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Secular Changes in Mongolia: Shift in Tempos of Growth

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ABSTRACT

The patterns of secular changes in children and adolescents of the city of Ulaan-Baatar in the Republic of Mongolia measured in 2010–11 by the authors and in the group of children observed by Uranchimeg in the same place in 1989[1] have been analyzed. Total number of the investigated children and adolescents from 9 to 17 years of age was 1351. The last survey was conducted in accordance with bioethical procedures. The program included standard anthropometric measurements, descriptive characteristics[2] and pubertal stages evaluation[3]. Mean age of development of secondary sexual characteristics was calculated graphically. For most of the anthropometric indices significant differences between the Mongolian teenagers of two series of measurements were revealed. The patterns of secular changes in body size confirmed the interaction of »tempo and amplitude«[4]: significant changes in pubertal growth were observed with the same average values at 16–17-year old boys and girls. The increase in body circumferences observed in modern Mongolian schoolchildren was possibly based on the increase of body fat component, parallel to the global trend worldwide.

Key words: *auxology, secular changes, tempos of growth, physical development, sexual maturation, stature, BMI, modern Mongolian schoolchildren*

Introduction

Studies of secular trends and secular changes still remain one of the most discussed topics in auxological research. Taking into account enormous amount of works on this subject it could be assumed that little new could be said or added to what is already known. However this is not the case. Fast changes in life conditions serve as basis for quick changes in patterns of growth and development of children in different countries, thus supporting a well-known conclusion that growth is a mirror of the conditions of the society[5].

Recently, comprehensive reviews were published summarizing separate facts of changes in different body dimensions and in different countries in an attempt to find a general direction of secular trend. For example, two reviews on changes in BMI and height in 200 countries during the last 100 years or so were published in 2016. They were prepared by a consortium of scientists, so called NCD Risk Factor Collaboration (NCD-RisC), and published in the journal »Lancet« and in on-line edition ELife[6, 7]. A detailed consideration of the countries included in the long list of collaborating research shows that still many are absent, including Mongolia. However, starting from 1980's, anthropological population surveys were conducted there by both Russian and Mongolian scientists[8-13]. Due to these archive materials collected according to the same research protocol, it is possible to analyze secular changes that occurred in the Mongolian population during the last decades.

The aim of the present paper is to follow secular changes for the last 20 years in Mongolian children and adolescents living in the capital of Mongolia, the city of Ulaan-Baatar.

Materials and Methods

Mongolia is the 18th largest and the most sparsely populated country in the world. With the size of land of approximately 1.500 000 sq. km. it has a population of around 3 million people. It is also the world's second-largest landlocked country. Much of its area is covered by grassy steppe, with mountains to the north and west and the Gobi Desert to the south. Ulaan-Baatar, the capital and the largest city of the country, is home to about 45% of the country's population[14].

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Subjects

In 2010–11 an anthropological survey was conducted in the capital city of Ulaan-Baatar by a joint team of researchers from the Research Institute and Museum of Anthropology, Lomonosov Moscow State University, Moscow, Russia, and the Mongolian National Institute of Physical Education, Ulaan-Baatar Republic of Mongolia. Children and adolescents of both sexes from 7 to 17 were investigated, with the total number of 1,500 individuals.

For the present paper, the data collected in the course of this survey were compared with the published materials of Uranchimeg, who investigated children and adolescents of Ulaan-Baatar in 1989[1].

The limitations of this study are as follows: 1) only data for the age period from 9 to 17 years old were used for the comparison because no data on 7 or 8-year-old children of both sexes were included in the previous study; 2) intergenerational comparisons were made on mean values of all parameters; 3) in the first data set it was not exactly specified what kind of instrument was used for skinfold measurements: special skinfold caliper of any type or sliding caliper.

Exact numbers of children per age and sex group used for comparative analysis are given in Table 1. All of the investigated children were of Mongolian nationality. One age group consisted of children whose age fell within the interval + 6 months of the whole year (e.g., 7-year olds: from 6.5 to 7.5, etc.).

TABLE 1

NUMBER OF CHILDREN PER AGE AND SEX STUDIED IN 1989 AND 2011

Age (years)	Ulaan-Baatar, 1989		Ulaan-Baatar, 2011	
	Boys	Girls	Boys	Girls
9	82	79	50	63
10	102	87	98	91
11	69	81	85	97
12	73	67	81	92
13	70	66	82	65
14	65	79	76	100
15	58	70	69	75
16	66	70	61	60
17	56	68	46	60
Total	641	667	648	703

Children were measured during or immediately after school-hours. All anthropometric measurements were taken according to standard techniques[2,15]. Subjects were measured bare-feet, wearing only underwear. All of the observations were performed in agreement with bioethical procedures; protocols of consent were filled either by the subject (elder children) or by his/her parent(s).

Program

A large number of anthropometric and anthroposcopic characteristics (about 50) were taken on each individual. Standing height and heights of anthropometric points were measured using a Model 101 – Anthropometer[16]; weight was measured on a digital scale. Circumferences were measured using a measuring tape; body diameters – with spreading caliper; joints breadths (e.g., elbow breadth) with sliding caliper; skinfold thickness with Harpenden skinfold caliper.

The stages of secondary sex characteristics were evaluated in girls based on breast development (Ma), pubic hair (P), axillary hair (Ax), age at menarche (Me) and in boys based on nipple enlargement (C), pubic hair (P), axillary hair (Ax) and voice mutation. Data on menarcheal age were collected by status-quo method. The stages of secondary sexual characteristics were evaluated according to the scale used by Russian anthropologists[3]. The scores given to the stages differ from the Tanner's stages[17] by 1 unit: e.g., Tanner's »stage 1« equals »stage 0« according to Solovyeva's scale etc. However for the present paper it does not make any difference because only presence or absence of certain characteristics was taken into account for the subsequent estimation of mean ages of development of those.

The following characteristics were calculated from the measurements:

Leg length = (height of illiospinale anterius + height of symphysion): 2.

Arm length = acromion height – dactylion height.

Corpus length = height – leg length.

BMI = W/H^2, where W – weight in kilos, H – height in meters.

Corpus length/Height ratio (%).

Leg length/ Height ratio (%).

Biiliocristal diameter/Height ratio.

Chest index: sagittal chest/transversal chest ratio.

Frame index = (elbow breadth in mm*100) / (height in cm).This index was considered as a measure of external skeletal robustness[18].

Statistical analysis was performed with the Statistica (v. 8.0) software (Statsoft Inc., Tulsa, USA). Descriptive statistics for anthropometric measurements was calculated. Student's T-test was used for comparison of means in two subsamples for each analyzed trait.

Results

The analysis showed that most morphological characteristics significantly differed in children of two sets of measurements. Modern Mongolian schoolchildren were ahead of their counterparts from the previous generation in all total dimensions up to the age of 16–17 years ($p<0.000$). However at the age of 17 there were no secular differences in height for both males and females (Figure 1), in weight – for girls (Figure 2); at the age of 16 years – no differences in chest circumference for both sexes (Figure 3) and in weight for males were found. A very similar

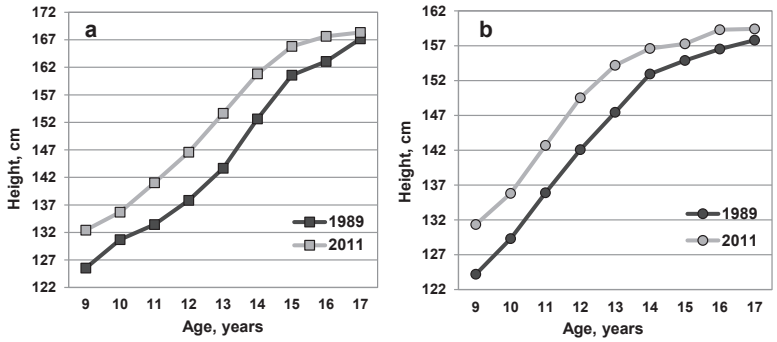

Fig. 1. Growth curves of height of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

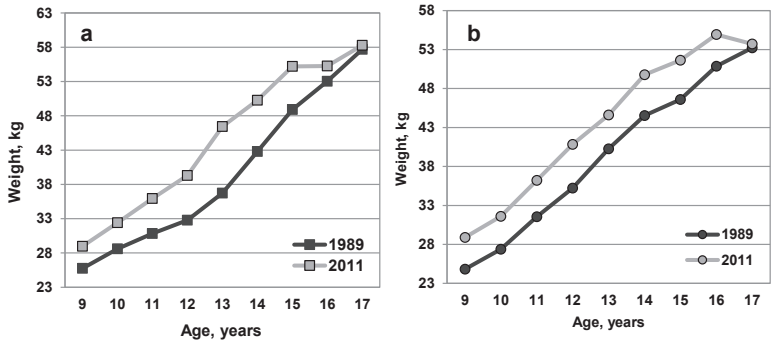

Fig. 2. Growth curves of weight of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

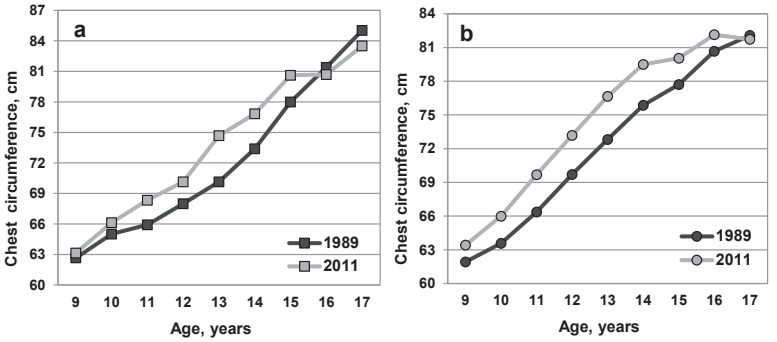

Fig. 3. Growth curves of chest circumference of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

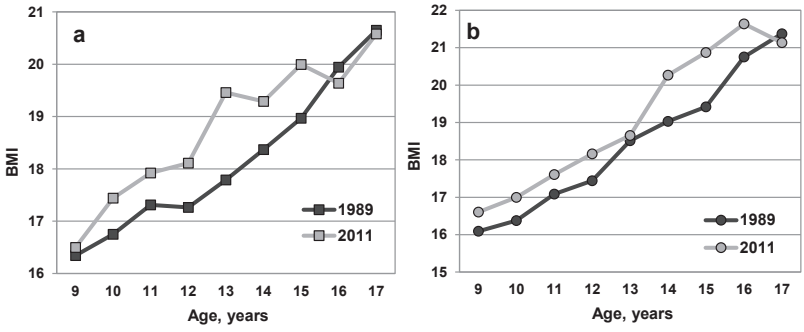

Fig. 4. Growth curves of BMI of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

picture was detected for BMI: at some age groups investigated in 2011 the average values of BMI were significantly higher but at 17 years of age no differences were found (Figure 4).

Practically in all age groups average values of leg length ($p<0.05$) and corpus length ($p<0.001$) were higher in modern Mongolian schoolchildren (Figures 5, 6). Thus, it can be concluded that the differences in height were due to the increase in both leg and corpus length but the contribution of corpus length was more significant, particularly in boys. This is confirmed by the analysis of body proportions: modern Mongolian boys from the age 14 and modern Mongolian girls at 12–13 years are characterized by a comparatively bigger corpus length ($p<0.02$ and $p<0.01$, respectively) and a relatively lower leg length ($p<0.02$ and $p<0.01$, correspondingly, Figures 7, 8) than those in the previous generation. At the same time the arm length significantly increased ($p<0.003$) in the Mongolian schoolchildren.

Secular changes in biacromial diameter are parallel to height: modern Mongolian children and adolescents had significantly higher values of this trait ($p<0.000$) up to the age of 17 years (Figure 9). For biiliocristal diameter modern children also surpass their counterparts from the previous generation up to the age of 14 years (Figure 10). For 15–17-year-old boys and 14–17-year-old girls no statistically significant differences in this characteristic were found. However, when average values of relative pelvic breadth were compared in two groups, they tended to be smaller in modern children (Figure 11).

Average values of chest breadth were higher in modern girls at 9–15 age groups (significant at 11–12 and 14 years, $p<0.006$) and in boys at 10–16 years (significant at 13–15 years, $p<0.004$). By the end of the growth period no differences were found for either boys or girls (Figure 12).

For chest length however there were no differences between the two data sets at any of the age groups (Figure 13). The increase in chest width with no increase in chest length led to changes in chest shape in modern Mongolian schoolchildren. This is confirmed by changes in chest index, which was lower in boys starting from 12 years (significantly different at 14–15 years, $p<0.01$) and in girls from 11 year (significantly different at 12, 16 and 17, $p<0.03$). Thus, it can be concluded that modern Mongolian teenagers were characterized with flatter chest shape compared to those from the previous generation.

In most of the circumferences (waist, hip, upper arm, lower leg) modern Mongolian children had higher average values than their counterparts from the previous generation up to the age of 16–17 years. At the end of the growth period, the differences, like in many other cases, disappeared. In modern 17-year-old girls average values of hip circumference were even smaller ($p<0.02$), than in their counterparts measured in 1989 (Figure 14).

Secular changes of average values of skinfold thicknesses were characterized with consistent increase (Figures 15, 16). All skinfolds were much thicker in modern Mongolian schoolchildren. However it should be kept in mind that, as already mentioned, in the 1989 series, it was not specified what kind of instrument was used for skinfold measurements, which might contribute to the differences revealed.

Intergenerational differences in elbow breadth revealed approximately the same changes as for many other traits discussed above: average values of this dimension were significantly higher in modern children and adolescents up to the age of 15 years, with no differences found after puberty (Figure 17). Frame index was slightly higher in the 1989 data set, starting from 12 years onward, although the differences were non-significant (Figure 18).

For better understanding of the revealed differences in growth patterns, annual increments of body dimensions were also analyzed. As can be seen from Figures 19 and 20, annual increase of growth occurred earlier in modern Mongolian children, which was particularly clear for weight and more pronounced for boys than for girls.

The analysis showed that main differences between Mongolian children and adolescents measured in 1989 and 2011 were due to differences in biological age. This was confirmed by mean age of development of secondary sexual characteristics (Table 2).

In girls breast development was earlier by 1 year 10 months, pubic hair – by 1 year 10 months and menarcheal age – by 8 months. In boys mean age of pubic hair development was 9 months earlier.

Discussion

The differences found when two sets of measurements of Mongolian urban children living in the city of Ulaan-Baatar in 1989 and in 2011 were compared, showed a very consistent pattern: two populations differed in their dimensions until the end of pubertal period. After that no statistically significant differences were found. This confirms the viewpoint that differences in size were mainly due to differences in tempo[4].

Secular changes in height in Mongolian children were due to increase both in leg length and in corpus length. In the »classical« auxological studies, secular increase in height was mostly connected with the increase in leg length[17,19]. However in some populations the pattern of the changes could be different with most of the increase in height occurring in corpus length[20,21]. The differences in leg length may serve as an evidence of the quality of life and environment, particularly in the prepubertal period of the ontogenesis, therefore, a leg length decrease and parallel increase of trunk length (corpus length, sitting height) could be considered as a marker of the unfavorable growth conditions[22]. According to the relative values of leg length and corpus length, for Mongolian boys increase in corpus length was more typical, while for the girls no intergenerational differences in these two indicators of

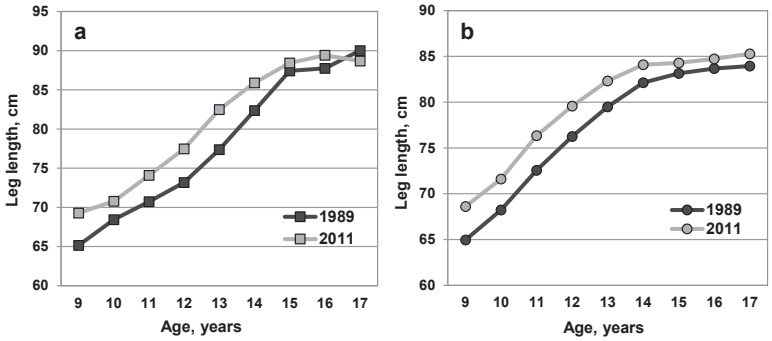

Fig. 5. Growth curves of leg length of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

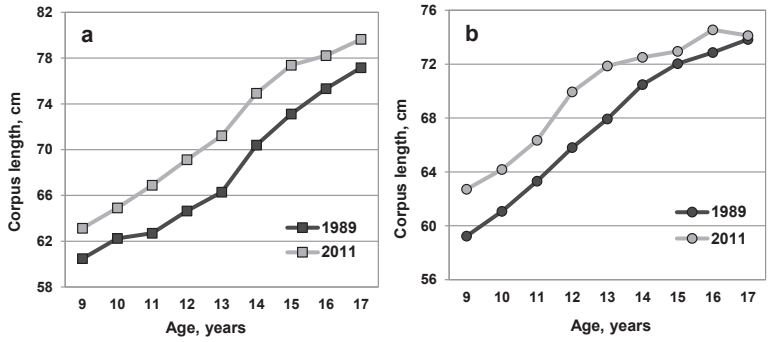

Fig. 6. Growth curves of corpus length of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

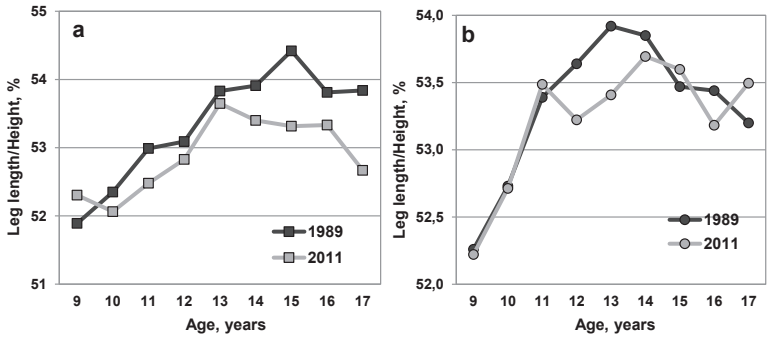

Fig. 7. Growth curves of leg length/height ratio of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

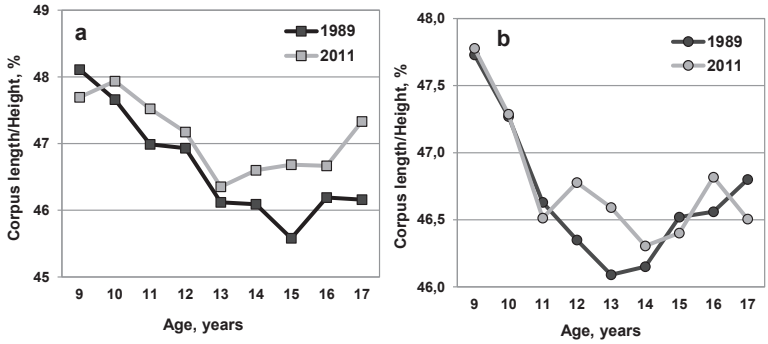

Fig. 8. Growth curves of corpus length/height ratio of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

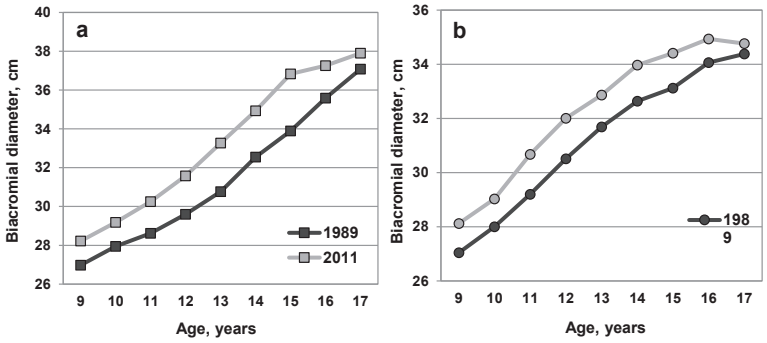

Fig. 9. Growth curves of biacromial diameter of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

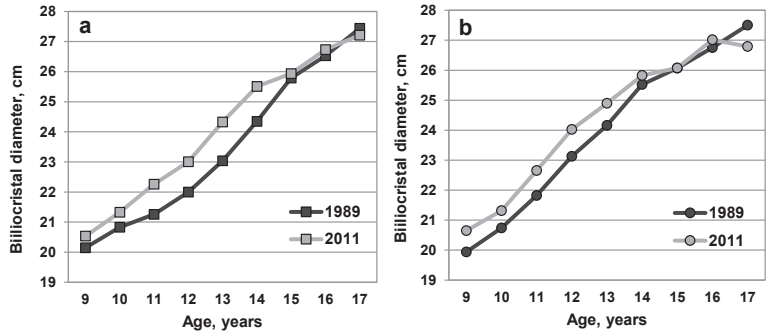

Fig. 10. Growth curves of biiliocristal diameter of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

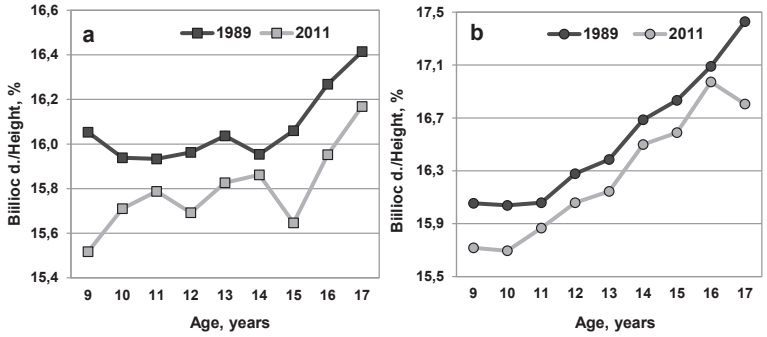

Fig. 11. Growth curves of biiliocristal diameter/height ratio of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

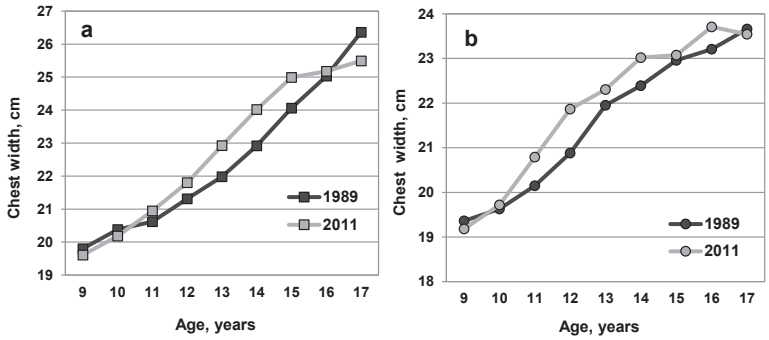

Fig. 12. Growth curves of chest width of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

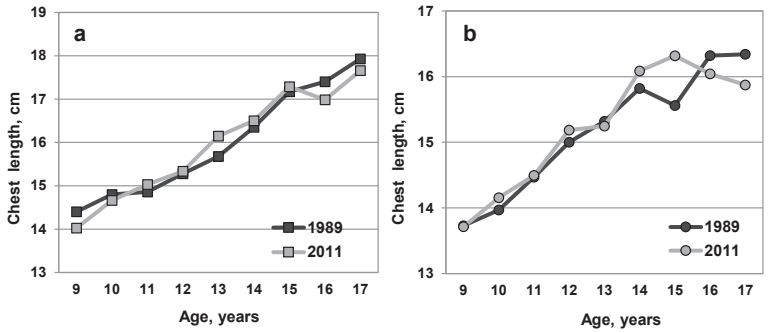

Fig. 13. Growth curves of chest length of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

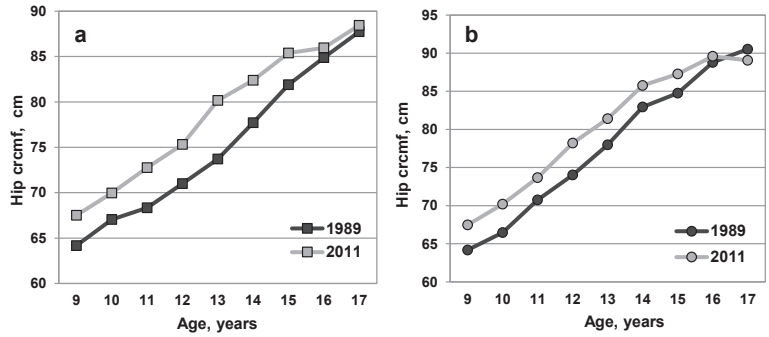

Fig. 14. Growth curves of hip circumference of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

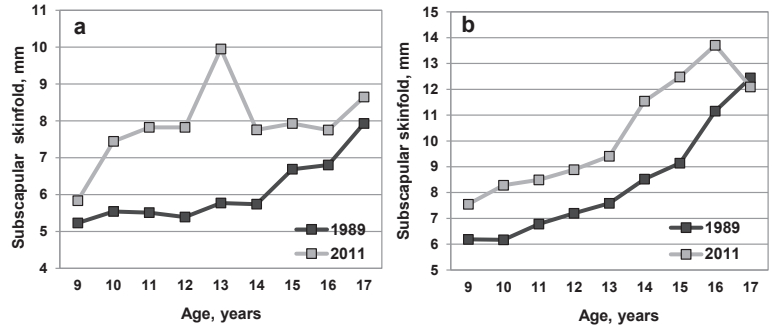

Fig. 15. Growth curves of subscapular skinfold thickness of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

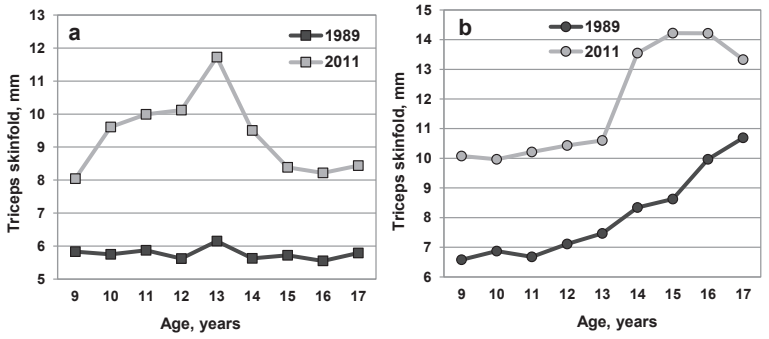

Fig. 16. Growth curves of triceps skinfold thickness of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

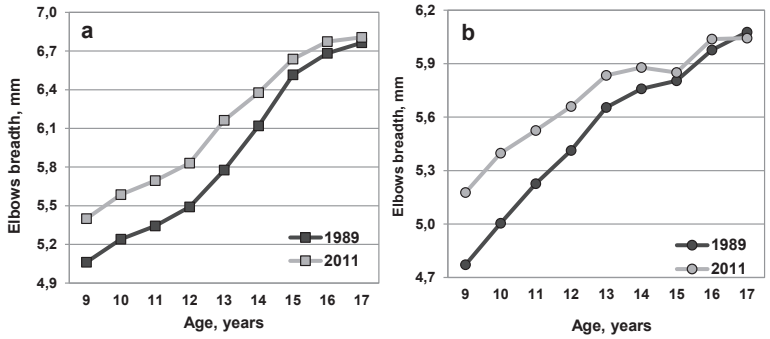

Fig. 17. Growth curves of elbow breadth of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

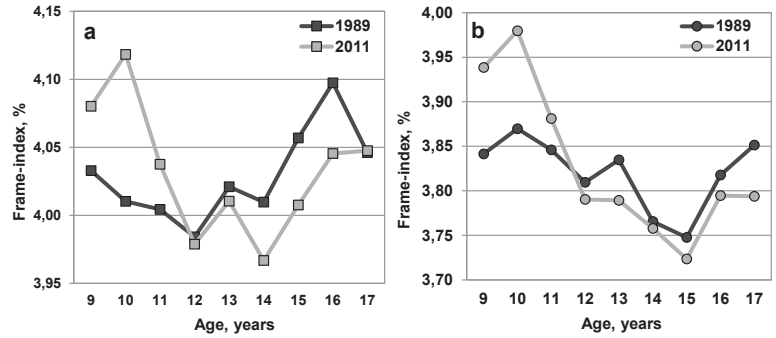

Fig. 18. Growth curves of frame index of Mongolian children in two series of measurements: a) – Boys, b) – Girls.

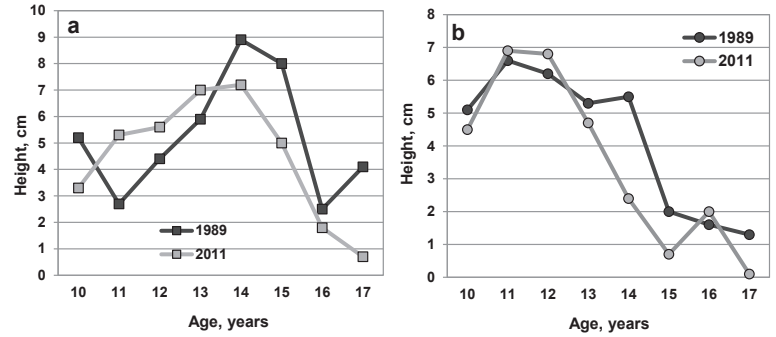

Fig. 19. Annual increments of height in Mongolian children of two series of measurements: a) – Boys, b) – Girls.

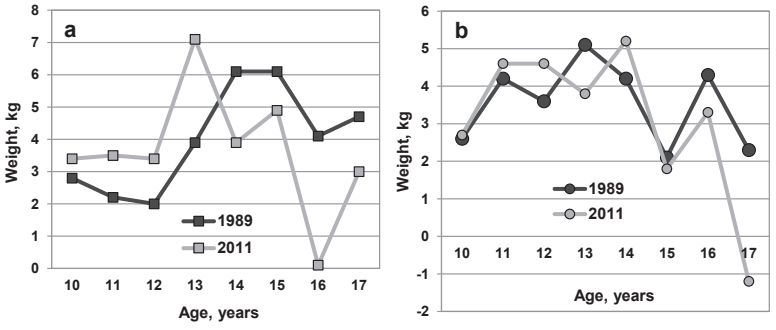

Fig. 20. Annual increments of weight in Mongolian children of two series of measurements: a) – Boys, b) – Girls.

TABLE 2.

MEAN AGE OF DEVELOPMENT OF SECONDARY SEXUAL TRAITS IN THE ADOLESCENTS OF ULAAN-BAATAR IN TWO SERIES OF MEASUREMENTS

Characteristics	Ulaan-Baatar, 1989	Ulaan-Baatar, 2011
Girls		
Ma	11 years 6 months	9 years 8 months
P	13 years 9 months	11 years 11 months
Ax	15 years 2 months	11 years 3 months
Menarche (Me)	13 years 2 months	12 years 6 months
Boys		
C	-----	12 years 11 months
P	14 years 4 months	13 years 7 months
Ax	16 years 2 months	14 years 4 months

growth were found. This may mean that family environment could be different by gender but this suggestion could not be testified because no information on socioeconomic family status, living conditions etc. was collected in 1989.

Though in absolute values of biacromial and biiliac diameters modern children surpassed their counterparts from the previous generation, when values of relative pelvic breadth were compared in two groups, they tended to be significantly smaller in modern children, which can support the view that modern youth has more gracile skeletons[23]. However in such traits as elbow breadth and Frame index this trend was not revealed. Elbow breadth was bigger in modern children and values of Frame index did not significantly differ between two sets of measurements. It was previously shown that for many other modern populations the trend towards decrease of bone mass was typical. It was explained by changes in modern life style and diminished degree of physical activity in present-day children and adolescents[24, 25]. Possibly, for Mongolian population this is not yet the case, and Mongolian schoolchildren still have enough physical exercise even in the urban environment.

The results show that due to different changes in transversal and sagittal chest diameters, the chest of modern Mongolian children became much flatter. Similar changes in chest parameters and chest shape, more pronounced in girls, were found by other authors who connected such changes with socioeconomic conditions[26].

Secular changes of average values of skinfold thickness were characterized with a consistent increase. These results were similar to many other studies showing the global trend towards obesity in the populations worldwide[27–32]. At the same time, unlike other populations[21] the increase in subcutaneous fat in Mongolian schoolchildren was similar both in trunk and in extremities. These results indicate also that the increase in circumferences in modern Mongolian children was mainly due to the increase in fat layer, which again is typical for many other studies of modern schoolchildren.

The comparison of mean age of development of secondary sexual characteristics and age of menarche showed that modern Mongolian children were characterized by an accelerated age of development, which was also expressed in early pubertal growth. In this case modern Mongolian children certainly differ from children of other groups where secular changes stopped or stabilized.

Conclusion

For most of the anthropometric indices significant differences between the Mongolian teenagers of two series of measurements were revealed. The patterns of secular changes in body size confirmed the interaction of «tempo and amplitude»[4]: significant changes in pubertal growth were observed with the same average values at 16–17-year old boys and girls. The increase in body circumferences observed in modern Mongolian schoolchildren was possibly based on the increase of body fat component, parallel to the global trend worldwide.

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SEKULARNE PROMJENE U MONGOLIJI: POMAK U BRZINI RASTA

S A Ž E T A K

Aspekti sekularnih promjena u djece i adolescenata u Ulaan-Baatar-u u Republici Mongoliji mjereni tijekom 2010. i 2011. godine uspoređeni su s podacima koje je na skupini djece iz istog grada analizirao Uranchimeg 1989. godine. Ukupan uzorak obuhvatio je 1351 djece i adolescenata u dobi između 9 i 17 godina. Novija studija je provedena u skladu s bioetičkim načelima. Program mjerenja uključio je standardne antropometrijske mjere, deskriptivne karakteristike i procjenu stupnja pubertetskih promjena. Srednja vrijednost dobi razvoja sekundarnih spolnih obilježja je izračunata grafički. Za većinu antropometrijskih mjera uočene su značajne razlike između dvije serije mjera. Obrasci sekularnih promjena u veličini tijela potvrdili su interakciju između brzine i opsega rasta: uočene su značajne promjene u pubertetskom rastu uz iste prosječne vrijednosti u dječaka i djevojčica starih 16-17 godina. Povećanje u opsezima tijela u novijoj generaciji mongolske školske djece je vjerojatno posljedica povećanja masnog tkiva, u skladu s globalnim svjetskim trendom.