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Article

Long-term changes in body proportions since 1952 to 2011 in children and adolescents from Kolkata (India)

Łukasz Kryst[1], Magdalena Żegleń[1], Agnieszka Woronkowicz[1], Rituparna Das[2], Rana Saha[3], Sukanta Das[4], Parasmani Dasgupta[2]

[1] University of Physical Education, Faculty of Physical Education, Department of Anthropology, Kraków, Poland
[2] Biological Anthropology Unit, Indian Statistical Institute, Kolkata, India
[3] Dinabandhu Mahavidyalaya, Bongaon,West Bengal, India
[4] Department of Anthropology, North Bengal University, West Bengal, India

With 8 figures and 4 tables

Abstract: The aim of this study was to investigate the intergenerational changes of the selected body proportions of children and adolescents from Kolkata (India). The analysis was based on anthropometric measurements of 7488 Bengali children (4222 boys and 3266 girls), aged 7–19, from the middle-class families. The cohorts from 1952–66 and 1999–2011, as well as series of boys from 1982–83, were compared in terms of body height, subischial leg length, biacromial width, biiliac width, reciprocal ponderal index (RPI), skelic index, pelvi-acromial index, shoulder-height ratio, pelvis-height ratio. The significance of the differences was determined by two-way ANOVA. All features, in both sexes, significantly differed between the 1952–66 and 1999–2011 cohorts. A general positive secular trend was observed for subischial leg length, biacromial width, and biiliac width and skelic index. Negative overall intergenerational changes were noted in the pelvi-acromial index, biacromial and biiliac width to body height ratio and RPI. In boys, the 1982–83 and 1999–2011 cohorts differed significantly only in the RPI. Between the 1952–66 and 1982–83 series the differences in subischial leg length, biacromial width, biiliac width (in older boys) and pelvi-acromial index (some age groups) were significant. Observed diversification of body proportions most likely results from the improvement of developmental conditions related to the socio-economic progress of India. However, increasing stoutness, visible in the RPI values, especially associated with its fatness, raises the risk of many health problems and diseases, even at the young age.

Keywords: body proportions; secular trend; anthropological indices

Introduction

Environmental factors have a significant impact on human growth and development. They include, among others, parents' educational and professional status, family wealth or urbanization structure of the inhabited setting (Bielicki et al. 2005; Eveleth & Tanner 1976; Komlos & Baten 2004; Perkins et al. 2016; Relethford & Lees 1980). It is therefore obvious, that changes in these factors, occurring over time, will have their reflection in the changing dimensions of the human body.

Investigation on the direction and pace of intergenerational changes is one of the most popular methods of assessing the impact of the socio-economic factors on human growth and development. Until now, however, most authors have focused on studies concerning mainly height measurements, or indicators of overweight, obesity, as well as the body composition, which also applies to the research performed on Indian population (Dasgupta et al. 2008; Kleanthous et al. 2017; Kowal et al. 2013; Kowal et al. 2015; Kryst et al. 2012; Mori 2016; Topçu et al. 2017; Vijayakumar et al. 2018).

However, the studies investigating the problem of the intergenerational changes in body dimensions, including the measurements of the width and length of its individual segments and their interrelations, are much less frequent. Still, this is a significant problem. Comparing the dynamics of the development of individual features helps, for example, to determine the level and harmony of the development of the examined child, as well as the differences occurring in body proportions, between the generations (Woronkowicz et al. 2016).

As mentioned before, the socio-economic conditions of human development are reflected by the presence and direction of the secular trends. Therefore, it is a particularly important research problem in populations of developing

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countries, such as India. (International Statistical Institute 2017). Unfortunately, not all intergenerational changes associated with socio-economical progress are positive. In the last 10 years, the significant increase in the prevalence of abdominal obesity, waist circumference and the BMI were observed in the Indian population (Arora et al. 2017; Dasgupta et al. 2008; Singhal et al. 2010).

The aim of the study was to examine the intergenerational changes on selected measurements of the body proportions of children and adolescents living in Calcutta (India), based on the measurements collected between the periods of 1952–66 and 1999–2011.

Material and methods

The data constitutes three series of anthropometric measurements. The results of anthropometric measurements of 7488 Bengali children (4222 boys and 3266 girls), from the middle class, aged 7–19, were obtained. The series in 1999–2011 consisted of 3621 children and adolescents (1725 boys and 1896 girls), one from 1952–1965 consisted of 3042 people (1672 boys and 1370 girls), and the cohort from 1982–83 consisted of 825 boys aged 7–16.

Measurements of the series from the years 1999–2011 were carried out in 66 schools in Kolkata (India), on the birthdays or half-birth dates of the subjects verified through hospital discharge certificate. All the measurements were taken according to the protocol of IBP (International Biological Programme 1969) and Martin's technique (Martin & Saller 1957), using a set of tools (anthropometer, calliper) made by GPM (Switzerland). Also, a portable weighing machine was used. Details of the used methods and the exact characteristic of the research group are presented in previous publications (Das et al. 2016; Dasgupta et al. 2015).

The following measurements were taken: body height (cm), subischial leg (lower limbs) length (mm), biacromial width (mm), biiliac width (mm), which were the base to calculate anthropometric indices such as:

- reciprocal ponderal index (RPI) [body height (cm) / body mass (kg)$^{1/3}$]
- skelic index [(subischial leg length / sitting height) × 100]
- pelvi-acromial index [(biiliac width / biacromial width) × 100]
- shoulder-height ratio [(biacromial width / body height) × 100]
- pelvis-height ratio [(biiliac width / body height) × 100]

The results of the measurements and anthropometric indicators for the 1982–83 cohort were taken from the Kolkata Growth Study 1 (KG 1) (Dasgupta & Das 1997; Pakrasi et al. 1988). Ones of the 1952–1966 in turn from the Sarsuna-Barish Research Growth Study (SBG) (Das et al. 1986; Das 1985; Hauspie et al. 1980).

Changes in mean values of features and indices in successive cohorts within the age groups were analyzed using two-way analysis of variance. Tukey's HSD test was used for post hoc comparisons between the cohorts. All the statistical analyses were made using Statistica 12.0.

Results

Among the individual measurements, subischial leg length in both sexes generally manifested a positive secular trend between 1952–66 and 1999–2011 (p<0.001) (Table 4, Fig. 1). In girls, after correcting for age, the analysed cohorts differed significantly up to 15 years of age (Table 3). In boys, the bigger differences of the subischial leg length were noted between the 1952–66 and 1982–83 series, than between the 1982–83 and 1999–2011 cohorts (Table 1). After age correction, in boys, the differences between 1952–66 and 1982–83 cohorts were found to be statistically significant. However, for the series 1982–83 and 1999–2011 said measurement did not differ significantly (Table 1).

Similarly, for mean biacromial width, in both sexes, general positive intergenerational changes were observed (p<0.001) (Table 4, Fig. 2). In girls, the differences between the series, after adjusting for age, showed statistical significance in all age groups (Table 3). Among boys the discrepancies between the 1952–66 and 1999–2011 cohorts were significant in most age groups – the only exception was noticed at 18 years. However as already observed for subischial leg length the two growth data series namely 1999–2011 and 1982–83 did not differ significantly for this measurement. In described sex, the observed differences were strongly significant between the 1952–66 and 1982–83-cohort (Table 1).

The contemporary boys exhibited also a larger mean biiliac width than their peers from two preceding cohorts of 1952–66 and 1982–83 (p<0.001) (Table 4, Fig. 3). After age correction, the differences between the 1952–66 and 1999–2011 cohorts were statistically significant from the age 8 to 16. The discrepancies between the series from 1952–66 and 1982–83, as well as form 1982–83 and 1999–2011, were small, and, for the most part, not significant (Table 1). In girls, a positive secular trend was observed up to 17 years of age. Surprisingly, 18 and 19-year-old girls from 1952–66 achieved higher values of the discussed measurement than the succeeding cohorts, which may be due to small sample size for these ages (Table 3). Without the age correction, in females, the discrepancies between the series 1952–66 and 1999–2001 were statistically significant (p<0.001) (Table 4, Fig. 3). However, after correcting for age, only the differences occurring from the age of 8 to 14 remained significant (Table 3).

Among the five studied indices, the mean reciprocal ponderal index in both sexes manifested a general negative secular trend (p<0.001) (Table 4, Fig. 4). It implies that the contemporary children are characterized by a more stout

Table 1. Differences in analysed body features and proportions, between boys from analyzed cohorts (1952–66, 1982–83 and 1999–2011).

Age	Subischial leg length			Biacromial width			Biiliac width			RPI		
	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011
7	4.14***	0.94	5.07***	1.53***	–0.19	1.34***	0.66	–0.11	0.55	0.38	–1.27*	–0.89
8	3.78***	1.46	5.24***	1.43***	0.12	1.55***	0.49	0.40	0.89***	0.17	–1.55***	–1.39***
9	3.51***	2.16*	5.66***	1.66***	0.27	1.93***	0.60	0.56	1.16***	–0.49	–1.27**	–1.77***
10	3.42***	2.32	5.74***	1.40***	0.57	1.97***	0.90*	0.18	1.07***	–0.66	–1.51***	–2.17***
11	4.56***	2.19*	6.75***	1.73***	0.43	2.16***	0.66	0.50	1.16***	–0.49	–1.68***	–2.16***
12	4.52***	2.42**	6.94***	2.00***	0.44	2.44***	0.76*	0.74	1.50***	–0.60	–1.92***	–2.52***
13	5.79***	1.93	7.73***	2.87***	0.39	3.26***	1.20***	0.46	1.66***	–0.23	–1.77***	–2.00***
14	4.79***	2.34*	7.12***	2.69***	0.71	3.40***	1.25***	0.79*	2.05***	–0.41	–1.58***	–1.98***
15	3.49***	0.94	4.43***	2.41***	0.62	3.03***	0.88*	0.60	1.49***	–0.94	–1.37**	–2.31***
16	2.06	1.91	3.98***	2.28***	0.48	2.76***	1.14*	–0.01	1.13***	–0.98	–1.59**	–2.57***
17	–	–	2.21**	–	–	1.52***	–	–	0.64	–	–	–2.70***
18	–	–	1.59	–	–	0.47	–	–	0.24	–	–	–2.58***
19	–	–	1.25	–	–	1.66***	–	–	0.29	–	–	–2.85***

* – $p \leq 0.05$, ** – $p \leq 0.01$, *** – $p \leq 0.001$

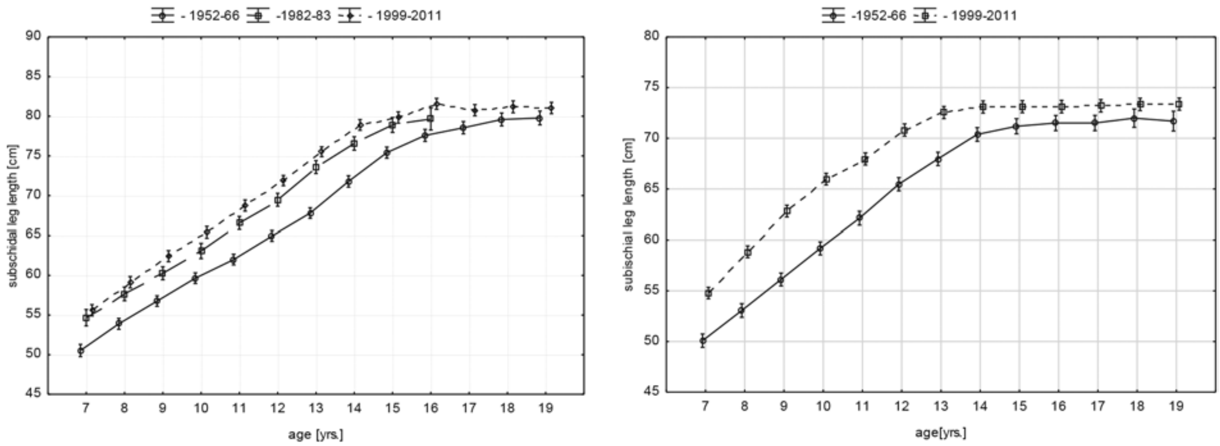

Fig. 1. Subischial leg length of boys (left) and girls (right) from all cohorts.

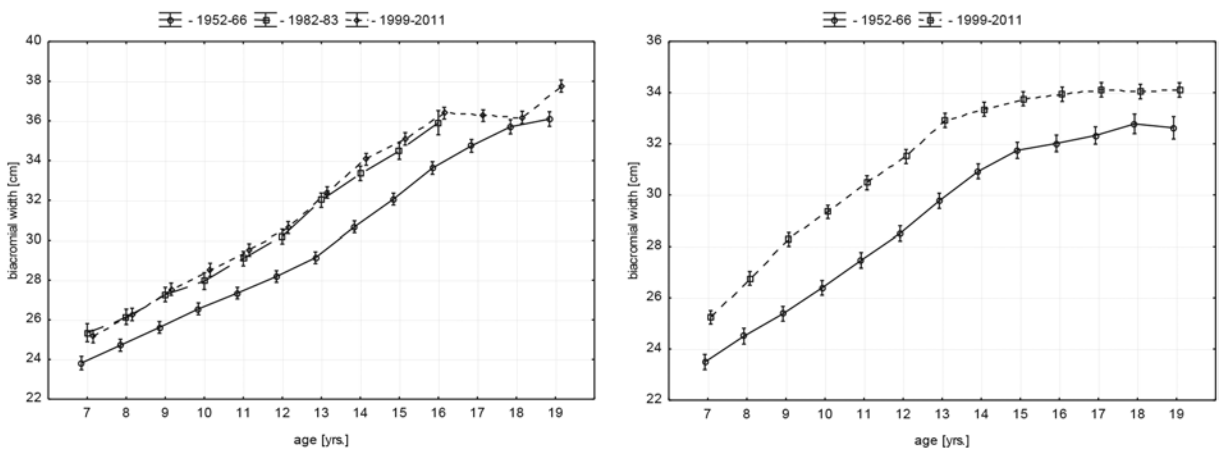

Fig. 2. Biacromial width of boys (left) and girls (right) from all cohorts.

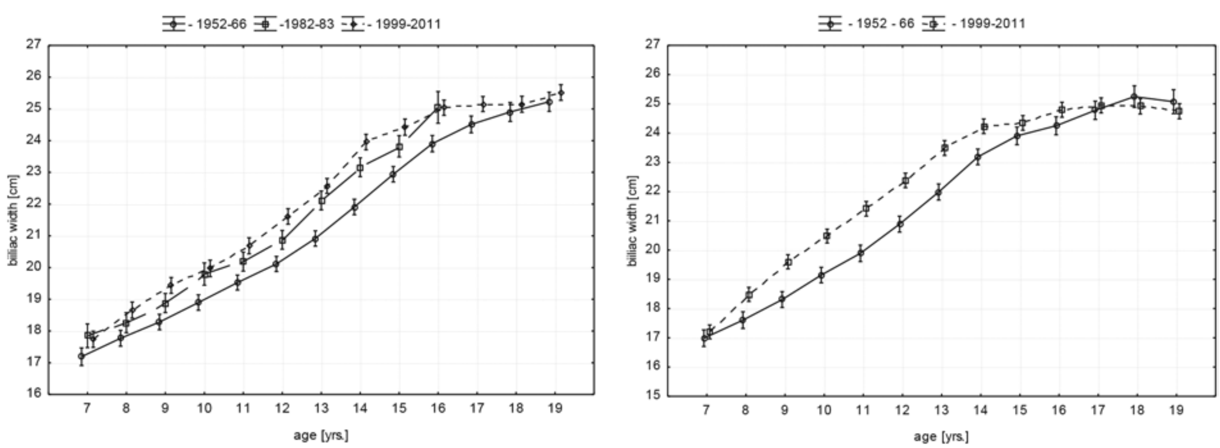

Fig. 3. Biiliac width of boys (left) and girls (right) from both cohorts.

Table 2. Differences in analysed body proportions, between boys from analyzed cohorts (1952–66, 1982–83 and 1999–2011).

Age	Skelic index			Pelvi-acromial index			Biacromial width to body height ratio			Biailiac width to body height ratio		
	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011	1952–66 vs. 1982–83	1982–83 vs. 1999–2011	1952–66 vs. 1999–2011
7	1.69	0.78	2.47**	–1.65	–0.01	–1.66	–0.12	–0.40	–0.51**	–0.43	–0.28	–0.71***
8	1.06	0.12	1.17	–1.79	0.94	–0.85	–0.11	–0.38	–0.50**	–0.49**	–0.04	–0.53***
9	0.93	1.35	2.28**	–1.95	1.07	–0.89	0.23	–0.42	–0.18	–0.28	–0.03	–0.32
10	0.33	1.44	1.77	–0.32	–0.87	–1.18	0.00	–0.18	–0.17	–0.11	–0.26	–0.37*
11	1.91	1.37	3.28***	–1.81	0.50	–1.31	0.05	–0.21	–0.16	–0.35	–0.04	–0.39**
12	1.70	0.88	2.58***	–2.27**	1.48	–0.79	0.27	–0.32	–0.06	–0.29	0.07	–0.21
13	0.86	0.99	1.85	–2.63***	0.50	–2.12***	0.31	–0.16	0.15	–0.36	0.02	–0.34*
14	0.14	0.42	0.56	–1.91	0.85	–1.06	0.36	–0.13	0.24	–0.15	0.09	–0.06
15	–1.24	0.04	–1.20	–2.37**	0.52	–1.85*	0.45	0.05	0.50**	–0.18	0.12	–0.06
16	–1.81	2.26	0.45	–1.21	–1.14	–2.35***	0.55	0.09	0.64***	0.11	–0.15	–0.03
17	–	–	0.06	–	–	–1.19	–	–	0.25	–	–	–0.10
18	–	–	–0.25	–	–	–0.32	–	–	–0.18	–	–	–0.19
19	–	–	–0.65	–	–	–2.27**	–	–	0.61***	–	–	–0.10

* – $p \leq 0.05$, ** – $p \leq 0.01$, *** – $p \leq 0.001$

Table 3. Differences in body proportions between girls from analyzed cohorts (1952–66 and 1999–2011).

Age	Subischial leg length	Biacromial width	Biiliac width	RPI	Skelic index	Pelvi-acromial index	Biacromial width to body height ratio	Biailiac width to body height ratio
7	4.70***	1.75***	0.22	–0.94	3.11***	–4.34***	0.05	–0.87***
8	5.79***	2.26***	0.88**	–1.38***	4.23***	–3.00***	0.19	–0.45**
9	6.69***	2.89***	1.29***	–1.42***	4.88***	–2.94***	0.42*	–0.34
10	6.78***	2.95***	1.33***	–2.02***	3.29***	–2.60***	0.30	–0.34
11	5.84***	3.01***	1.52***	–2.33***	0.76	–2.36***	0.37	–0.21
12	5.35***	3.00***	1.50***	–2.17***	0.62	–2.20***	0.45**	–0.13
13	4.57***	3.15***	1.50***	–2.23***	–0.26	–2.41***	0.69***	–0.03
14	2.71***	2.43***	1.05***	–2.41***	0.16	–2.32***	0.79***	0.10
15	1.94*	2.02***	0.44	–2.40***	–0.97	–3.32***	0.68***	–0.20
16	1.62	1.92***	0.55	–2.53***	–0.85	–2.80***	0.67***	–0.10
17	1.70	1.79***	0.17	–2.36***	–1.21	–3.51***	0.53**	–0.38
18	1.36	1.26***	–0.33	–2.30***	–0.31	–3.43***	0.40	–0.47
19	1.68	1.48	–0.33	–2.29***	–0.16	–4.49***	0.43	–0.58**

* – $p \leq 0.05$, ** – $p \leq 0.01$, *** – $p \leq 0.001$

body built than their peers from the earlier periods. After the age correction in girls, the differences remained statistically significant, with the exception of the 7-year-olds (Table 3). In boys, the described discrepancies between the 1952–66 and 1999–2011 cohorts were mostly statistically significant. Likewise, the differences between series of 1982–83 and 1999–2011 manifested statistical significance after age adjustment. The smallest and not significant, differences were noted between the 1952–66 and 1982–83 cohorts (Table 1).

On the other hand, the mean skelic index turned out to be generally higher for the contemporary children (p<0.001) (Table 4, Fig. 5). This suggests, that they were characterized by relatively longer legs than their peers from previous populations. In girls, after correcting for age, the described trend was present and statistically significant up to 10 years of age. In older age groups of this sex, the values of the skelic index were similar for both cohorts, or even slightly lower for contemporary girls (Table 3). In boys, the differences between the cohorts from 1952–66 and 1999–2011 as well as those noted for the series 1952–66 and 1982–83 and 1982–83 and 1999–2011 were mostly not statistically significant (Table 2).

The mean pelvi-acromial index generally exhibited negative intergenerational changes when results of 1952–66 and 1999–2011 cohorts were compared (p=0.029 in boys and p=0.006 in girls) (Table 4, Fig. 6). This suggests that children examined in 1999–2011 had proportionally wider shoulders in relation to the pelvis than their peers of 1952–66 cohort. After age correction, in girls, these discrepancies remained significant in all the age groups (Table 3). In boys, between 1952–66 and 1982–83 series, as well as those from 1952–66 and 1999–2011 the differences were also, for the most part, not significant after correction for age. However, the comparison of the 1982–83 and 1999–2011 series suggests, that the contemporary boys had higher values of this indicator than their peers from the earlier study. Those differences indicate the presence of the proportionally wider pelvis observed in the cohort from 1999–2011, but they were not statistically significant. Differences observed while comparing the cohorts were, for the most part, similar in size (Table 2).

With respect to shoulder width to body height index in boys, a negative secular trend, between the 1952–66 and 1999–2011 cohorts, was observed up to the age of 12 years. The similar intergenerational change was found between the 1952–66 and 1982–83 series in 7 and 8-year-olds, as well as between 1982–83 and 1999–2011 cohorts up to 14 years of age. Those results, suggest the presence of the relatively narrower shoulders for the contemporary boys. In most of the older male age groups, however, this index showed higher values in the boys examined in 1999–2011, suggesting the presence of proportionally broader shoulders (Table 2). Without age correction, the described discrepancies were statistically significant (p<0.001) (Table 4, Fig. 7). After the age correction, however, the differences were not significant in most age groups of this sex. Described discrepancies between the three male cohorts were also, for the most part, similar in size (Table 2). Among girls, a positive secular trend was observed in case of this index (p<0.001) (Table 4, Fig. 7), which suggests that the greater relative value of shoulder width characterizing girls from the contemporary population. After age-adjustment in a majority of the older age groups, the differences remained statistically significant (Table 3).

Mean pelvic width to height ratio in both sexes generally showed the presence of negative intergenerational changes

Table 4. Statistical significance of the differences in body proportions between the age groups and cohorts (1952–66, 1982–83 and 1999–2011).

		Subischial leg length		Biacromial width		Biiliac width		RPI		Skelic index		Pelvi-acromial index		Biacromial width to body height ratio		Biiliac width to body height ratio	
		Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Age	**Sum square**	204064.80	136750	31344.51	28435	14171.19	21548	1496.77	857	41493.10	12344	293.14	8499	53.11	114	26.90	677
	Mean square	22673.87	11.39	3482.72	2370	1574.58	1796	166.31	71	4610.34	1029	32.57	708	5.90	10	2.99	56.4
	F	1417.54	907.3	1085.66	888	754.99	806.6	41.67	16	230.49	59	2.27	57	7.90	13	5.14	82
	p	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	0.015	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001
Cohort	**Sum square**	18760.50	10678	3693.66	3913	915.88	408	3775.98	3060	954.13	735	1523.19	6701	1.95	148	55.07	65.5
	Mean square	18760.55	10678	3693.66	3913	915.88	408	3775.98	3060	954.13	735	1523.19	6701	1.95	148	55.07	65.5
	F	1172.89	850.2	1151.41	23	439.15	183.5	945.99	681	47.70	42	106.21	537	2.61	208	94.74	95.1
	p	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	0.106	≤0.001	≤0.001	≤0.001
Interaction	**Sum square**	3235.10	2862	563.41	275	225.22	283	242.58	178	1576.89	3088	500.60	347	111.31	33	35.33	44.8
	Mean square	154.05	239	26.83	23	10.73	24	11.55	15	75.09	257	23.84	29	5.30	3	1.68	3.7
	F	9.631	19	8.36	9	5.14	10.6	2.89	3	3.75	15	1.66	2	7.09	4	2.89	5.4
	p	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	≤0.001	0.029	0.006	≤0.001	≤0.001	≤0.001	≤0.001

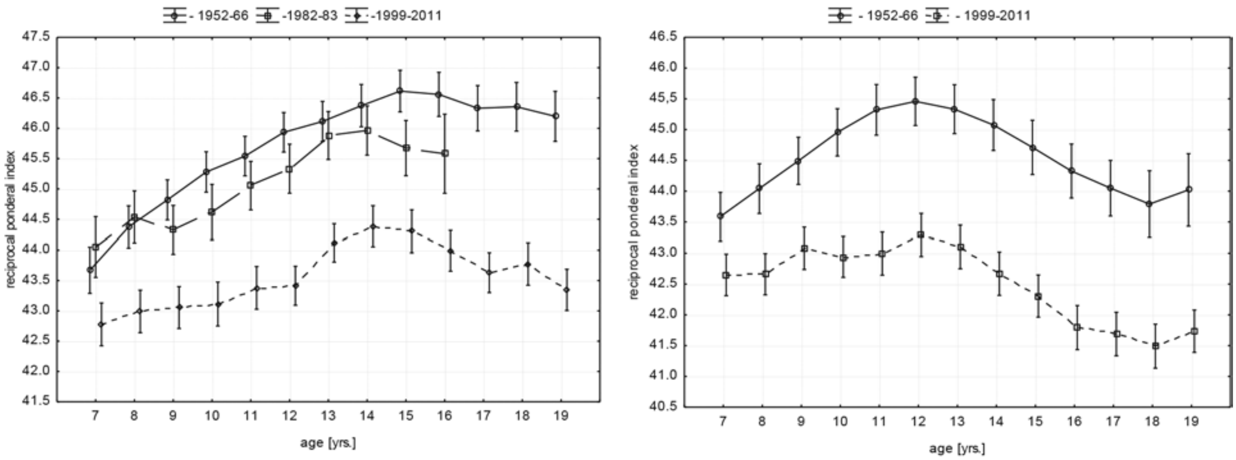

Fig. 4. Reciprocal ponderal index of boys (left) and girls (right) from both cohorts.

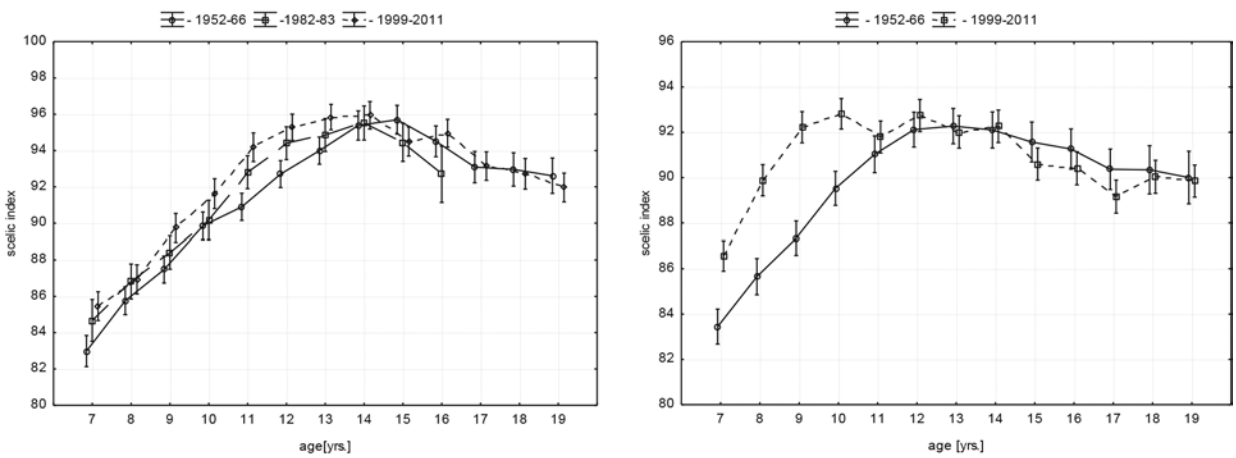

Fig. 5. Skelic index of boys (left) and girls (right) from both cohorts.

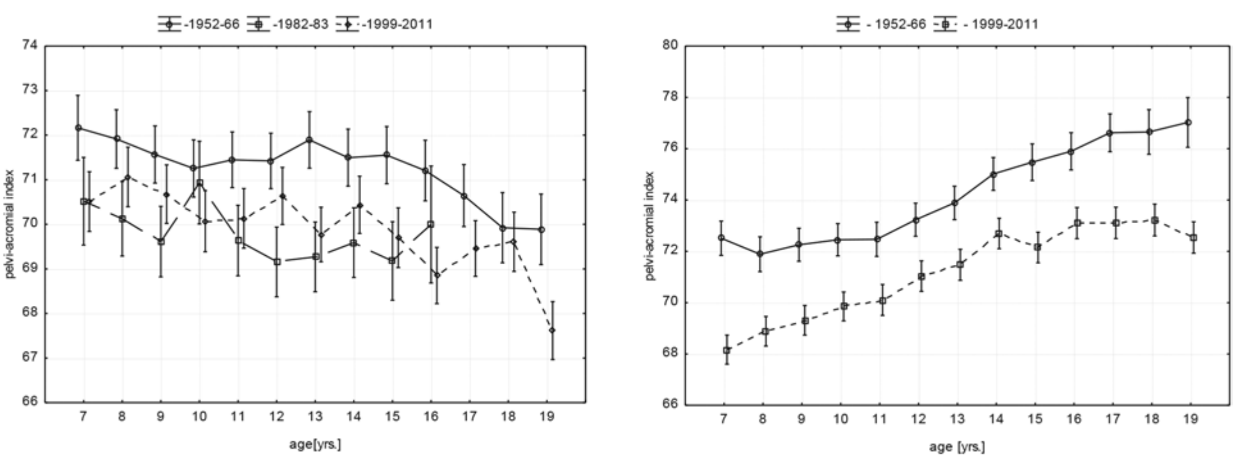

Fig. 6. Pelvi-acromial index of boys (left) and girls (right) from both cohorts.

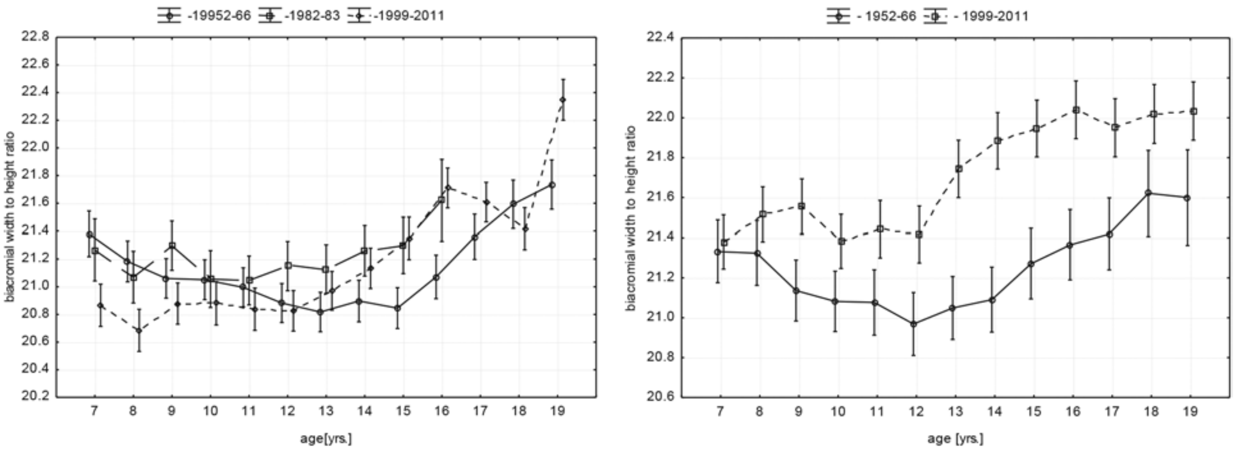

Fig. 7. Biacromial width to height ratio of boys (left) and girls (right) from both cohorts.

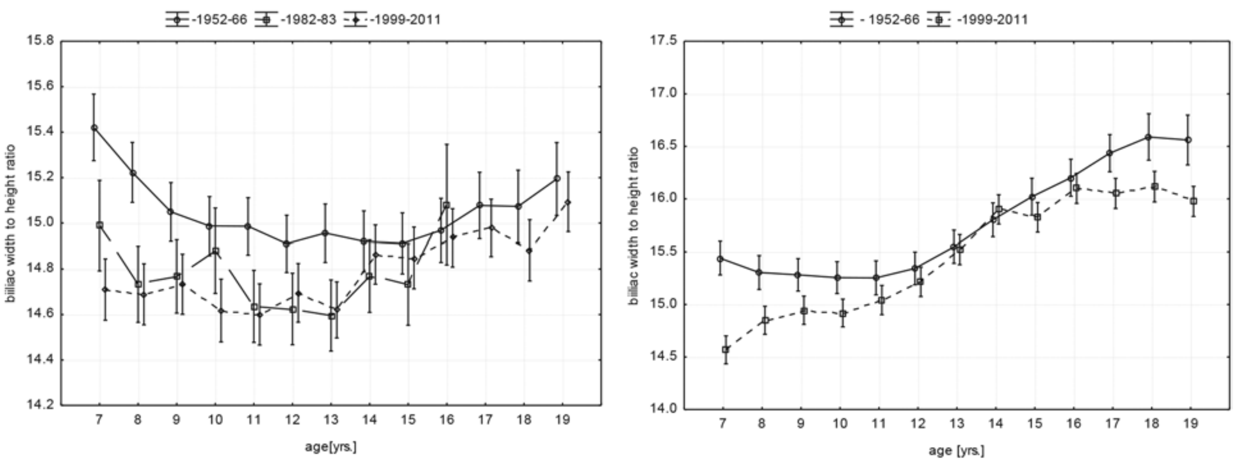

Fig. 8. Biiliac width to height ratio of boys (left) and girls (right) from both cohorts.

(p<0.001) (Table 4, Fig. 8) which suggests the occurrence of the relatively narrower pelvis in contemporary children, than those observed in the earlier study periods. In both sexes, after age-adjustment, the described differences lose statistical significance, in most age groups (Table 2, Table 3). However, in boys over 11 years of age, a positive secular trend was noticed when the data sets from the 1999–2011 and 1982–83 cohorts, were compared (Table 2). This suggests that the contemporary adolescent boys had a proportionately wider pelvis than their peers from the earlier study.

It is to be especially noted from the three series of data on boys that the magnitude of secular changes depends on the time interval between the comparing study periods., i.e. the longer the time interval, the greater will be the secular change as observed by comparing the study periods namely, 1955–66 to 1982–83, 1982–83 to 1999–2011 and finally 1952 to 1999–2011.

Discussion

Results of this study showed that in both sexes, generally, there is a positive secular trend in the length of the lower limbs. The presence of such tendency is also evident from the values of the skelic index, which were found to be the highest for the contemporary children. Similar trend regarding the leg length was found in the earlier analysis of the Indian children and adolescents (Das et al. 2016). Also, as in the presented study, a positive secular trend for leg length was observed in Turkish and Mexican populations (Malina et al. 2004; Özer 2007). It seems important to mention, that said studies included cohorts from the years 1939–2006 for the Turkish and 1968–2000 for the Mexican population. This means, that they partly overlapped with the time when the research presented in this study was performed. This, in turn, suggests, that the secular increase in lower limb length may have occurred in different countries at the similar time. According to the literature, such phenomenon is observed mainly in the highly industrialized countries, because more favourable developmental conditions can lead to a relatively faster growth of this segment of the body (Bogin & Varela-Silva 2010; Cole 2003; Dangour et al. 2002; Tanner et al. 1982). Therefore, the noted positive secular changes may be related to the dynamic socio-economic development occurring presently in India (International Statistical Institute 2017). The sensitivity of the leg length to such environmental factors was also confirmed by the study performed on the Polish population. The children and adolescents whose development occurred at the time of the economic crisis in this country turned out to have shorter lower limbs than their peers from previous years, growing up in more stable economic conditions (Woronkowicz et al. 2016).

Our results have also shown, in both sexes, a positive secular trend regarding the shoulder width and the shoulder width to body height index. However, the second one is present only between the cohorts from 1952–66 and 1999–2011. When the 1999–2011 and 1982–83 groups were compared, the boys from the preceding series turned out to have relatively wider shoulders than their contemporary peers. This suggests that boys from 1999–2011 had relatively more feminine body proportions in comparison to the boys studied between the years 1982–83. Similar trends have also been observed among the children and adolescents from Poland, where the studied cohorts were examined in the years partly overlapping with those analysed in the present study (Woronkowicz et al. 2016).

Positive intergenerational changes were also observed for the pelvic width in a majority of the age groups of both sexes. Woronkowicz et al. (2016), as well as Bigec (2013), have obtained the same results in the Polish and Slovenian populations, in the time spans overlapping those analysed in the present study. Interestingly, in the presented study, the pelvic-height ratio manifested a negative secular trend. This, occurring at the same time as the positive one regarding the absolute pelvis width may be due to the relatively higher body height observed previously in the series from the years 1999–2011 (Das et al. 2016). Likewise, the German population manifested negative secular trend for relative pelvis width. Although in this research, unlike in our study, the said trend occurred in connection with the negative intergenerational change in the absolute value of pelvis width (Scheffler & Hermanussen 2014). These phenomena were then attributed by the authors to the increase in the sedentary behaviour of the German population.

The pelvi-acromial index, have manifested a negative trend between the study periods of 1952–66 to 1999–2011. From this, it becomes evident that the contemporary children and adolescents have proportionately wider shoulders in relation to the pelvis than their peers studied about six decades ago. It also suggests that the noted positive secular trend regarding the biacromial width was more pronounced than the one observed for the biiliac width. Interestingly, in the present study also a positive intergenerational change of this index was observed when the 1999–2011 and 1982–83 male cohorts were compared. The similar increase in the relative pelvis width was also noted in the Polish study (Woronkowicz et al. 2016).

The reciprocal ponderal index has manifested a negative secular trend in both sexes, suggesting that contemporary boys and girls are characterized by a more stout body build than their peers from earlier study period. The opposite tendency was noted for the preschool children and the oldest girls in Polish population – they were characterized by a more slender physique than their peers from previous years. In the same study, however, in the older male groups, the negative secular trend regarding reciprocal ponderal index was observed (Woronkowicz et al. 2016). Our findings are consistent with the results obtained in an earlier study reported on Bengali population (Das et al. 2016). The recorded trend is particularly important because this index is related to the level of physical fitness of children and adolescents. Children with relatively higher values of this indicator tend to be characterized by greater overall physical fitness than their peers with a more stout physique (Bustamante Valdivia et al. 2015; Kryst et al. 2016; Malina & Katzmarzyk 2006; Silva et al. 2016).

As it was recently suggested, the secular trend regarding body height of Indian population is not correlated with socio-economic conditions, measured by the nutritional status or monthly family expenditure (Scheffler et al. 2018). However, the intergenerational changes as observed in this study, regarding different body proportions can be attributed to the current dynamic social and economic development of India. Such process involves, among others, progress in the fields of public health, hygiene and health care. In India, advancement in these areas can be illustrated for example, by a significant drop in neonatal mortality rate, observed between the years in with the analysed cohorts were examined (The World Bank 2017b). Additionally, the under-five mortality rate decreased from 126 in the year 1990 to 53 in 2013. Similarly, at the same time, there was s decrease in maternal mortality ratio from 560 to 190, per 100000 live births (WHO 2015). In addition, there were as much as 26 years of increase in the life expectancy between the years 1960 and 2011, which also indicates an improvement of the quality of healthcare in the country (The World Bank 2017a). As mentioned before, these phenomena might have influenced the changes in body proportions of children in subsequent generations. Research proves that progress in the field of medicine can be one of the reasons for obtaining positive secular trends in human growth and maturation (Beunen et al. 2006; Blanksby 1995; Malina 1978; Malina 2004). Another factor, associated with the socioeconomic progress of the country, is the increasing educational status of the population (Bhattacharya et al. 2016; Office of the Registrar General & Census Commissioner 2011). The educational status of parents has been correlated, for example, with the length of the children's lower limbs, often greater in boys and girls representing families with a higher level of education (Sohn 2015). The financial status of the family is also an important socioeconomic modificator of development. In the time interval, between two study periods (1952–1966 to 1999–2011) there was a significant rise in the average income and expenditure level of Indian families as well as increase in absolute average earnings in relation to the changing price index (Das et al. 2016; Ministry of Statistics and Programme Implementation 2014). In addition, the poverty index has also decreased (The World Bank 2017c). Published literature confirms the correlation of income in a given family, with the status of somatic development of the children (Marques-Vidal et al. 2008; Norgan 1995; Welch et al. 2009). Similar results are observed in many populations, as well as in an earlier study performed in Calcutta, India (Dasgupta et al. 2008; Mungreiphy & Kapoor 2010). Additionally, the average income has been found to be positively correlated with the rising subischial leg length of the Bengali children (Das et al. 2016).

Unfortunately, the improvement of socio-economic conditions is related also to the lifestyle changes, that are not always positive. They include, for example, choices regarding diet and leisure time activities. According to published literature, more than 36% of Indian teenagers eat junk food more than 3 times a week (Hajare et al. 2016). Moreover, nearly 16% of 10–15-year-olds declared that they were not engaging in any form of physical activity, and almost 65% of them spend their time in this way for less than 4 hours a week. Almost half of the Indian teenagers spend over 7 hours a week watching TV (Hussain et al. 2016). It is widely known, that the sedentary lifestyle results in increased risk of overweight and obesity, but it is important to stress, that it can also negatively affect the bone frame (Rietsch et al. 2013). Also, according to research, the positive secular trend regarding total body adiposity can be present, even if the mean BMI in the population is still within the healthy range. it can happen, because of the general feminisation of the body fat distribution, which is currently observed for example in the German population (Scheffler & Dammhahn 2017). Additionally, India currently has the highest percentage of adolescents suffering from overweight among the Central Asian countries (Jayawardena et al. 2017). Described phenomena, may, for example, be some of the reasons for the observed negative secular trend in the reciprocal ponderal index.

All results presented in this study on selected body proportions constitute a very important source of information on the studied population. They obviously help to examine the development status of the contemporary children and youth, as well as to compare it with the earlier generations, in the context of the socio-economic conditions prevailing at a given time. However, what is particularly important is to identify the possible risk factors related to specific proportions of the body. For example, the low value of the lower limbs length is generally associated with an increased risk of chronic diseases such as hypertension, diabetes, obesity, liver or cardiovascular diseases (Kozieł et al. 2016). Similarly, the increasing stoutness of body, especially associated with its fatness also raises, even at an early age, the risk of gallbladder dysfunction, hypertension, bones and joints inflammation, or dyslipidemia (Sharma et al. 2007).

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Declaration of interests

The authors declare that they have no conflict of interests.

References

Arora, M., Shinde, S. & Patwardhan, R. (2017): Prevalence of Overweight or Obesity in Adolescent School Children from Pune, India. – Imp. J. Interdiscip. Res. 3 (3): 1272–1276.

Beunen, G.P., Rogol, A.D. & Malina, R.M. (2006): Indicators of Biological Maturation and Secular Changes in Biological Maturation. – Food Nutr. Bull. 27 (4_suppl 5): S244–S256.

Bhattacharya, S., Kumar Tiwari, S.K., Gautam, V., Das, C. & Dey, J. (2016): Educational Statistics at a Glance. – New Delhi.

Bielicki, T., Szklarska, A., Koziel, S. & Ulijaszek, S.J. (2005): Changing patterns of social variation in stature in Poland: effects of transition from a command economy to the free-market system? – J. Biosoc. Sci. 37 (4): 427–434.

Bigec, M. (2013): Generational changes in the growth of children from Maribor and Slovenia. – Coll. Antropol. 37 (Suppl. 2): 197–209.

Blanksby, B.A. (1995): Secular changes in the stature and mass of Western Australian secondary school children. – Am. J. Hum. Biol. 7 (4): 497–505.

Bogin, B. & Varela-Silva, M.I. (2010): Leg Length, Body Proportion, and Health: A Review with a Note on Beauty. – Int. J. Environ. Res. Public Health 7 (3): 1047–1075.

Bustamante Valdivia, A., Maia, J. & Nevill, A. (2015): Identifying the ideal body size and shape characteristics associated with children's physical performance tests in Peru. – Scand. J. Med. Sci. Sports 25 (2): e155–e165.

Cole, T.J. (2003): The secular trend in human physical growth: a biological view. – Econ. Hum. Biol. 1 (2): 161–168.

Dangour, A.D., Schilg, S., Hulse, J.A. & Cole, T.J. (2002): Sitting height and subischial leg length centile curves for boys and girls from Southeast England. – Ann. Hum. Biol. 29 (3): 290–305.

Das, R., Das, S., Datta Banik, S., Saha, R., Chakraborty, A. & Dasgupta, P. (2016): Secular trends in physical growth and maturation in 7 to 21 year-old Bengali boys and girls from Kolkata, India, over six decades of time interval. – Int. J. Anthropol. 31 (3–4): 185–226.

Das, S., Mukherjee, D., Bose, L. & Das, A. (1986): Mixed-longitudinal growth data for 22 measures: The Sarsuna-Barisha series. Girls. – Anthropological Survey of India, Goverment of India, II. Calcutta.

Das, S.R. (1985): Mixed longitudinal growth data for 22 measures. – The Sarsuna Barisha Series, West Bengal, India, 1.

Dasgupta, P. & Das, S.R. (1997): A cross-sectional growth study of trunk and limb segments of the Bengali boys of Calcutta. – Ann. Hum. Biol. 24 (4): 363–369.

Dasgupta, P., Saha, R. & Nubé, M. (2008): Changes in body size, shape and nutritional status of Middle-Class Bengali boys of Kolkata, India, 1982–2002. – Econ. Hum. Biol. 6 (1): 75–94.

Dasgupta, P., Nube, M., Sengupta, D. & de Onis, M. (2015): Academic Report of the Project "Physical Growth, Body Composition and Nutritional Status of Bengali School aged Children, Adolescents and Young adults of Calcutta, India: Effects of Socioeconomic Factors on Secular Trends" (ID 158). – Kolkata.

Eveleth, P.B. & Tanner, J.M. (1976): Worldwide variation in human growth (8th ed.) – CUP Archive, London.

Hajare, S.T., Deoke, A.R. & Saoji, P.A. (2016): Life style profile of High School students and its association with Body Mass Index in Nagpur city, Central India. – Indian J. Community Heal. 28 (3): 248–253.

Hauspie, R.C., Das, S.R., Preece, M.A. & Tanner, J.M. (1980): A longitudinal study of the growth in height of boys and girls of West Bengal (India) aged six months to 20 years. – Ann. Hum. Biol. 7 (5): 429–440.

Hussain, M., Tenglikar, P. & Nigudgi, S. (2016): Physical activity and its association with body mass index among 10–15 years school children in Kalaburagi city, Karnataka, India. – Int. J. Community Med. Public Heal. 3 (8): 2264–2269.

International Statistical Institute (2017): Developing Countries. – https://www.isi-web.org/index.php/resources/developing-countries [Retrieved: January 1, 2018]

Jayawardena, R., Ranasinghe, P., Wijayabandara, M., Hills, A.P. & Misra, A. (2017): Nutrition Transition and Obesity Among Teenagers and Young Adults in South Asia. – Curr. Diabetes Rev. 13 (5): 444–451.

Kleanthous, K., Dermitzaki, E., Papadimitriou, D.T., Papaevangelou, V. & Papadimitriou, A. (2017): Secular changes in the final height of Greek girls are levelling off. – Acta Paediatr. 106: 341–343.

Komlos, J. & Baten, J. (2004): Looking Backward and Looking Forward: Anthropometric Research and the Development of Social Science History. – Soc. Sci. Hist. 28 (2): 191–210.

Kowal, M., Kryst, Ł., Sobiecki, J. & Woronkowicz, A. (2013): Secular trends in body composition and frequency of overweight and obesity in boys aged 3–18 from Krakow, Poland, within the last 30 years (from 1983 to 2010). – J. Biosoc. Sci. 45 (1): 111–134.

Kowal, M., Kryst, Ł., Woronkowicz, A. & Sobiecki, J. (2014): Long-term changes in body composition and prevalence of overweight and obesity in girls (aged 3–18 years) from Kraków (Poland) from 1983, 2000 and 2010. – Ann. Hum. Biol. 41 (5): 415–27.

Kozieł, S., Gomula, A. & Nowak-Szczepańska, N. (2016): The association between social factors and body length proportions in Polish schoolchildren from Lower Silesia. – Anthropol. Rev. 79 (4): 397–408.

Kryst, Ł., Kowal, M., Woronkowicz, A., Sobiecki, J. & Cichocka, B.A. (2012): Secular changes in height, body weight, body mass index and pubertal development in male children and adolescents in Krakow, Poland. – J. Biosoc. Sci. 44 (4): 495–507.

Kryst, Ł., Woronkowicz, A., Jankowicz-Szymańska, A., Pociecha, M., Kowal, M., Sobiecki, J., Brudecki, J. & Żarów, R. (2016): Physical fitness of overweight and underweight preschool children from southern Poland. – Anthropol. Anz. 73 (2): 117–124. doi: 10.1127/anthranz/2016/0561

Malina, R. (1978): Secular changes in growth, maturation, and physical performance. – Exerc. Sport Sci. Rev. 6: 203–255.

Malina, R.M. (2004): Secular trends in growth, maturation and physical performance: A review. – Anthropol. Rev. 67 (6): 3–31.

Malina, R.M., Peña Reyes, M.E., Tan, S.K., Buschang, P.H., Little, B.B. & Koziel, S. (2004): Secular change in height, sitting height and leg length in rural Oaxaca, southern Mexico: 1968–2000. – Ann. Hum. Biol. 31 (6): 615–633.

Malina, R.M. & Katzmarzyk, P.T. (2006): Physical Activity and Fitness in an International Growth Standard for Preadolescent and Adolescent Children. – Food Nutr. Bull. 27 (4_suppl 5): 295–313.

Marques-Vidal, P., Madeleine, G., Romain, S., Gabriel, A. & Bovet, P. (2008): Secular trends in height and weight among children and adolescents of the Seychelles, 1956–2006. – BMC Public Health 8 (1): 166.

Ministry of Statistics and Programme Implementation (2014): National Accounts Statistics, Statement 1.2.

Mori, H. (2016): Secular Changes in Body Height and Weight of Population in Japan since the End of WW II in Comparison with South Korea. – The Monthly Bulletin of Social Science 636: 13–25.

Mungreiphy, N.K. & Kapoor, S. (2010): Socioeconomic changes as covariates of overweight and obesity among Tangkhul Naga tribal women of Manipur, north-east India. – J. Biosoc. Sci. 42 (3): 289.

Norgan, N.G. (1995): Changes in patterns of growth and nutritional anthropometry in two rural modernizing Papua New Guinea communities. – Ann. Hum. Biol. 22 (6): 491–513.

Office of the Registrar General & Census Commissioner (2011): Census of India 2011. – http://censusindia.gov.in/ [Retrieved January 4, 2018]

Özer, B.K. (2007): Secular Changes in Height and Leg Length Among Turkish Children During The Last Century. – Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi 47 (1): 95–113.

Pakrasi, K., Dasgupta, P., Dasgupta, I. & Majumder, P.P. (1988): Growth in height, weight and skinfold thickness of Bengali boys of Calcutta, India. – Anthropol. Anz. 46 (1): 1–16.

Perkins, J.M., Supramanian, S.V., Smith, G.D. & Özaltin, E. (2016): Adult height, nutrition, and population health. – Nutr. Rev. 74: 149–165.

Relethford, J. & Lees, F. (1980): The effects of ageing and secular trend on stature in rural western Ireland. – Am. J. Phys. Anthropol. 55: 81–88.

Rietsch, K., Eccard, J.A. & Scheffler, C. (2013): Decreased external skeletal robustness due to reduced physical activity? – Am. J. Hum. Biol. 25 (3): 404–410.

Scheffler, C. & Dammhahn, M. (2017): Feminization of the fat distribution pattern of children and adolescents in a recent German population. – Am. J. Hum. Biol. 29 (5): e23017.

Scheffler, C. & Hermanussen, M. (2014): Is there an influence of modern life style on skeletal build? – Am. J. Hum. Biol. 26 (5): 590–597.

Scheffler, C., Krützfeldt, L.M., Dasgupta, P. & Hermanussen, M. (2018): No association between fat tissue and height in 5019 children and adolescents, measured between 1982 and in 2011 in Kolkata/India. – Anthropol. Anz. 74 (5): 403–411. doi: 10.1127/anthranz/2018/0827

Sharma, A., Sharma, K. & Mathur, K.P. (2007): Growth pattern and prevalence of obesity in affluent schoolchildren of Delhi. – Public Health Nutr. 10 (5): 485–491.

Silva, S., Bustamante, A., Nevill, A., Katzmarzyk, P.T., Freitas, D., Prista, A. & Maia, J. (2016): An Allometric Modelling Approach to Identify the Optimal Body Shape Associated with, and Differences between Brazilian and Peruvian Youth Motor Performance. – PLOS ONE 11 (3).

Singhal, N., Misra, A., Shah, P., Rastogi, K. & Vikram, N.K. (2010): Secular trends in obesity, regional adiposity and metabolic parameters among Asian Indian adolescents in north India: a comparative data analysis of two selective samples 5 years apart (2003, 2008). – Ann. Nutr. Metab. 56 (3): 176–181.

Sohn, K. (2015): Is leg length a biomarker of early life conditions? Evidence from a historically short population. – Am. J. Hum. Biol. 27 (4): 538–545.

Tanner, J.M. (1992): Growth as a measure of the nutritional and hygienic status of a population. – Horm. Res. 38 (Suppl. 1): 106–115.

The World Bank (2017a): Life expectancy at birth, total (years). Data. – https://data.worldbank.org/indicator/ SP.DYN.LE00.IN?end=2011&locations=IN&start=1960 [Retrieved January 6, 2018]

The World Bank (2017b): Mortality rate, infant (per 1,000 live births). Data. – https://data.worldbank.org/indicator/SP.DYN.IMRT.IN?end=2011&locations=IN&start=1960 [Retrieved January 6, 2018]

The World Bank (2017c): Poverty headcount ratio at national poverty lines (% of population). – https://data.worldbank.org/indicator/SI.POV.NAHC?locations=IN [Retrieved January 4, 2018]

Topçu, S., Şimşek Orhon, F., Ulukol, B. & Başkan, S. (2017): Secular trends in height, weight and body mass index of primary school children in Turkey between 1993 and 2016. – J. Pediatr. Endocrinol. Metab. 30 (11): 1177–1186.

Vijayakumar, P., Wheelock, K.M., Kobes, S., Nelson, R.G., Hanson, R.L., Knowler, W.C. & Sinha, M. (2018): Secular changes in physical growth and obesity among southwestern American Indian children over four decades. – Pediatr. Obes. 13 (2): 94–102.

Welch, J.R., Ferreira, A.A., Santos, R.V., Gugelmin, S.A., Werneck, G. & Coimbra, C.E.A. (2009): Nutrition Transition, Socioeconomic Differentiation, and Gender Among Adult Xavante Indians, Brazilian Amazon. – Hum. Ecol. 37 (1): 13–26.

WHO (2015): India: WHO statistical profile. – http://www.who.int/gho/countries/ind/country_profiles/en/

Woronkowicz, A., Kryst, Ł., Kowal, M., Brudecki, J. & Sobiecki, J. (2016): Long-term changes in body proportions since 1983 to 2010 in children and adolescents from Kraków (Poland). – Anthropol. Anz. 73 (2): 125–143. doi: 10.1127/anthranz/2016/0578

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