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CHANGES IN BODY BUILD OF AWF STUDENTS 1967–2008. CAN A SECULAR TREND BE OBSERVED?

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ABSTRACT
Purpose. Previous research on intergenerational changes in body build has focused on body height and mass. The aim of this study was to determine both the direction and sexual dimorphism of secular changes in body build by using a sample population of students attending the University School of Physical Education (AWF) in Wrocław, Poland. **Methods.** The anthropometric data used in this study were collected every year from 1967 to 2008 and included a sample size of 4688 males and 3922 females. The subjects were analyzed for changes in somatotype by use of Sheldon's method, as modified by Heath and Carter. Basic statistical analysis for significance and post-hoc tests were used to analyze the data with Statistica 9.0 software. The data were then converted in Excel 2003 into chart form to analyze the direction of changes. **Results.** Analysis of the successive classes of male and female subjects during the 40-year period under study revealed a number of different directional changes in the mean values of body height, mass and the level of body build components. Trend lines, calculated by the mean values of five-year intervals, indicated an increasing tendency in both body height and mass in the two genders. Mesomorphy was found to be the largest factor of body build composition of females and males. Throughout the entire analyzed period, the endomorphy of males was significantly lower in comparison to females. In women, the level of fatness was similar to their level of musculature, but during the last several years the observed level of muscle in the students exceeded their fatness level. Ectomorphy happened to be the most stable component of both sexes. **Conclusions.** Analysis on the male and female sample population revealed a constant increase in body mass and height in successive generations. In female subjects, intergenerational changes were found to be characterized by a decrease in endomorphy and an increase in ectomorphy, while the level of mesomorphy remained at a similar level. In men, a secular trend was visible with an increase in mesomorphy, while the levels of endomorphy and ectomorphy stayed constant.

Key words: somatotype, body components, body composition, body height and weight, secular trend, sexual dimorphism

Introduction

Secular changes in body height and mass, themselves important determinates of body build, have been observed in the population of Poland [1–4] and other European countries [5–9] and widely reported in research. It should be emphasized that the changes observed in successive generations featured both accelerating changes as well as drops in mean body height and mass. The most important factors related to the occurrence of these secular trends are attributed to the general progress of civilization and a rise in living standards [10], where an improvement of living conditions is related to an increase in body mass and height. In addition, research has pointed to many socioeconomic factors as also playing a role, these being: social class [11], income and education level [12], family size [13], urbanization level [14], place of residence [15] and nourishment levels, illness, birth weight, etc. Decreases in mean body mass and height are frequently related to a population's deterioration of living conditions, undernourishment and various forms of stress.

The majority of research conducted on intergenerational changes in body build focused on examining body height and mass. A large amount of research data published by, e.g., Proos [16], Loesch et al. [17], Fredriks et al. [18], was taken from health examinations conducted on recruits or children. There are few studies that have been conducted on adult subjects, especially women, and even less have tackled the problem of intergenerational changes in body structure and the mutual proportion of individual body build components. Hence, the question arises: is such an intergenerational trend also related to somatotype?

The aim of this study was to determine the intergenerational changes in body build of adult students attending the University School of Physical Education (AWF) in the city of Wrocław, Poland. Sheldon's method, as modified by Carter and Heath [19], was applied in order to assess body build composition. Analysis was focused on the directions of changes of individual body build components and the sexual dimorphism of these changes.

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Material and methods

The data used in this study were taken from the anthropometric measurement of 4688 male and 3922 female AWF students, collected annually from 1967 to 2008 always in the same season – autumn. The disproportional number of males compared to females, as well as the rather diversified number of individuals in each student year, reflects the demographical structure of the school and students over the past forty years. Cross-sectional study allowed for the selection of subjects who were at least 19 when anthropometric measurements were taken (it was assumed that at that point in time their growth had stopped). The body measurement results were then used to calculate the somatotype components (characterized as the level of endomorphy, mesomorphy or ectomorphy) as per Sheldon's method, modified by Carter and Heath [19]. Endomorphy, as the somatotype component connected with fatness, was based on skinfold thickness measurements (at the subscapular, abdominal and arm sites). The level of mesomorphy, which reflects musculature, was based on the circumference of the arm and calf, as well as elbow and knee breadth. In both cases, in order to assess the final results, it was necessary to consider the subject's body height. Ectomorphy, which reflects body leanness, was assessed on the basis of body height and mass.

Although the individuals in charge of taking measurements changed over the forty-year period, all anthropological measurements were always taken by physical anthropologists experienced in anthropometry. During the whole period under study, the same type of equipment was used (GPM Anthropological Instruments, Siber Hegner Machinery, Switzerland) with the instruments regularly calibrated. Body height was measured with the use of a Martin-type anthropometer, while body mass with an electronic weight scale (accurate to 0.1 kg). The breadth of the humerus and femur were measured with the use of sliding caliper (accurate to 1 mm). A Holtain skinfold caliper was used to assess skin thickness (accurate to 0.2 mm). The girth of the arm and calf was measured with the use of anthropometric tape (accurate to 1 mm).

Analysis of mean body height and mass values and the mean levels of body build components were calculated at one- and five-year intervals. The study subjects were divided into five-year groups (related to the five subsequent years of research) as such a division better presented intergenerational changes. The mean age of the subsequent groups varied between 19.5–23.9 years. The raw data was then organized into chart form by use of Microsoft Office's Excel 2003, which presented the direction of changes in the mean values of body height, body mass and the three somatotype components.

Basic statistical analysis was performed using Statistica 9.0 software, with the data tested for significant differences (Student's *t*-test, ANOVA) as well as with Scheffe's post-hoc test. Changes in somatotypes were estimated by the use of Somatotype Analysis of Variance test (SANOVA) [19]. The significance level was set at $p \leq 0.05$.

Results

Analysis of the successive student years of males and females during the 40-year period revealed numerous changes in the mean values of body height and mass (Tab. 1, 2). The observed changes occurred in different directions. Trend lines, determined by the mean values of the five-year periods, indicated an increasing tendency for both genders in both body height (Fig. 1, 2) and body mass (Fig. 3, 4).

The mean body height of female students in the 1970s did not exceed 164 cm. In the 1980s, these values varied between 163–167 cm, while in the 1990s the mean value was approx. 166 cm (Tab. 1). The differences in the mean values between some years reached 3 or 4 cm. Men were characterized with a higher body height than women. The height of male subjects in the 1960s and 1970s was 173–174 cm, in the 1970s and 1980s 176–177 cm, in the 1990s between 178–179 cm, and after the year 2000 average body height exceeded 180 cm (Tab. 2). Analysis of the mean values did not reveal any significant differences in classes of around the same timeframe, however, students separated by larger time intervals did show significant differences (Tab. 3, 4). In addition, the variability of the subsequent groups of women seemed to decrease. The mean values of body height reported in the latter (more recent) years were found to be not statistically significant (Tab. 3).

The lowest mean body mass values of women during the analyzed period were observed between the 1960s and 1970s (approx. 55 kg). After the 1990s, the mean values of body mass in female subjects were approx. 60 kg (Tab. 1). The trend line based on the mean values of the five-year intervals revealed a constant but slight increase in female body mass in the successive groups (Fig. 3). The body mass of male subjects was higher by approximately a few kilograms. At the end of the 1960s and in the 1970s, body mass ranged between 66–70 kg. In the 1980s, mean body mass values did not exceed 72 kg, while in the 1990s they were in the range of 72–74 kg. After the year 2000, the mean body mass of men ranged between 75–77 kg (Tab. 2). The diversity of mean body mass values observed between male and female students during the successive years was similar to what was reported in body height. Similarly, students who studied during the same period did not reveal any significant differences in reference to body mass while those separated by larger time intervals did show significant differences. However, the

Table 1. Basic statistical data of the analyzed parameters for the female students in the years under study

Year	*N*	Mean age	Body height (cm)		Body weight (kg)		Endomorphy		Mesomorphy		Ectomorphy	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1967	40	19.7	162.8	4.60	57.3	5.71	4.4	1.10	3.6	0.89	2.4	0.99
1968	51	19.6	160.2	5.03	53.8	6.77	4.0	1.21	3.9	0.93	2.6	1.00
1969	54	19.7	161.7	4.96	54.7	6.04	4.0	0.91	3.8	0.92	2.7	0.99
1970	78	19.8	162.7	5.38	55.3	7.20	2.9	0.78	3.8	0.92	2.8	0.97
1971	46	19.6	161.0	5.46	54.1	5.09	4.0	0.87	3.8	0.84	2.7	0.93
1972	73	19.6	161.6	6.67	55.5	7.05	3.7	0.84	3.7	0.88	2.5	0.95
1973	131	19.6	162.4	5.36	55.9	7.04	2.9	0.91	3.8	0.81	2.6	0.89
1974	157	19.8	163.9	6.00	56.3	6.57	4.1	1.14	3.9	0.99	2.8	1.01
1975	103	19.8	164.0	5.80	56.3	6.38	3.5	0.86	3.8	0.98	2.8	0.95
1976	128	19.8	163.0	5.91	56.2	7.56	4.0	1.08	3.6	0.96	2.7	1.09
1977	40	19.7	163.1	5.75	54.6	6.05	3.2	0.78	3.6	0.89	2.9	0.89
1978	110	19.7	164.3	5.79	56.0	6.11	3.9	0.90	3.8	1.05	2.9	1.09
1979	132	19.6	165.2	5.95	57.0	6.95	3.3	0.82	3.7	1.01	2.9	0.99
1980	115	19.7	164.8	5.48	57.8	6.20	3.4	0.69	4.0	0.91	2.7	0.93
1981	127	19.7	165.7	5.14	57.9	6.16	2.6	0.95	3.8	0.96	2.8	0.91
1982	47	19.8	163.6	4.42	56.7	5.50	3.8	0.91	3.9	1.01	2.7	1.00
1983	126	19.6	164.2	6.23	55.7	6.50	3.8	0.93	3.9	0.91	3.0	0.96
1984	148	19.8	164.1	5.57	59.2	6.46	4.3	0.88	4.4	1.05	2.3	1.02
1985	72	20.3	165.0	6.90	56.3	6.89	3.3	0.98	3.9	1.07	3.0	1.17
1986	132	19.7	165.0	6.42	56.5	7.06	3.4	0.81	3.3	1.08	3.0	0.89
1988	154	19.6	165.4	5.89	56.7	6.91	3.7	0.84	3.3	0.86	3.0	0.97
1989	154	19.7	165.5	5.53	57.9	6.71	4.1	1.11	3.4	0.96	2.8	1.05
1990	133	19.7	165.3	5.81	57.2	7.17	3.4	0.81	3.4	1.03	2.9	1.16
1991	29	23.9	164.3	4.15	56.4	4.89	2.9	0.83	4.0	1.00	2.9	1.16
1992	61	21.4	166.3	6.31	59.7	6.54	3.1	0.72	4.0	0.97	2.6	0.91
1993	39	20.3	166.6	6.80	60.2	7.94	3.9	0.82	3.9	1.16	2.9	0.98
1994	52	21.8	166.3	5.61	58.2	6.12	2.2	0.76	4.0	1.07	2.9	1.02
1995	96	20.9	166.2	6.01	57.6	10.85	2.8	0.88	3.9	1.10	2.8	1.02
1996	103	20.7	167.2	5.66	59.7	6.62	3.2	0.83	3.7	1.02	2.8	1.00
1997	79	20.6	165.5	5.86	59.7	7.64	3.4	0.88	3.8	0.97	2.5	1.00
1998	55	20.4	164.3	4.84	57.7	7.43	2.8	0.82	3.7	1.12	2.7	1.12
1999	55	20.5	166.4	5.55	58.9	7.06	3.0	0.74	3.9	0.97	2.8	1.01
2000	69	20.5	167.3	6.10	59.5	7.74	3.1	0.90	3.4	1.09	2.9	1.09
2001	57	20.5	167.5	5.98	59.8	7.77	3.1	0.99	3.6	0.96	2.9	1.04
2002	91	20.2	165.9	5.65	59.4	7.44	3.8	1.14	3.8	0.98	2.6	1.06
2003	78	20.4	166.2	6.20	57.5	5.43	3.3	0.91	3.2	1.01	3.0	1.03
2004	157	20.1	166.8	6.75	58.6	7.26	3.3	0.97	3.9	1.00	2.9	0.96
2005	134	20.1	168.2	6.56	60.0	7.39	3.4	1.09	3.8	1.05	2.9	0.98
2006	167	20.1	166.7	5.80	58.3	7.18	3.4	1.14	3.9	1.05	3.0	1.00
2007	96	19.7	169.1	7.21	60.7	7.56	3.6	1.06	3.9	1.14	3.0	1.13
2008	153	19.7	167.6	6.86	59.3	7.71	3.2	0.93	3.8	1.09	3.0	1.12

Table 2. Basic statistical data of the analyzed parameters for the male students in the years under study

Year	*N*	Mean age	Body height (cm)		Body weight (kg)		Endomorphy		Mesomorphy		Ectomorphy	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1967	65	20.6	174.1	5.77	67.3	6.60	2.8	0.80	4.6	1.02	2.8	0.86
1968	66	20.9	173.6	5.23	68.0	6.30	2.6	0.78	4.8	0.94	2.6	0.88
1969	61	20.8	173.3	5.89	67.5	7.06	2.6	0.77	4.6	1.00	2.6	0.88
1970	90	20.9	174.0	6.59	69.6	7.29	2.4	0.63	5.0	0.89	2.4	0.79
1971	46	20.8	172.6	5.83	66.2	7.16	2.8	0.77	4.6	1.05	2.7	0.98
1972	57	20.7	173.9	5.85	67.8	8.33	2.7	0.70	4.4	0.99	2.7	1.06
1973	183	20.7	174.3	5.97	67.6	7.12	2.2	0.84	4.9	0.99	2.8	1.00
1974	110	20.7	175.0	6.85	69.3	7.94	2.9	0.96	5.2	1.10	2.7	0.91
1975	146	20.8	176.4	6.14	70.3	7.13	2.6	0.75	4.8	0.99	2.8	0.94
1976	146	20.8	176.1	6.51	69.8	8.23	2.9	0.92	4.6	1.01	2.8	0.98
1977	64	20.8	176.4	7.55	69.7	7.47	2.0	0.49	4.6	1.05	2.9	1.20
1978	122	20.8	175.8	6.14	68.8	8.45	2.7	0.83	4.7	1.04	2.9	0.93
1979	139	20.8	177.0	6.85	70.3	7.98	2.4	0.78	4.8	1.16	2.9	1.03
1980	105	20.8	177.0	5.68	70.8	7.86	2.3	0.66	4.9	0.98	2.8	1.05
1981	134	20.7	177.0	6.05	70.3	7.48	2.0	0.60	4.7	1.01	2.9	0.92
1982	78	20.8	176.5	5.80	69.9	7.31	2.6	0.81	4.6	0.94	2.8	0.88
1983	166	20.7	177.2	5.88	70.2	7.06	2.8	0.90	4.7	1.13	2.9	1.03
1984	186	20.7	177.0	6.51	72.5	7.99	3.0	0.79	5.0	1.08	2.6	0.96
1985	129	21.3	177.4	6.41	70.5	7.41	2.3	0.81	4.8	0.94	2.9	0.97
1986	140	21.3	176.9	6.71	71.2	7.61	2.2	0.71	4.3	1.11	2.7	0.83
1987	133	19.5	177.3	6.82	69.3	8.00	2.3	0.67	4.5	0.93	3.1	0.93
1988	157	20.7	178.1	6.48	70.2	7.71	2.3	0.86	4.5	0.97	3.0	1.01
1989	179	20.8	177.9	6.31	72.3	8.36	2.7	0.88	4.6	1.12	2.7	1.01
1990	157	20.8	178.9	6.43	72.6	8.92	2.4	0.70	4.6	1.12	2.9	1.12
1991	56	23.5	178.4	5.66	74.1	8.96	2.4	0.84	4.9	1.11	2.6	0.97
1992	72	21.6	179.0	6.50	74.0	7.94	2.2	0.72	4.9	1.04	2.7	0.86
1993	99	21.5	179.1	6.71	74.0	8.15	2.3	0.68	5.2	1.05	2.7	0.94
1994	58	22.2	177.8	7.24	72.9	7.34	2.3	0.77	5.1	0.91	2.5	0.79
1995	78	21.6	179.9	7.77	73.6	7.91	2.3	0.79	5.1	1.24	2.7	1.19
1996	56	20.8	178.8	6.33	73.8	8.03	2.6	0.89	4.9	1.07	2.6	0.88
1997	56	20.7	177.0	5.46	72.1	6.41	2.2	0.61	5.0	1.01	2.6	0.93
1998	84	21.2	181.3	6.53	76.3	9.96	2.3	0.81	4.7	1.14	2.8	1.02
1999	99	21.1	179.2	6.97	76.3	11.25	2.4	1.02	5.2	1.12	2.4	0.94
2000	123	21.1	179.1	7.23	77.1	9.26	2.6	1.08	5.0	1.07	2.3	0.96
2001	121	21.3	179.9	6.86	75.7	10.70	2.4	1.06	5.0	1.25	2.6	1.07
2002	124	21.1	180.8	5.62	76.0	8.52	2.7	1.08	4.8	1.13	2.7	0.91
2003	197	21.3	180.2	6.06	75.4	8.02	2.6	0.90	4.2	1.15	2.7	1.00
2004	181	20.9	179.1	7.54	75.0	10.21	2.4	0.99	5.2	1.30	2.5	1.05
2005	143	20.8	179.9	6.97	75.2	8.72	2.6	1.02	4.9	1.20	2.7	1.06
2006	116	20.7	180.6	6.61	75.3	8.58	2.9	1.11	5.0	1.20	2.8	1.06
2007	70	20.8	180.4	6.91	76.0	10.40	2.6	1.00	5.2	1.23	2.7	1.14
2008	96	20.6	180.5	6.57	75.6	8.36	2.3	0.74	5.0	1.06	2.7	0.93

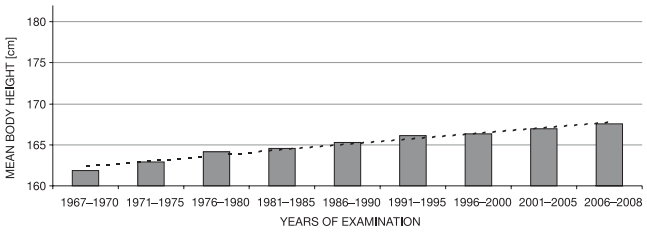

Figure 1. Mean body height for female students in five-year periods with a trend line

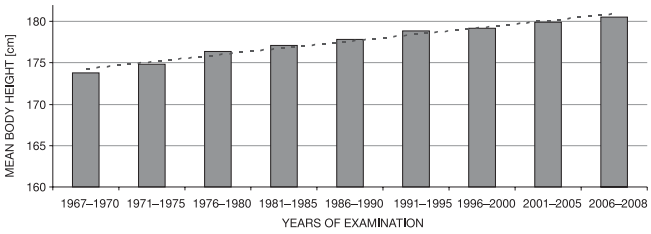

Figure 2. Mean body height for male students in five-year periods with a trend line

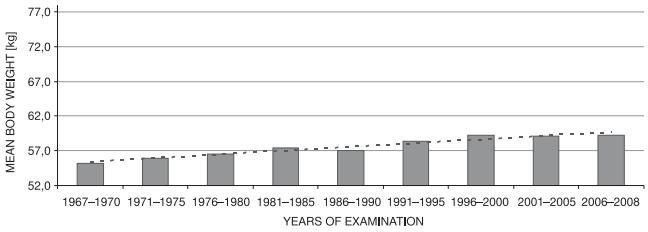

Figure 3. Mean body weight of female students in five-year periods with a trend line

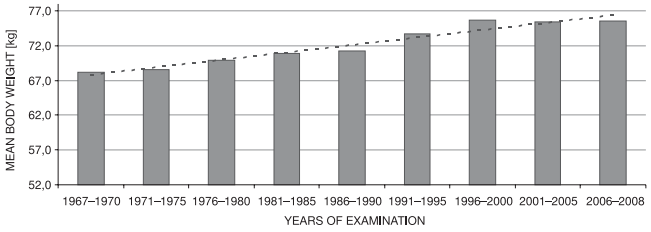

Figure 4. Mean body weight of male students in five-year periods with a trend line

Table 3. Results of post-hoc testing for the mean height of female students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

		Years of examination								
		1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
Years of examination	1967 – 1970		0.7813	**0.0027**	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1971 – 1975	0.7813		0.1648	**0.0114**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1976 – 1980	**0.0027**	0.1648		0.9977	0.3164	**0.0189**	**0.0011**	**0.0000**	**0.0000**
	1981 – 1985	**0.0001**	**0.0114**	0.9977		0.8627	0.1677	**0.0288**	**0.0000**	**0.0000**
	1986 – 1990	**0.0000**	**0.0000**	0.3164	0.8627		0.9111	0.6556	**0.0067**	**0.0000**
	1991 – 1995	**0.0000**	**0.0000**	**0.0189**	0.1677	0.9111		1.0000	0.8729	0.2639
	1996 – 2000	**0.0000**	**0.0000**	**0.0011**	**0.0288**	0.6556	1.0000		0.9435	0.3432
	2001 – 2005	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0067**	0.8729	0.9435		0.9702
	2006 – 2008	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.2639	0.3432	0.9702	

Table 4. Results of post-hoc testing for the mean height of male students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

		Years of examination								
		1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
Years of examination	1967 – 1970		0.7746	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1971 – 1975	0.7746		**0.0279**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1976 – 1980	**0.0001**	**0.0279**		0.9303	**0.0481**	**0.0001**	**0.0000**	**0.0000**	**0.0000**
	1981 – 1985	**0.0000**	**0.0000**	0.9303		0.7371	**0.0149**	**0.0004**	**0.0000**	**0.0000**
	1986 – 1990	**0.0000**	**0.0000**	**0.0481**	0.7371		0.5857	0.1398	**0.0000**	**0.0000**
	1991 – 1995	**0.0000**	**0.0000**	**0.0001**	**0.0149**	0.5857		0.9999	0.6219	0.2937
	1996 – 2000	**0.0000**	**0.0000**	**0.0000**	**0.0004**	0.1398	0.9999		0.9199	0.5938
	2001 – 2005	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.6219	0.9199		0.9916
	2006 – 2008	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.2937	0.5938	0.9916	

Table 5. Results of post-hoc testing for the mean body mass of female students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

		Years of examination								
		1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
Years of examination	1967 – 1970		0.9898	0.6191	0.0514	0.1538	**0.0011**	**0.0000**	**0.0000**	**0.0000**
	1971 – 1975	0.9898		0.9656	0.1755	0.4574	**0.0039**	**0.0000**	**0.0000**	**0.0000**
	1976 – 1980	0.6191	0.9656		0.9038	0.9933	0.1465	**0.0002**	**0.0001**	**0.0001**
	1981 – 1985	0.0514	0.1755	0.9038		0.9999	0.8801	0.0673	0.0621	**0.0428**
	1986 – 1990	0.1538	0.4574	0.9933	0.9999		0.5998	**0.0090**	**0.0060**	**0.0043**
	1991 – 1995	**0.0011**	**0.0039**	0.1465	0.8801	0.5998		0.9746	0.9899	0.9676
	1996 – 2000	**0.0000**	**0.0000**	**0.0002**	0.0673	**0.0090**	0.9746		1.0000	1.0000
	2001 – 2005	**0.0000**	**0.0000**	**0.0001**	0.0621	**0.0060**	0.9899	1.0000		1.0000
	2006 – 2008	**0.0000**	**0.0000**	**0.0001**	**0.0428**	**0.0043**	0.9676	1.0000	1.0000	

Table 6. Results of post-hoc testing for the mean body mass of male students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

		Years of examination								
		1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
Years of examination	1967 – 1970		1.0000	0.4827	**0.0099**	**0.0008**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1971 – 1975	1.0000		0.5573	**0.0036**	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1976 – 1980	0.4827	0.5573		0.8220	0.3753	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	1981 – 1985	**0.0099**	**0.0036**	0.8220		0.9995	**0.0003**	**0.0000**	**0.0000**	**0.0000**
	1986 – 1990	**0.0008**	**0.0001**	0.3753	0.9995		**0.0031**	**0.0000**	**0.0000**	**0.0000**
	1991 – 1995	**0.0000**	**0.0000**	**0.0000**	**0.0003**	**0.0031**		0.2849	0.2921	0.4742
	1996 – 2000	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.2849		1.0000	1.0000
	2001 – 2005	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.2921	1.0000		1.0000
	2006 – 2008	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.4742	1.0000	1.0000	

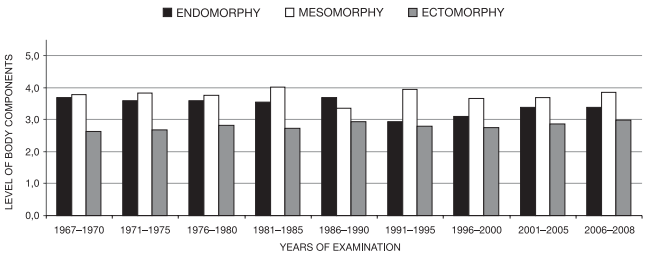

Figure 5. Mean level of somatotype components of females from AWF Wrocław

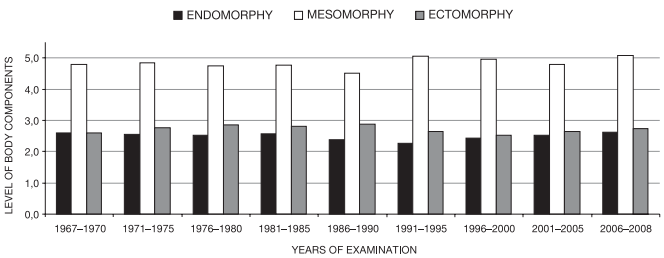

Figure 6. Mean level of somatotype components of males from AWF Wrocław

differences reported in male and female subjects in the latter years were less discernible (Tab. 5, 6). In addition, it should be emphasized that the tendency of increased body mass was also probably affected by the increase in body height.

Analysis on the successive classes of male and female subjects during the 40-year period revealed many changes in the body build characteristics (endomorphy, mesomorphy and ectomorphy) (Tab. 1, 2), with the observed changes occurring in different directions.

Analysis of the five-year periods revealed mesomorphy, which describes body musculature and skeletal size, to have had the greatest effect on body build composition in females (Fig. 5) as well as in males (Fig. 6). The level of endomorphy (fatness) in female students was mostly similar to the level of musculature until the end of the 1970s, but in separate student year classes, body fatness was greater than musculature (Tab. 1). The mean level of mesomorphy in women ranged between 3.2–4.4, while the mean level of endomorphy was 2.2–4.4. After the 1980s, the observed level of musculature of the AWF students exceeded their fatness level (Fig. 5). The distortion between these parameters could be most observed in the second half of the 1980s. At that time, the level of musculature was the lowest for the whole analyzed period.

Table 7. Results of post-hoc testing for the mean endomorphy values of female students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

Years of examination	Years of examination								
	1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
1967–1970		0.9964	0.9906	0.9218	1.0000	**0.0000**	**0.0000**	0.0516	0.1013
1971–1975	0.9964		1.0000	0.9994	0.9864	**0.0000**	**0.0000**	0.1091	0.2318
1976–1980	0.9906	1.0000		0.9999	0.9644	**0.0000**	**0.0000**	0.1589	0.3082
1981–1985	0.9218	0.9994	0.9999		0.7545	**0.0000**	**0.0000**	0.4687	0.6561
1986–1990	1.0000	0.9864	0.9644	0.7545		**0.0000**	**0.0000**	**0.0012**	**0.0070**
1991–1995	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**		0.8185	**0.0000**	**0.0001**
1996–2000	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	0.8185		0.0558	0.0585
2001–2005	0.0516	0.1091	0.1589	0.4687	**0.0012**	**0.0000**	0.0558		1.0000
2006–2008	0.1013	0.2318	0.3082	0.6561	**0.0070**	**0.0001**	0.0585	1.0000	

Table 8. Results of post-hoc testing for the mean mesomorphy values of female students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

Years of examination	Years of examination								
	1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
1967–1970		0.9998	1.0000	0.3251	**0.0003**	0.8813	0.9949	0.9984	0.9983
1971–1975	0.9998		0.9891	0.3769	**0.0000**	0.9700	0.7190	0.7590	1.0000
1976–1980	1.0000	0.9891		**0.0203**	**0.0000**	0.5541	0.9954	0.9988	0.9633
1981–1985	0.3251	0.3769	**0.0203**		**0.0000**	0.9989	**0.0016**	**0.0008**	0.6520
1986–1990	**0.0003**	**0.0000**	**0.0000**	**0.0000**		**0.0000**	**0.0030**	**0.0001**	**0.0000**
1991–1995	0.8813	0.9700	0.5541	0.9989	**0.0000**		0.1681	0.1741	0.9945
1996–2000	0.9949	0.7190	0.9954	**0.0016**	**0.0030**	0.1681		1.0000	0.6067
2001–2005	0.9984	0.7590	0.9988	**0.0008**	**0.0001**	0.1741	1.0000		0.6448
2006–2008	0.9983	1.0000	0.9633	0.6520	**0.0000**	0.9945	0.6067	0.6448	

Table 9. Results of post-hoc testing for the mean ectomorphy values of female students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

Years of examination	Years of examination								
	1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
1967–1970		0.9999	0.7768	0.9943	0.1141	0.9156	0.9927	0.3668	**0.0378**
1971–1975	0.9999		0.8648	0.9999	0.0707	0.9746	0.9998	0.3681	**0.0188**
1976–1980	0.7768	0.8648		0.9887	0.9191	1.0000	0.9977	0.9984	0.6521
1981–1985	0.9943	0.9999	0.9887		0.2814	0.9991	1.0000	0.7333	0.0984
1986–1990	0.1141	0.0707	0.9191	0.2814		0.9496	0.5211	0.9997	0.9997
1991–1995	0.9156	0.9746	1.0000	0.9991	0.9496		0.9998	0.9984	0.7616
1996–2000	0.9927	0.9998	0.9977	1.0000	0.5211	0.9998		0.8818	0.2425
2001–2005	0.3668	0.3681	0.9984	0.7333	0.9997	0.9984	0.8818		0.9718
2006–2008	**0.0378**	**0.0188**	0.6521	0.0984	0.9997	0.7616	0.2425	0.9718	

Ectomorphy happened to be the most stable somatotype component in women. The mean values of the successive student years ranged between 2.4–3.0 (Tab. 1). These results indicate a greater tendency of the subjects towards stockier and stronger body builds which was caused by considerably higher levels of musculature and fatness.

In comparison to other groups, analysis between the female groups over the five-year periods revealed that women examined in the second half of the 1980s and in the 1990s displayed the greatest difference in their endomorphy level (Tab. 7). Other groups did not show significant differences in fatness. The greatest differences in musculature were observed between the women examined in the 1980s and the rest of the female subjects (Tab. 8). In the case of body leanness, no statistically significant differences were observed in the female groups who studied at relatively similar periods. However, a significant difference in body leanness was observed between women examined in 2006–2008 and those who were tested in the 1960s and 1970s (Tab. 9).

Table 10. Results of post-hoc testing for the mean mesomorphy values of male students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

Years of examination	Years of examination								
	1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
1967–1970		1.0000	1.0000	1.0000	0.1084	0.3732	0.8590	1.0000	0.3295
1971–1975	1.0000		0.9913	0.9956	**0.0007**	0.4150	0.9285	0.9997	0.3757
1976–1980	1.0000	0.9913		1.0000	**0.0525**	0.0404	0.3671	1.0000	0.0425
1981–1985	1.0000	0.9956	1.0000		0.0171	0.0422	0.3941	1.0000	0.0455
1986–1990	0.1084	**0.0007**	**0.0525**	**0.0171**		**0.0000**	**0.0000**	**0.0031**	**0.0000**
1991–1995	0.3732	0.4150	0.0404	0.0422	**0.0000**		0.9963	**0.0800**	1.0000
1996–2000	0.8590	0.9285	0.3671	0.3941	**0.0000**	0.9963		0.5507	0.9884
2001–2005	1.0000	0.9997	1.0000	1.0000	**0.0031**	**0.0800**	0.5507		**0.0823**
2006–2008	0.3295	0.3757	0.0425	0.0455	**0.0000**	1.0000	0.9884	**0.0823**	

Table 11. Results of post-hoc testing for the mean endomorphy values of male students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

Years of examination	Years of examination								
	1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
1967–1970		1.0000	0.9995	1.0000	0.2421	**0.0072**	0.7766	0.9961	1.0000
1971–1975	1.0000		1.0000	0.9999	0.2448	**0.0045**	0.8825	1.0000	0.9991
1976–1980	0.9995	1.0000		0.9982	0.3711	**0.0092**	0.9461	1.0000	0.9949
1981–1985	1.0000	0.9999	0.9982		0.0258	**0.0002**	0.5326	0.9828	1.0000
1986–1990	0.2421	0.2448	0.3711	0.0258		0.7760	0.9992	0.4167	0.1279
1991–1995	**0.0072**	**0.0045**	**0.0092**	**0.0002**	0.7760		0.4971	**0.0099**	**0.0026**
1996–2000	0.7766	0.8825	0.9461	0.5326	0.9992	0.4971		0.9722	0.6231
2001–2005	0.9961	1.0000	1.0000	0.9828	0.4167	**0.0099**	0.9722		0.9779
2006–2008	1.0000	0.9991	0.9949	1.0000	0.1279	**0.0026**	0.6231	0.9779	

Table 12. Results of post-hoc testing for the mean ectomorphy values of male students (table contains *p* values, bold font indicates statistically significant difference, $p \leq 0.05$)

Years of examination	Years of examination								
	1967–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2008
1967–1970		0.8337	0.1539	0.3649	0.0465	0.9999	0.9982	0.9998	0.9358
1971–1975	0.8337		0.9472	0.9982	0.7621	0.9731	0.1355	0.9292	1.0000
1976–1980	0.1539	0.9472		0.9998	1.0000	0.3422	**0.0010**	0.1146	0.9769
1981–1985	0.3649	0.9982	0.9998		0.9897	0.6473	**0.0063**	0.3557	0.9992
1986–1990	0.0465	0.7621	1.0000	0.9897		0.1265	**0.0000**	0.0143	0.8959
1991–1995	0.9999	0.9731	0.3422	0.6473	0.1265		0.9231	1.0000	0.9937
1996–2000	0.9982	0.1355	**0.0010**	**0.0063**	**0.0000**	0.9231		0.7986	0.3987
2001–2005	0.9998	0.9292	0.1146	0.3557	0.0143	1.0000	0.7986		0.9875
2006–2008	0.9358	1.0000	0.9769	0.9992	0.8959	0.9937	0.3987	0.9875	

Mean mesomorphy levels for male students were found to be 4.2–5.2 (Tab. 2). Overall, the mean values revealed a slight increase of musculature in AWF students, particularly since the 1990s. Accurate significant difference analysis between the separate groups indicated that only the group tested in the second half of the 1980s significantly differed in musculature from the other groups (Tab. 10). The level of musculature in that group was lower than in the remainder of the subjects.

Throughout the entire analyzed period, the fatness of males was significantly lower in comparison to that of females, with the level being 2.0–3.0 (Tab. 2, Fig. 6). Only the group examined in the first half of the 1990s displayed statistically significant differences in the mean level of endomorphy (Tab. 11), as their level was lower in comparison to other groups.

Ectomorphy was the most stable component both in men and women. The mean values of leanness in men ranged between 2.4–3.1 (Tab. 2). The lowest leanness

level was observed in the group examined in the second half of the 1990s (Tab. 12, Fig. 6).

SANOVA test analysis of somatotype diversity showed statistically significant changes in female body build. In the seventies, female students were characterized as endomorph-mesomorph, while in eighties as more mesomorph-endomorph and, since the beginning of nineties, they were found to be as a balanced category of mesomorphy. The changes in body build of males were smaller and statistically insignificant. The most frequent category was the balanced mesomorph. In eighties, the mesomorphic-ectomorphic somatotype was observed.

Discussion

This study's results paralleled the observed increase in body height of the populations of Poland and other European countries, as had been reported in a number of studies [3–4, 20–24]. Tanner et al. [25] reported that the increase in body height of successive generations was mainly related to a lengthening of the lower limbs with only slight change in sitting height. In successive generations, body height increased in both male and female students and the pace of growth was similar for both genders. However, Ziółkowska-Łajp [4] found contrary results: changes in body height over a 30-year period were more pronounced and more dynamic in student males than in females. Eveleth and Tanner [26] also claimed that men are more "ecosensitive", that is, male body height being more susceptible to environmental changes. Then again, Tanner et al. [25] and Kuh et al. [11] stated that the contemporary trend of increased body height is more observable in women than in men, while Cole [9] confirmed a greater sexual dimorphism in body height between the two genders. Other research has proven that the pace of body height change in recent years has decreased or even disappeared [8]. However, this was not confirmed in this study, as the pace of body growth throughout the entire examined period was found to be rather constant.

Analysis of body mass also revealed a consistent increase in the successive generations of male and female students. This finding was confirmed in the work done by Ziółkowska-Łajp [4], Fredriks et al. [23] and Roelants et al. [24]. In comparison to women, men displayed a visible increase in body mass which was largely the result of an increase in musculature (with the level of fatness nearly unchanged). However, a decrease in fatness and a slight increase of leanness could be observed in women. The existence of a secular trend in body mass was also confirmed by Cole [27].

Mesomorphy, which describes body musculature, had the greatest effect on the somatotypes of both male and female students. This was probably related to the specific character of the University School of Physical Education. The level of male musculature was significantly higher than that of women. The level of musculature in women was constant while men displayed a slight increase in musculature in more recent times. The values of endomorphy (fatness) in women were higher than in men, with the dimorphism of body build composition being largely the result of differences in the hormonal profile between both sexes, which is connected with different evolutionary roles.

Analysis of somatotype in the five-year periods revealed that the students examined in the second half of the 1980s displayed the lowest muscle level throughout the entire period under study (significantly lower in comparison to other groups), while the groups of male and female students examined in the 1990s displayed significantly different levels of endomorphy in comparison to other groups. They were characterized by the lowest level of fatness. Students who applied to the University during this time were born during the post-WWII baby boom. In order to be accepted by the University, they needed to pass physical fitness tests. The increased number of applicants could have caused students with better performance capabilities to have a considerable advantage over others. In addition, many researchers also pointed to the influence of paragenetic factors (during pregnancy and in infancy) on ontogenetic processes in later development of the body [28–30]. Furthermore, no sexual dimorphism was observed in the leanness level; both male and female students displayed similar mean values of ectomorphy (2.4–3.1). Such values indicate a tendency towards having a stocky and strong body build due to developed muscles.

The data obtained in this study supports previous conclusions and demonstrated the existence of secular trends in body build. However, the detailed results obtained by different authors in themselves slightly differ, which confirms the fact that changes in body proportion and constitution observed in many generations are worth monitoring. Moreover, research evaluating body build composition in adults and ageing people enables the control of undernourishment, malnourishment or eating disorders and facilitates the monitoring of health conditions within a population. Likewise, it enables the determination of links between fat distribution and the risk of many diseases as well as the death rate [31].

Conclusions

Different types of secular trends could be observed in different somatic structures of AWF students. This is reflected by the changing conditions of lifestyle as well as different university admission criteria. The conclusions drawn from the research material were as follows:

- Changes in the mean values of the analyzed parameters (body height, body mass, endomorphy, ectomorphy, mesomorphy) between the examined groups were in different directions for both males and females.
- Analysis, on the basis of five-year intervals, indicated an increase in both body mass and height in successive generations.
- Mesomorphy, which describes musculature, was the somatotype component which was most dominant both in male and female AWF students.
- Men displayed a higher level of mesomorphy in comparison to women, while women were characterized by a higher level of fatness.
- For female subjects, intergenerational changes were found to compose of a decrease in endomorphy and an increase in ectomorphy while mesomorphy remained at a similar level.
- For men, a secular trend is visible with an increase in mesomorphy, whereas endomorphy and ectomorphy stayed constant.

References

1. Wolański N., Secular trends in *Homo sapiens*, its elements and causes [in Polish]. *Kosmos*, 1967, 16 (4), 381–401.
2. Milicer H., Skibińska A., Skład M., Secular trend in body size and proportions of academic youth [in Polish]. *Wych Fiz Sport*, 1974, XVIII(4), 63–73.
3. Piechaczek H., Lewandowska J., Orlicz B., Changes in body build of academic youth in period of 35 years [in Polish]. *Wych Fiz Sport*, 1996, 3, 3–14.
4. Ziółkowska-Łajp E., Study in tendency of changes of morphological features – conditionings and effects in the light of long-term research [in Polish]. *Monografie Akademii Wychowania Fizycznego w Poznaniu*, 1999, 336.
5. Roche A.F., Secular trends in human growth, maturation, and development. *Monogr Soc Res Child Dev*, 1979, 44 (3–4), 1–120. http://www.jstor.org/discover/10.2307/1165883?uid=3738840&uid=2134&uid=2&uid=70&uid=4&sid=56057010043
6. Tanner J.M., Growth as a mirror of the condition of society: secular trends and class distinctions. *Acta Paediatrica Japonica*, 1987, 29, 96–103, doi: 10.1111/j.1442-200X.1987.tb00015.x
7. Malina R.M., Research on secular trends in auxology. *Anthropol Anz*, 1990, 48 (3), 209–227, doi: 0003-5548/90/0048-0209.
8. Hauspie R.C., Vercauteren M., Susanne C., Secular changes in growth and maturation: an update. *Acta Paediatr Suppl*, 1997, 423, 20–27.
9. Cole T.J., Secular trends in growth. *Proc Nutr Soc*, 2000, 59 (2), 317–324, doi: 10.1017/S0029665100000355.
10. Tanner J.M., Growth as a measure of the nutritional and hygienic status of a population. *Horm Res*, 1992, 38 (suppl. 1), 106–115, doi: 10.1159/000182580.
11. Kuh D.L., Power C., Rodgers B., Secular trends in social class and sex differences in adult height. *Int J Epidemiol*, 1991, 20 (4), 1001–1009, doi: 10.1093/ije/20.4.1001.
12. Meyer H.E., Selmer R., Income, educational level and body height. *Ann Hum Biol*, 1999, 26 (3), 219–227, doi: 10.1080/030144699282723.
13. Chinn S., Rona R.J., Price C.E., The secular trend in height of primary school children in England and Scotland 1972–79 and 1979–86. *Ann Hum Biol*, 1989, 16 (5), 387–395, doi: 10.1080/03014468900000512.
14. Weber G., Seidler H., Wilfing H., Hauser G., Secular change in height in Austria: an effect of population stratification? *Ann Hum Biol*, 1995, 22, 277–288, doi: 10.1080/03014469500003952.
15. Padez C., Johnston F., Secular trends in male adult height 1904–1996 in relation to place of residence and parent's educational level in Portugal. *Ann Hum Biol*, 1999, 26 (3), 287–298, doi: 10.1080/030144699282787.
16. Proos L.A., Anthropometry in adolescence-secular trends, adoption, ethnic and environmental differences. *Horm Res*, 1993, 39 (suppl. 3), 18–24, doi: 10.1159/000182781.
17. Loesch D.Z., Stokes K., Huggins R.M., Secular trend in body height and weight of Australian children and adolescents. *Am J Phys Anthropol*, 2000, 111 (4), 545–556, doi:10.1002/(SICI)1096-8644(200004)111:4<545::AID-AJPA9>3.0.CO;2-X.
18. Fredriks A.M., van Buuren S., Burgmeijer R.J., Meulmeester J.F., Beuker R.J., Brugman E. et al., Continuing positive secular growth change in The Netherlands 1955–1997. *Pediatr Res*, 2000, 47 (3), 316–323.
19. Carter J.E.L., Heath B.H., Somatotyping – development and applications. *Cambridge Studies in Biological Anthropology*, 1990, 5.
20. Bielicki T., Szklarska A., Secular trends in stature in Poland: national and social class-specific. *Ann Hum Biol*, 1999, 26 (3), 251–258, doi: 10.1080/030144699282750.
21. Gerver W.J., De Bruin R., Drayer N.M., A persisting secular trend for body measurements in Dutch children. The Oosterwolde II Study. *Acta Paediatr*, 1994, 83 (8), 812–814, doi: 10.1111/j.1651-2227.1994.tb13150.x.
22. Schmidt I.M., Jørgensen M.H., Michaelsen K.F., Height of conscripts in Europe: is postneonatal mortality a predictor? *Ann Hum Biol*, 1995, 22 (1), 57–67, doi: 10.1080/03014469500003702.
23. Fredriks A.M., van Buuren S., Jeurissen S.E., Dekker F.W., Verloove-Vanhorick S.P., Wit J.M., Height, weight, body mass index and pubertal development reference values for children of Turkish origin in the Netherlands. *Eur J Pediatr*, 2003, 162 (11), 788–793, doi: 10.1007/s00431-003-1292-x.
24. Roelants M., Hauspie R., Hoppenbrouwers K., References for growth and pubertal development from birth to 21 years in Flanders, Belgium. *Ann Hum Biol*, 2009, 36 (6), 680–94, doi: 10.3109/03014460903049074.
25. Tanner J.M., Hayashi T., Preece M.A., Cameron N., Increase in length of leg relative to trunk in Japanese children and adults from 1957 to 1977: comparison with British and with Japanese Americans. *Ann Hum Biol*, 1982, 9 (5), 411–423.
26. Eveleth P.B., Tanner J.M., Worldwide Variation in Human Growth. Cambridge University Press, Cambridge,1990.
27. Cole T.J., The secular trend in human physical growth: a biological view. *Econ Hum Biol*, 2003, 1 (2), 161–168, doi: 10.1016/S1570-677X(02)00033-3.
28. Grabowska J., Social conditioning of body height and

mass in children and adolescents, as well as in adult inhabitants of the Konin Province, Poland. *Anthropol Anz*, 2001, 59 (2), 123–147, doi: 0004-5548/01/0059-0123.
29. Nowak-Starz G., Level of development of selected somatic features of children at the age of 6 from the Swietokrzyskie region depending on their biological state in their infancy [in Polish]. *Wiad Lek*, 2002, 55 (1), 364–369.
30. Ong K.K., Size at birth, postnatal growth and risk of obesity. *Horm Res*, 2006, 65 (suppl. 3), 65–69, doi: 10.1159/000091508.
31. Kuczmarski R.J., Need for body composition information in elderly subjects. *Am J Clin Nutr*, 1989, 50 (suppl. 5), 1150–1157.

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