

Secular Changes in Body Morphology and Fat Patterning in Moscow Children and Adolescents

Elena Z. Godina, Irina A. Khomyakova

Anuchin Research Institute and Museum of Anthropology, Lomonosov Moscow State University, Moscow, Russia

ABSTRACT

The trend towards overweight and obesity is one of the most researched and discussed topics in modern auxology. However changes in body proportions and the distribution of the subcutaneous fat layer are much less studied. The aim of the present paper is to follow recent secular changes in body measurements and fat patterning in Moscow children. Data used in this cross-sectional study were collected in 2012–16. 1800 boys and girls aged 7 to 17 years were investigated in several Moscow schools located in different city areas. The children were mostly of Russian ethnicity, born in Moscow. The program included about 50 measurements taken according to standard techniques. Body mass index (BMI) was calculated as weight (kg) divided by height (m)². Stages of secondary sexual characteristics were assessed, age at menarche was evaluated by status quo method. Obtained data were compared with the previous survey of Moscow children (2300 children of both sexes of the same age interval) conducted in 1996–99 by the same authors and under the same research protocol. It was shown that modern children surpass their peers of the previous survey in height, weight and BMI. There were distinct changes in body proportions in modern Moscow children expressed in an increase of trunk length and shortening of leg length. In boys there were also some changes in shoulder width which was smaller than in their peers in the previous studies. All the circumferences and skinfolds were bigger in modern children. One of the most distinctive features was the increase of the fat layer on the trunk in subscapular and abdominal areas. The trend towards earlier sexual maturation was also found. As similar changes were found by the authors earlier for some other Russian populations, it can be concluded that the processes of secular trend are continuing in Russia in some specific form.

Key words: biological anthropology, secular trend, morphological traits, body proportions, sexual maturation, Moscow children

Introduction

The literature on secular trends and secular changes in different countries and in various groups of people is enormous. Hundreds, if not thousands of papers are dedicated to this subject. Many authors wrote about the intergenerational increase in height and weight as well as the changes in body shape as part of the general trend. However there are distinct regional differences in the patterns of secular changes. That is why it is important to monitor growth changes in separate populations and to produce local references instead of global ones^{1,2}.

The aim of the present research was to analyze secular changes in body build and body proportions in Moscow schoolchildren measured in the 1990's and 2010's.

Materials and Methods

Study design

The data of a comprehensive anthropological examination of children and adolescents collected in 2012–2017 in various Moscow schools were used for this study. In total, more than 1800 schoolchildren aged 7 to 17 years were examined (Table 1). The material was collected cross-sectionally in compliance with the rules of bioethics and the signing of informed consent protocols for each subject (in younger schoolchildren, the protocols were signed by the parents). The survey included mainly persons of Russian ethnicity (85.2%). 7.3% of the total sample consisted of children from mixed marriages (mother or father of Russian origin) and 7.5% of schoolchildren (mainly of younger age) could not indicate the ethnicity of their parents.

TABLE 1

NUMBERS OF EXAMINED MOSCOW CHILDREN AND ADOLESCENTS BY AGE AND SEX GROUPS

Age, years	Year of investigation			
	1996–1999		2012–2016	
	Boys	Girls	Boys	Girls
7	98	83	61	51
8	100	100	82	93
9	114	103	65	77
10	101	100	81	69
11	101	97	116	101
12	101	106	95	82
13	100	98	113	86
14	102	109	97	78
15	124	121	87	73
16	108	131	98	77
17	99	101	61	58
Total	1148	1149	956	845

Participants

Archive data collected in 1996–1999 in Moscow schools were used to study secular trends and changes. The uniqueness of the compared materials lies in the fact that they were collected by the same researchers using the same measurement programs.

Anthropometric examination was carried out according to the standard technique^{3,4}. The program included an extensive set of measured and descriptive features – about 50 in total. The length dimensions of the body (stature, heights of various points above the floor), weight, shoulder and pelvic widths, transversal and sagittal chest diameters, body circumferences, skinfolds on the trunk and extremities were measured. Based on the measured traits, a number of indices were calculated:

- body mass index (BMI) according to the Quetelet formula $I = W / L^2$, where I is the index value, W is body weight in kg, L is height in m.
- leg length = (height of the point iliospinale anterior + height of the symphision point) / 2
- trunk length = height of the suprasternale point – the height of the symphision point
- arm length = acromiale height – dactylion height
- Frame Index, determined by the formula:

$$FI = (\text{Elbow width} / \text{Height}) * 100^{5,6}$$

Biological age was determined by the degree of development of secondary sexual characteristics⁷. The following signs were taken into account: in girls and boys – Ax – the development of axillary hair, P – the development of pubic hair; in girls: Ma – the development of the breast glands, Me – the age of the onset of menstruation; in boys: C –

pubertal swelling of the nipples, V – voice mutation, K – the degree of protrusion of the Adam’s apple.

A questionnaire was conducted taking into account the place of birth and ethnicity of the child and his parents.

Statistical analysis

Mathematical processing of the obtained data was carried out using the standard package of statistical programs Statistica 10. To confirm the significance of intergroup differences for traits with the distribution close to normal, student's T-test was used. For circumferences, skinfolds, weight and body mass index (BMI), a non-parametric Mann-Whitney U Test was used. For comparison of the samples from different surveys, standardization procedure was carried out with the further one-way ANOVA analysis. The significance of intergroup variation was assessed with Scheffe test. Mean age of development of secondary sexual characteristics was determined by the probit method.

A written informed consent of the parents or guardians of each child included in the research group, was obtained in accordance with the ethical principles for medical research involving human subjects in the Helsinki Declaration of World Medical Association (World Medical Association Declaration of Helsinki, 2000). Measurements were taken in elementary and secondary Moscow schools located in different areas of the city. Therefore, the investigated children belonging to different social backgrounds.

Results and Discussion

Secular changes in body morphology of Moscow children and adolescents

Figures 1–4 show the growth curves of total body dimensions and BMI in Moscow boys and girls in two series of measurements. It is clearly seen that in body height (Figure 1) modern girls are somewhat ahead of their peers who lived in the late 90s of the last century, but statistically significant differences are noted only for the three age groups – 7, 9 and 10-year-olds. In boys, there is a similar age dynamic of height and statistical significance is recorded only for 7, 9 and 12-year-olds. It may be concluded that in general this secular increase in height occurred only in prepubertal groups of both sexes.

By the age of 17, i.e. by the time the growth processes are more or less completed, the differences are almost leveled: modern girls and boys reach 164.4 and 177.6 cm of height and their peers from the previous generation 164.5 and 175.9 cm, respectively. This is a confirmation of the previous results obtained by the present authors^{8–11} and a number of other researchers^{12–14} about the stabilization of longitudinal growth in modern youth in most countries of the world.

A different trend was revealed for the changes in chest circumference (Figure 2). In the samples of girls of the

second series of measurements, the average values of this trait are significantly higher at all ages except for age 7, while in boys a similar situation is observed, but the differences are not significant for 8–9, 14 and 17-year-olds.

Growth curves of weight and body mass index repeat the pattern of chest circumference in modern children and adolescents. These indicators are higher than those found for their peers in 1996–99 (Figures 3 and 4). Moreover, significant differences in the average are noted in most age groups: in girls for body weight at 9–14 years, for BMI at 9–11, 13–14 and 17 years; in boys for weight at 7, 10–13 and 15–16 years, for BMI at 10–13 and 15–16 years.

Thus, it is possible to conclude that a change occurred in the direction of secular trends for weight and BMI, which was noted for Moscow schoolchildren in previous generation and was expressed in leptosomization of the physique – i.e., in more linear body structure⁹.

In modern Moscow children and adolescents, other, very peculiar changes in the length measurements and body proportions were noted. Figure 5 shows ANOVA results of absolute and relative leg length and trunk length in samples of boys and girls of different generations. Interestingly, against the background of minor changes in body length, quite significant changes occurred in the length of body parts and, as a result, in body proportions. A similar trend in the pattern of secular variability was observed by the authors in the analysis of physique in children and adolescents of Arkhangelsk, examined at two time points with the 20-year gap^{10,11}.

In classical studies on secular changes in body proportions, there is usually an increase in leg length and a decrease in the trunk length^{15,16}. In modern children and adolescents of Moscow, slightly different shifts occurred: although the length of the leg has significantly increased, the length of the trunk has also increased to an even greater extent in both girls and boys ($p < 0.001$). A comparison of body proportions showed a significant decrease in leg length relative to body length in girls ($p < 0.01$) and boys ($p < 0.05$). According to a number of authors, differences in leg length primarily indicate the quality of environmental conditions and their impact on growth in the prepubertal period of ontogenesis, so the relative shortening of the leg and lengthening of the trunk (or corpus length, sitting height) can serve as an indicator of unfavorable growth conditions^{17,18}.

It should be noted that some temporary changes affected the size of the chest, and in particular the ratio of longitudinal and transverse diameters, the so-called thoracic index (Figure 6). In modern girls, the longitudinal diameter of the chest has significantly decreased, and in boys, on the contrary, the transverse diameter has significantly increased. As a result, the values of the thoracic index decreased, which indicates flattening of the chest in both sex groups.

Significant changes were also observed when comparing the average values of the relative shoulder width (index "Shoulder width / Height") and the "Frame index", which reflects some changes in the skeleton and bone mass^{5,6}. As can be seen in Figure 7, modern children and adolescents of both

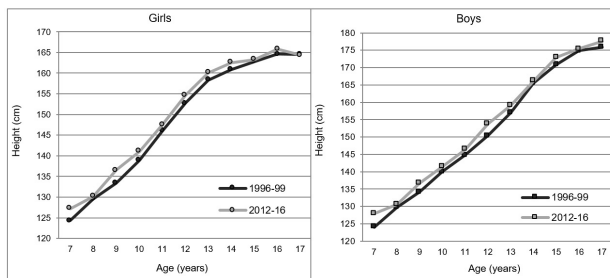


Fig. 1. Growth curves of height in Moscow girls and boys of two series of measurements.

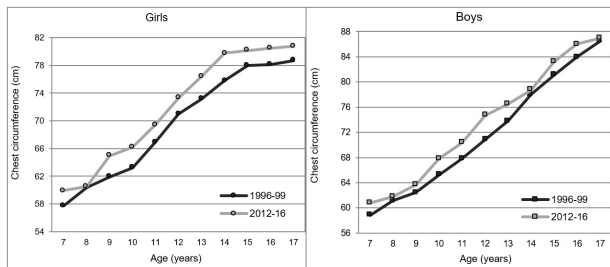


Fig. 2. Growth curves of chest circumference in Moscow girls and boys of two series of measurements.

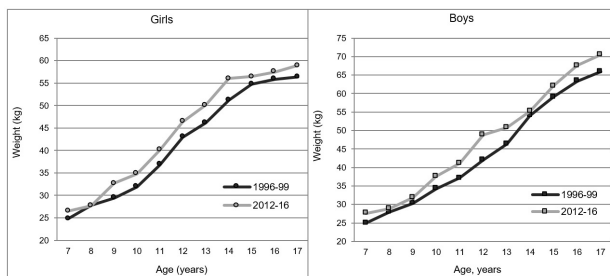


Fig. 3. Growth curves of weight in Moscow girls and boys of two series of measurements.

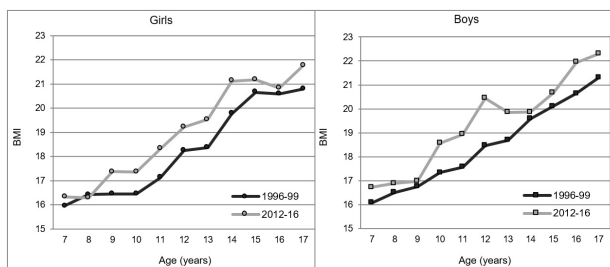


Fig. 4. Growth curves of BMI in Moscow girls and boys of two series of measurements.

sexes have a significant decrease in both indicators, which is more clearly expressed in boys. A similar trend in the secular variability of the transverse size of the skeleton and the shape of the chest (relative flattening), indicates the gracilization of the physique in modern youth. The obtained results are in good agreement with the studies by other authors¹⁹.

The most significant and unidirectional changes in modern boys and girls occurred in the body circumferences:

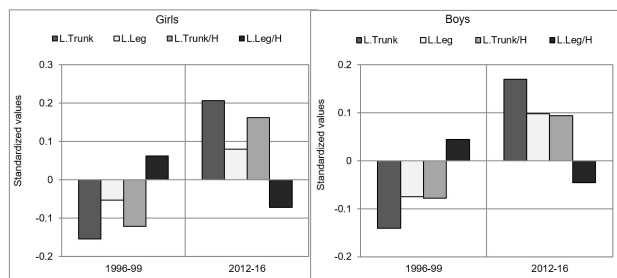


Fig. 5. ANOVA results of body proportions in Moscow girls and boys of two series of measurements. Abbreviations: L – length, H – height.

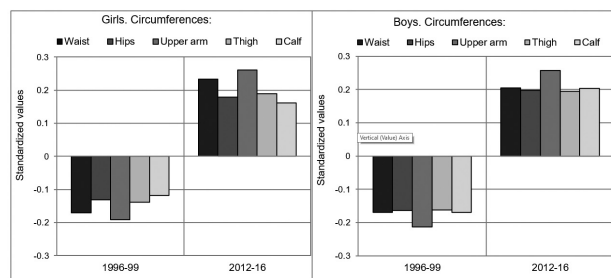


Fig. 8. ANOVA results of body circumferences in Moscow girls and boys of two series of measurements.

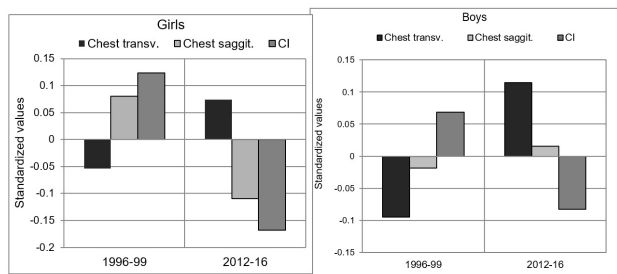


Fig. 6. ANOVA results of chest dimensions in Moscow girls and boys of two series of measurements. Abbreviations: Chest transv. – Transversal chest diameter, Chest saggit. – Saggital chest diameter, CI – Chest index.

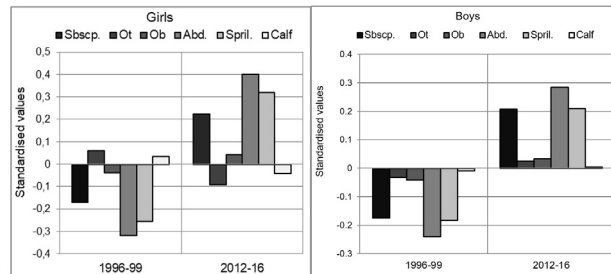


Fig. 9. ANOVA results of skinfolds thickness in Moscow girls and boys of two series of measurements. Abbreviations: Sbscp. - subscapular, Ot - over triceps, Ob - over biceps, Abd. - abdominal, Spril. - suprailiac, Calf.

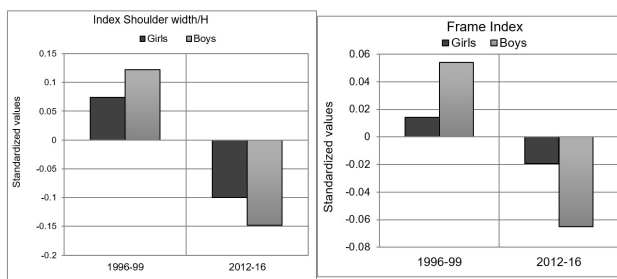


Fig. 7. ANOVA results of the index Shoulder width/H, and Frame Index in Moscow girls and boys of two series of measurements.

in almost all age groups, the circumferences of chest, waist, hips, arm, thigh, foreleg were significantly larger, especially in girls (Figure 8).

Moscow schoolchildren investigated in 2012–16 were characterized by significant changes, both in the total amount of fat mass and in its distribution over body surface. Figure 9 shows that for 16–17-year-olds there was a statistically significant increase in the subcutaneous fat layer on the trunk and its decrease on the limbs. A particularly significant increase, reaching 0.5–0.7 SDS, was noted for two skinfolds on the abdomen (abdominal and suprailiac). In some age groups (13–17 years in girls, 10–12 and 15–17 years in boys), the average values of abdominal skinfold thickness increased by 4–6 mm (in absolute units), which is a very significant gain.

It should be emphasized that the thickness of the subcutaneous fat layer on the back also increased significantly, and in girls almost the same as in boys. According to a

number of researchers, an increase in abdominal fat deposition is a rather formidable predictor of a number of diseases (cardiovascular diseases, diabetes mellitus, etc.) both in childhood and in adulthood²⁰. In this sense, the trends we noted, previously recorded for schoolchildren of the Arkhangelsk region^{10,11} may be considered as unfavorable forecasts in the health status of Moscow children and adolescents.

Sexual maturation

Over the past 17 years, separating the two generations of the examined adolescents, there have been significant

TABLE 2
SECULAR CHANGES IN MEAN AGE (YEARS) OF DEVELOPMENT OF SECONDARY SEXUAL CHARACTERISTICS IN MOSCOW ADOLESCENTS

Characteristics	Years of investigation	
	1996–1999	2012–2016
	Girls	
Ma	10.33	9.42
Ax	11.67	10.92
P	11.50	10.33
Me	13.00	12.75
	Boys	
C	13.33	11.92
Ax	13.50	12.83
P	12.50	12.29
Adam's apple	14.00	13.12
Voice mutation	13.37	12.75

changes in the timing of puberty. Table 2 presents the mean age of manifestation of secondary sexual characteristics, which clearly demonstrate the acceleration in the onset of puberty in modern Moscow girls and boys. At the same time, it should be noted that in the most important marker of puberty – the age of menarche – the differences were very small.

Conclusions

The study reveals the ongoing processes of the secular trend in children and adolescents of Moscow. To a greater extent, secular changes were manifested in the body shape and body proportions, in the increase of the subcutaneous fat layer and variations in its localization, and in earlier onset of puberty.

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The necessity to study the direction of secular changes is determined not only by purely theoretical problems, but to a greater extent by practical requests. Current trends in growth processes involve the development of new reference tables that will help specialists in the field of public health, school hygiene, sports selection, etc. to better assess individual growth and maturation strategies.

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E. Godina

Anuchin Research Institute and Museum of Anthropology, Lomonosov Moscow State University, Mokhovaya street 11, 125009 Moscow, Russia

e-mail: egodina11@gmail.com

SEKULARNE PROMJENE U TJELESNOJ MORFOLOGIJI I STRUKTURI MASNOG TKIVA DJECE I ADOLESCENATA U MOSKVI

SAŽETAK

Trend prema prekomjernoj tjelesnoj težini i pretilosti jedna je od tema koja se najviše istražuje i raspravlja u suvremenoj auksologiji. Međutim, promjene u tjelesnim proporcijama i raspodjeli potkožnog masnog sloja mnogo su manje proučavane. Cilj ovog rada je pratiti nedavne sekularne promjene u tjelesnim mjerama i strukturi masnog tkiva kod moskovske djece. Podaci korišteni u ovoj studiji presjeka prikupljeni su 2012.–16. Ispitano je 1800 dječaka i djevojčica u dobi od 7 do 17 godina u nekoliko moskovskih škola u različitim gradskim područjima. Djeca su uglavnom bila ruske nacionalnosti, rođena u Moskvi. Program je uključivao oko 50 mjerenja obavljenih prema standardnim tehnikama. Indeks tjelesne mase (BMI) izračunat je kao težina (kg) podijeljena s visinom (m)². Procijenjeni su stadiji sekundarnih spolnih obilježja, dob menarhe određena je status quo metodom. Dobiveni podaci uspoređeni su s prethodnim istraživanjem moskovske djece (2300 djece oba spola iste dobi) provedenim 1996.–99. od strane istih autora i po istom protokolu istraživanja. Pokazalo se da moderna djeca nadmašuju svoje vršnjake iz prethodnog istraživanja visinom, težinom i BMI vrijednostima. Došlo je do izrazitih promjena u tjelesnim proporcijama kod suvremene moskovske djece izraženih u povećanju duljine trupa i skraćivanju duljine nogu. Kod dječaka je također došlo do nekih promjena u širini ramena koja je manja nego kod njihovih vršnjaka u prethodnim studijama. Svi opsezi i kožni nabori bili su veći kod moderne djece. Jedna od najizrazitijih značajki bilo je povećanje masnog tkiva na trupu u subskapularnom i abdominalnom području. Uočen je i trend ranijeg spolnog sazrijevanja. Kako su slične promjene autori ranije utvrdili i za neke druge ruske populacije, može se zaključiti da procesi sekularnog trenda u Rusiji nastavljaju specifičan trend.