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Morphological and Functional Characteristics of Adolescents in Indigenous Minority Groups of Various Climatic Zones in Russian North

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ABSTRACT This work compares the morphological and functional indicators of adolescent children of indigenous peoples of Russian North living in different climatic zones: tundra (Dudinka) and forest-tundra (Neryungri). It was revealed that adolescents of Dudinka are more heavily built and have a higher Ketle index relative to their peers from Neryungri. The proportion of reserve fat in adolescents of Dudinka was higher, which is consistent with the study of the endomorphic component of the body. Boys from Neryungri had a physique type close to the asthenic body type. The vegetative Kerdo index of adolescents of Neryungri corresponds to normotonia; in adolescents of Dudinka, the index values were higher with a shift towards sympathicotonia. A study of heart rate variability showed that in 63.6 percent of Neryungri boys, the Baevsky stress index significantly exceeded the norm; it was close to normal in the rest of the boys.

INTRODUCTION

The severe climatic conditions in which the inhabitants of Russian Far North live are the main stress factor affecting the formation of morphological and functional features. Indeed, a number of researchers have reported a significant retardation in growth and weight gain in infants of indigenous minority groups of Russian North in contrast to corresponding features in children of non-indigenous population in nearly all age groups (Alekseyeva 1977; Baevskii and Berseneva 2008; Dutova et al. 2008). The anthropometric characteristics of children born to the indigenous population are usually at the bottom of the centile corridor of all Russian and international standards (Sosin et al. 1999). The indigenous population of the Arctic region regardless of their ethnicity shares many common traits regarding their build and several other physiological features. According to the adaptive types concept proposed by Alekseeva (1977), genetically unrelated populations residing in the same region and exposed to the same bioclimatic conditions share a lot of morphological and physiological characteristics. The features found in reaction to the conditions of Russian Far North was defined by the authors as the *Arctic adaptive type*, which is characterized by high body density, development of musculoskeletal mass, skeletal strength, cylindrical thoracic cage, and a near complete absence of asthenic body type.

Differences concerning body functional systems of inhabitants of Russian Far North were also observed. A study of the respiratory organs revealed a restructuring, which is attributed to the need to enhance the efficiency of respiratory metabolism in the extreme conditions. Morphological manifestations of such restructuring are basically marked by a significant development of the thoracic cage (Alekseyeva 1977) as well as an extension of the alveolar surface area and lung microcirculation volume

(Avtsyn et al. 1985). In comparison to the offspring of migrants, most children born to the indigenous population demonstrated retardation in their sexual maturation, which manifested as delayed development of secondary sexual characteristics and onset of menstruation in girls (Kozlov and Vershubskaya 1999; Chasnyk et al. 2008). Since the indigenous peoples of Russian North are exposed to the combined influence of severe climatic conditions and high psychoemotional pressure, the issue of their adaptation is of theoretical and practical interest (Agadzhanyan et al. 2007).

Objectives

The purpose of this study is to conduct a comparative analysis on the morphological and functional features of 14–16-year old adolescents of indigenous minority groups of Russian North residing in two major climatic zones in the context of adaptation.

MATERIAL AND METHODS

This study involves adolescents of Dudinka General Education Elementary Boarding School No. 1 (Dudinka) and Arktika Experimental Boarding School (Neryungri). A total of 75 pupils from the ethnic groups of Evenks, Enets, Nenets, Nganasans, Dolgans and Yakuts took part in the study. The boarding school in Dudinka educates children residing in Taymyr Dolgano-Nenets Municipal District of Krasnoyarsk Territory and is located in the tundra zone, with an Arctic climate. The area has an average annual temperature of 9.4ºÑ and an Arctic night lasting 45 days. The boarding school in Neryungri educates children from various areas of Sakha Republic (Yakutia). The territory belongs to the wooded tundra zone, with a sharp continental climate and an average annual temperature of -6.4ºÑ.

The study participants were aged 14–16 years, and all of them were healthy (as per the data submitted by the schools' medical staff). The sample size was 33 adolescents (17 females and 16 males) in Dudinka and 42 adolescents (28 females and 14 males) in Neryungri. The study was carried out in the morning hours in the medical office at a comfortable room temperature and with the written consent of their parents or lawful guardian. The survey was conducted in the spring and autumn of 2018.

The anthropometric parameters were measured using the method of Bunak (Martirosov et al. 2006). Based on the anthropometric data, namely body mass (BM) and body length (BL), the researchers calculated the body mass index (BMI) using the following formula: BMI = body mass, kg ÷ body length, m^2. The fat content was determined indirectly by calipermetry (Zhuravleva and Grayevskaya 1993). Body composition was determined using Sheldon's typology as modified by Heath and Carter (Carter et al. 1997). To estimate the state of the cardiovascular system, the following measurements were taken: heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP). HR was calculated based on the electrocardiogram intervals measured by the Alton 12-03 electrocardiograph from the normal range deflection. Arterial blood pressure (ABP) was measured by the Riva-Rocci apparatus using Korotkoff's auscultatory method. The functional state and adaptive resources of the body were evaluated using Kerdo vegetative index (KVI) and heart rate variability (HRV) analysis methods (Burtseva 2005; Kérdö 1966). The vegetative balance index (VBI), vegetative rhythms index (VRI) and Baevsky stress index (BSI) were analyzed.

The results were statistically processed using the SPSS (version 13.0) software package for non-parametric samples. Differences with a p-value of $p < 0.05$ were considered significant.

RESULTS AND DISCUSSION

Assessment of the physical development of the study participants revealed that Dudinka adolescents are more heavily built. The average BMI was higher in males from Dudinka (21.8 kg/m^2) compared with males from Neryungri (20.3 kg/m^2); also, the average BMI was higher in females from Dudinka (23.3 kg/m^2) compared with females from Neryungri (22.1 kg/m^2) (Fig. 1A). Adolescents from Dudinka demonstrated higher BMI compared with their peers from Neryungri by 5.14 percent in females and 4.42 percent in males. The average BM of females and males

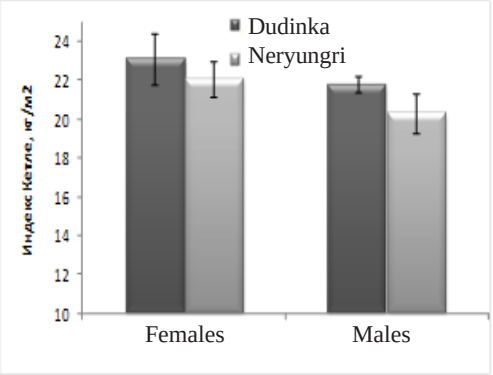

Fig. 1A. The body mass index

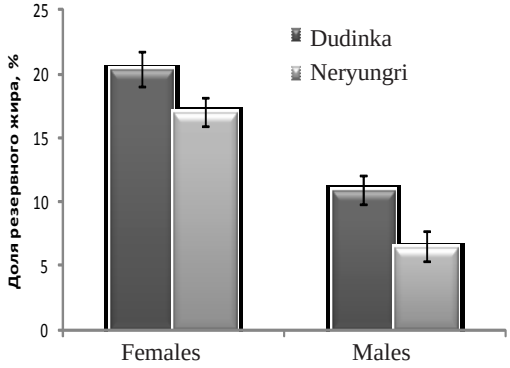

Fig. 1B. the proportional content of stored fat in adolescents from Dudinka and Neryungri (M±m)

from Dudinka was 53.1±3.0 kg and 60.6±1.7 kg respectively, and their BL was 152.6±1.4 cm and 166±1.3 cm respectively. The BM and BL of female and male adolescents of Neryungri amounted to 56.1±3.4 kg and 58.3±3.4 kg as well as 158.6±1.9 cm and 162.2±1.8 cm respectively. These parameters complied with the age and gender norm.

An analysis of the fat content revealed that the studied groups had significant differences in this regard ($p<0.05$), with adolescents from Dudinka having higher fat content (Fig. 1B). Females from Dudinka were characterized by a fat content percentage of 20.4±1.3 percent, while their counterparts from Neryungri had a value of 17±1.4 percent in this regard. Also, the differences between male adolescents proved to be significant: those from Dudinka demonstrated a fat content percentage of 10.9±1.1 percent, while those from Neryungri had a value of 6.5±1.2 percent, which is slightly lower than the age norm (<11%) (Martirosov et al. 2006). These indications agree with the body composition determined using Heath-Carter method. All components are evaluated using points from 1.5 to 6, a higher score indicating a more developed stage of a component. Endomorphy parameters, showing the fat deposit degree, were significantly higher in females than in males. The endomorphic component of females from Dudinka equaled 4.29±0.19 points, and that of their counterparts from Neryungri was 3.68±0.35 points. Compared with those of males, there were significant differences ($p<0.05$): 2.25±0.28 points for adolescents from Dudinka and 1.21±0.26 points for those from Neryungri.

In contrast, the ectomorphic component of males from Neryungri turned out to be highest and equaled 3.54±0.64 points, which significantly differed from that of males from Dudinka – 2.45±0.13 points ($p<0.05$). There were also significant differences ($p<0.05$) in the ectomorphic component between both genders; the value for females from Neryungri was 2.18±0.21 points and that for Dudinka females was 1.67±0.16 points. The above figures suggest that male and female adolescents from Neryungri have a rather more elongated build that is close to the asthenic body type in comparison with their counterparts from Dudinka. This data contradicts the opinion held by some researchers indicating that there are no individuals with asthenic body type among the indigenous minority groups of Russian North (Alekseyeva 1977). The mesomorphy parameters of Dudinka adolescents were significantly higher than those of their counterparts from Neryungri: 4.21±0.10 and 3.74±0.14 points respectively for males and 4.15±0.12 and 3.75±0.16 points respectively for females.

This study also analyzed the parameters related to the functional state of the cardiovascular system. It was found that the HR, SBP and DBP of all study participants agreed with the age and gender norm. The average HR was higher in adolescents from Dudinka (*$p<0.05$)* compared with their counterparts from Neryungri, especially in females (Table 1). Females from Dudinka had an HR of 85.5±31 bpm, and that of their peers from Neryungri was 72.7±1.8 bpm.

With regards to the arterial blood pressure parameters, particularly SBP, the compared groups did not reveal any differences; however, the DBP parameter did show significant differences. Significantly low DBP indications *(p<0.05)* were found in participants from Dudinka, at 60.3±1.95 mm Hg in females and 68.0±2.68 mm Hg in males. Some authors who studied the morphological and functional peculiarities of the cardiovascular system in the indigenous minority groups of Russian North reported a low level of ABP in comparison to the European norm (Uvarova et al. 2009), which may be attributed to adaptation to the colder environment.

The type of vegetative regulatory activity of the heart was evaluated by means of KVI. It was found that adolescents from Neryungri belong to the normotension zone (Table 1), while their counterparts from Dudinka showed higher KVI values, with a slight tilt towards sympathicotonia, especially in females. More detailed data were obtained by analyzing the variation pulsometry parameters (Table 2). It was revealed that the VBI values of the studied group complied with normotension, with the exception of females from Neryungri. Their VBI significantly differed from that of the group from Dudinka (*p<0.05)* and equaled 64.1±6.5 c. u. This suggests the enhanced influence of parasympathetic outflow on the heart rhythm. The variation pulsometry data agrees with the KVI analysis results. A study of the VRI values of all study participants revealed significant differences in the female group. Female adolescents from Neryungri had a lower VRI than females from Dudinka, 2.24±0.36 c. u. and 7.01±1.20 c. u. respectively. This suggests that females from Neryungri have a vegetative balance that is tilted towards the parasympathetic system and high activity in the autonomous heart rhythm regulation contour. The VRI in male adolescents from both groups proved to be within the norm; no significant differences were found.

Baevsky stress index is used to evaluate the adaptability of the cardiovascular system to given environmental conditions (climatic conditions, age and gender changes, social conditions, and others); the normal range equals 80–140 units. Low values of the index suggest the prevalence of activity in the autonomous heart rate regulation contour and point to a low level of stress. Low values of BSI were found in the male group from Dudinka (Table 2), and only 11.1 percent of them showed BSI values over 140 (Fig.2). High values in people with a healthy cardiovascular system indicate a high level of centralization in the heart rhythm regulation, that is, the level of stress – the higher the value, the higher the level of stress. Marked differences in BSI were found among the male adolescents: the BSI values in males from Neryungri amounted to 239±32 units (Table 2). Intra-group analysis of BSI in males from Neryungri showed that no adolescent had this parameter within the normal

Table 1: Parameters of the cardiovascular system (M±m)

Town	*Sex*	*HR, bpm*	*SBP, mm Hg*	*DBP, mm Hg*	*KVI, c. u.*
Dudinka	Females	85.5±3.1*	108.2±1.9	60.3±1.95*	28.4±3.69
Neryungri	Females	72.7±1.8	111.7±1.8	77.1±1.63	-7.75±3.61
Dudinka	Males	79.7±3.5	119.5±2.9	68.0±2.68*	12.7±5.1
Neryungri	Males	73,6±1,4	118.3±3.2	80.4±2.40	-9.85±3.90

Note: *– significant difference in relation to the analyzed group (p<0.05).

Table 2: Parameters of heart rate variability (M±m)

Town	*Sex*	*VBI,c. u.*	*VRI,c. u.*	*Baevsky stress index, c. u.*
Dudinka	Females	231±64*	7.01±1.20*	167±34
Neryungri	Females	64.1±6.5	2.24±0.36	142±18
Dudinka	Males	175±47	5.81±1.01	119±40
Neryungri	Males	238±15	7.80±0.96	239±32

Note: *– significant difference in relation to the analyzed group (p<0.05).

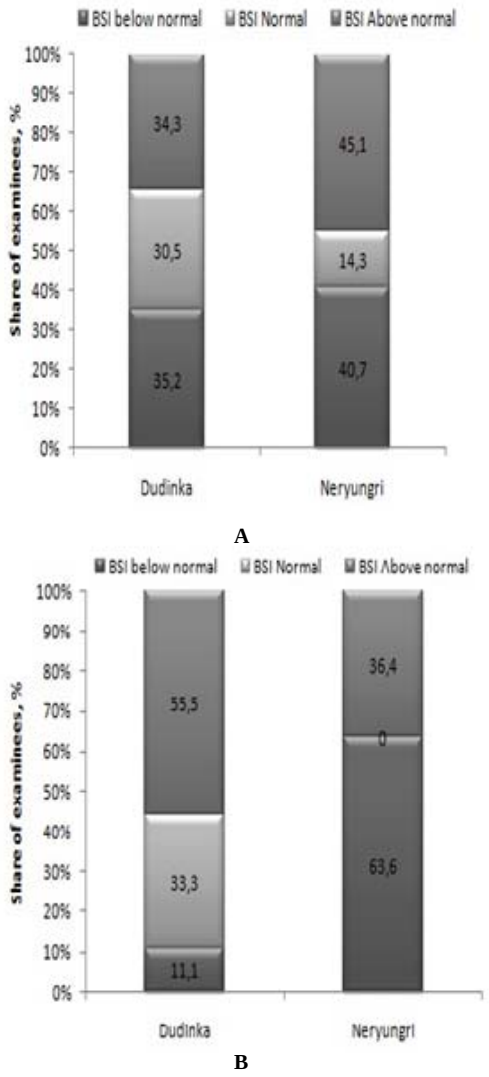

Fig. 2. Distribution of study participants by Baevsky stress index:
A – in females; B – in males

range, and in 63.6 percent of them, it was over 140 units. The BSI in the female groups also proved to be higher than the norm; no significant differences between the groups were revealed (Table 2). The intra-group analysis showed that BSI in about a third of the study participants was high: it was 35.2 percent in females from Dudinka and 40.7 percent in those from Neryungri.

CONCLUSION

In conclusion, this study looked at the morphological and functional characteristics of adolescents of indigenous minority groups of Russian North residing in the towns of Neryungri and Dudinka, located in different climatic zones. It was found that females and males from Dudinka demonstrate a slightly higher BMI in comparison to their peers from Neryungri and are marked by a significantly higher body fat content. This result agrees with the studies on adolescent body composition. Endomorphy parameters, indicating the degree of fat deposition, were significantly higher in females and males from Dudinka in contrast to their peers from Neryungri. Apart from lower stored fat percentage, adolescents from Neryungri, especially males, demonstrated higher ectomorphy values, which to a great degree characterize their body type as asthenic type. This does not agree with the opinion held by some researchers who claim that such a body type is absent among the indigenous minority groups of Russian North. Estimation of the functional state of the cardiovascular system showed that the HR, SBP and DBP of all study participants correspond to the age and gender norm. However, it was noted that adolescents from Dudinka demonstrated a higher HR and lower DBP in comparison with their counterparts from Neryungri. Earlier researchers pointed to a lower ABP in inhabitants of Russian Far North in comparison to that typical of Europeans. However, there were significant differences in the DBP obtained within the indigenous minority groups of Russian North residing in areas marked by different climatic conditions. The lower DBP can be attributed to the adaptation of their bodies to colder conditions. The study of the heart rhythm variability showed that many of the study participants, especially males from Neryungri, demonstrated a high Baevsky stress index, which points to the adaptive transformation of their cardiovascular system. We put forward the proposition that the formation of phenotypical differences in some of the morphological and functional features of the adolescents residing in various areas of Russian Far North can be attributed to the differences in the climatic conditions of those areas.

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