	0.706	0.288	–0.011	0.159
Lower arm length	0.040	0.678	0.191	0.020	–0.005
Hip length	–0.006	0.583	0.561	–0.031	0.123
Tibial length	0.033	0.718	0.344	0.111	–0.065
Expl.Var	5.135	4.919	2.406	1.569	1.040
Prp.Totl	0.270	0.259	0.127	0.083	0.055
Eigenvalue	7.349	3.723	1.690	1.299	1.008
Total variance %	38.681	19.594	8.895	6.839	5.305
Cumulative %	38.681	58.275	67.170	74.009	79.314

* Names of the factors used in further tables and figures: M1 – Fat body factor, M2 – Vertical body score factor, M3 – Trunk/leg length ratio factor, M4 – Thoracal form factor, M5 – Bone aging factor

TABLE S6
FACTOR ANALYSIS OF HEAD AND FACIAL MORPHOMETRIC TRAITS*

Trait	H1	H2
Head Length	0.05	0.95
Head Breadth	0.54	–0.01
Bizygomatic diameter	0.89	0.16
Morphological Facial Height	0.87	0.46
Expl.Var	1.84	1.13
Prp.Totl	0.46	0.28
Eigenvalue	2.04	0.94
Total variance %	50.99	23.41
Cumulative %	50.99	74.40

* H1 – Facial factor, H2 – Head factor

TABLE S7
FACTOR ANALYSIS OF BIOCHEMICAL TRAITS*

Trait	B1	B2	B3
Hemoglobin	0.00	0.60	–0.34
Cholesterol	–0.15	0.02	0.69
Protein	0.18	0.78	0.51
Albumin	–0.62	0.69	0.05
α1 globulin	0.78	–0.10	–0.08
α2 globulin	0.83	0.05	0.00
β globulin	0.80	0.04	0.23
γ globulin	0.39	–0.06	0.67
Expl.Var	2.53	1.46	1.35
Prp.Totl	0.32	0.18	0.17
Eigenvalue	2.68	1.63	1.04
Total variance %	33.48	20.32	12.98
Cumulative %	33.48	53.79	66.77

* Names of the factors used in further tables and figures: B1 – Albumin/Globulin factor, B2 – Haemoglobin/Protein factor, B3 – Cholesterol/γ-globulin factor

TABLE S8
FACTOR ANALYSES OF BMD MEASUREMENTS

Trait	BMD factor
BMD_distal phalanx	–0.85
BMD_middle phalanx	–0.81
BMD averaged	–0.98
Expl.Var	2.35
Prp.Totl	0.78
Eigenvalue	2.35
Total variance %	78.38
Cumulative %	78.38

TABLE S9
FACTOR ANALYSIS OF OXYGEN CONSUMPTION TRAITS

Trait	OX factor
AB phase	0.94
AB phase to Weight ratio	0.94
Blood flow time	0.37
Expl.Var	1.91
Prp.Totl	0.64
Eigenvalue	1.91
Total variance %	63.51
Cumulative %	63.51

TABLE S10
FACTOR ANALYSIS OF CLIMATIC CHARACTERISTICS*

Trait	F1	F2
DAYJN	0.830	–0.406
DAYJL	–0.901	0.343
TMPJN	0.923	0.205
TMPJL	0.873	–0.346
PRSJN	0.046	–0.877
PRSJL	–0.200	0.438
ALTTD	0.146	–0.812
Eigenvalue	3.179	2.065
Total variance %	45.418	29.504
Cumulative %	45.418	74.922

*F1: Temperature/Humidity factor, F2: Altitude-Barometric