Anthropological Review • Vol. 79(3), 311–329 (2016)

DE GRUYTER OPEN

ANTHROPOLOGICAL REVIEW
Available online at: https://doi.org/10.1515/anre-2016-0023

Short term secular change in body size and physical fitness of youth 7–15 years in Southwestern Poland: 2001–2002 and 2010–2011

Zofia Ignasiak[1], Teresa Sławińska[1], Robert M. Malina[2]

[1]Department of Biostructure, University School of Physical Education, Wrocław, Poland
[2]Professor Emeritus, Department of Kinesiology and Health Education, University of Texas at Austin, USA

ABSTRACT: Short term secular change in body size and physical fitness of Polish youth 7–15 years of age resident in an industrial region of Lower Silesia in southwestern Poland was considered across two surveys, 2001–2002 and 2010–2011. Subjects were students in the same schools in both surveys 1892 boys and 1992 girls in the first and 1237 boys and 1236 girls in the second. In addition to height and weight, performances in six fitness tests were measured in each survey. Height, weight and BMI increased significantly across surveys. Statistically controlling for secular gains in height and weight, only static strength (hand grip) and running speed – agility (shuttle run) improved significantly between surveys in three age groups (7–9, 10–12, 13–15 years), while explosive power (standing long jump) showed negligible changes except in girls 13–15 years among whom performances declined significantly. Speed of upper limb movement (plate tapping), flexibility (sit and reach) and trunk strength (sit-ups) declined between surveys, except for trunk strength in boys 13-15 years which did not change. In conclusion, after statistically controlling for secular gains in body size, physical fitness items changed variably over the decade.

KEY WORDS: height, weight, BMI, strength, performance

Introduction

Secular change in the physical fitness of youth generally parallels corresponding change in body size and maturation (Malina 1978). Secular gains in hand grip have been reported in Belgian (1830s–1971), American (1899–1964) and Japanese (1923–1969) youth, and the observed gains are largely proportional to secular gains in weight and height (Malina 1978 2004). In contrast, muscular strength has declined in Danish youth since the 1950s (Heebøll-Nielsen 1982), in Russian youth since the 1960s (Godina 1998), and in Belgian boys between 1969–74 and 2002–04 and girls between 1979–80 and 2002–04 (Matton et al. 2007).

Data addressing secular changes in other components of youth physical fitness do not have the time depth as those for hand grip and the trends have been

Original Article Received: February 10, 2016; Accepted for publication: July 20, 2016
DOI: 10.1515/anre- 2016-0023

more variable. For example, changes in several fitness items between the late 1960s and 2004 were not consistent in the Belgian youth (Matton et al. 2007). Comparisons of United States youth across four national surveys between 1958 and 1985 indicated major improvements in fitness between 1958 and 1965, but little change from 1965 to 1985. The one mile run (1.6 km) also did not change between 1979 and 1986 in American youth. The improvement between 1958 and 1965 reflected in part national emphasis on fitness testing in schools in the 1960s (Malina 2007). Swedish youth 16 years of age declined in the bench press, sit-ups and endurance run but improved in the two-hand lift between 1974 and 1995 (Westerstahl et al. 2003), while between 1985 and 1997 aerobic fitness (1.6 km run-walk time) and running speed (50 m dash) declined and explosive power (standing long jump) remained stable among South Australian youth 10–11 years (Dollman 2003).

Trends in the physical fitness of Japanese youth 12–17 years between 1964 and 1997 showed a variable pattern. Fitness scores improved from 1964 to 1974, were variable between 1975 and 1985, and then declined from 1986 through 1997 (Nishijima et al. 2003a; 2003b; Shingo and Takeo 2002).

Composite data for youth 6– 19 years from 33 countries worldwide indicated a systematic decline between 1960 and 2003 in endurance, but more variable patterns for measures of power and speed. Both items improved somewhat through the mid– 1980s; power then declined to 2003, while speed showed no change to about 2000 (Tompkinson and Olds 2007; Tompkinson 2007).

Surveys of youth fitness of youth across time have not generally considered the potential influence of secular changes in body size on performances. Performances of youth on a variety of strength and motor tasks are related to body size (Malina et al. 2004) so that it is likely that changes in some fitness items across time are affected by corresponding changes in height and weight. As noted, the apparent secular gains in hand grip in several earlier surveys were generally proportional to changes in body size over time (Malina 1978; 2004). In addition, when the decline in several tests of muscular strength among Danish youth between 1956 and 1981 was expressed for the same height, the more recent sample was notably weaker than the earlier sample (Heebøll-Nielsen 1982). The preceding highlights the association between body size and muscular strength, and also the need to consider body size in secular comparisons of youth physical fitness.

Among Polish youth in Upper Silesia, strength and endurance declined in decennial surveys from 1965 to 1995, especially after 12–14 years, while running speed did not change between 1965 and 1985, but was considerably poorer in 1995. On the other hand, agility did not change across the four surveys (Raczek 2002). More recently, performances of national samples of Polish youth 7–17 years in several physical fitness tests improved between 1979 and 1989, while changes between 1989 and 1999 varied among fitness items (Trześniowski 1990; Przewęda and Trześniowski 1996). Between 1989 and 1999, running speed (50 m dash) and explosive power (standing long jump) declined; hand grip changed negligibly; while running speed – agility (4 × 10 m shuttle run) and trunk strength improved (Przewęda and Dobosz 2003). A subsequent national sur-

vey in the 2009/ 2010 school year noted mixed results relative to the 1999 survey. The standing long jump (explosive power) and speed of upper limb movement (plate tapping) declined in girls; the shuttle run (running speed – agility) declined in both sexes; grip strength and sit and reach (flexibility) improved in both sexes; and sit-ups (trunk strength) improved in girls and to a lesser degree in boys (Stupnicki et al. 2003; Dobosz 2012). Heights and weights increased, on average, across time in these surveys, but secular changes in body size were not considered in the evaluation of changes in fitness items across time.

In the context of the preceding observations on Polish youth, the present study addresses short term secular change in the size and physical fitness of Polish youth 7–15 years of age resident in an industrial region of Lower Silesia in southwestern Poland. It specifically considers changes in height, weight, and several indicators of physical fitness of youth surveyed over a ten year interval, 2001–2002 and 2010–2011. Lower Silesia is a somewhat unique region. It is considered as ecologically threatened, but is one of the wealthiest regions of Poland (Lower Silesian Environmental Report 2001, 2011; Strugała-Stawik and Pietraszkiewicz 2000; Ignasiak et al. 2006; 2007; Domaradzki 2013).

Methods

Participants

The surveys of youth physical fitness were approved by the Senate Ethics Committee of the University School of Physical Education in Wrocław and also by local school authorities. The surveys were a part of several ongoing cross-sectional studies of school children in the region (Ignasiak et al. 2002; 2007). Parents also provided informed consent for the participation of their children in the study; note, however, the participation of children was voluntary.

Subjects were 6357 boys and girls 7 to 15 years of age in attendance at the same schools in several communities in the Legnica-Głogów Copper Basin in Lower Silesia, Southwestern, Poland, in the 2001–2002 and 2010–2011 school years. The 2001–2002 survey included 3884 school youth, 1892 boys and 1992 girls (Ignasiak et al. 2002), while the 2010–2011 survey included 2473 school youth, 1237 boys and 1236 girls. Allowing for subject refusal (note, participation was voluntary), and illness and/or injury and absence from school at the time of the surveys, the samples in each survey represented about 75% of the school age population in the region. All children were of Polish ancestry and were born and raised in the area.

Procedures

All youth were measured and tested by staff of the Department of Biostructure in the University School of Physical Education in Wrocław. Chronological age expressed as decimal age was difference between date of birth and date of measurement. Height and weight were measured using the procedures of Martin and Saller (1957). The body mass index (BMI, kg/m^2) was calculated. Six fitness tests were administered (Eurofit 1991):

1. static strength – grip strength of the right hand (adjustable Jamar dynamometer, nearest 1.0 kg), better of two trials was used for analysis;

2. trunk strength – number of complete sit-ups performed in 30 seconds (timed sit-ups), one trial was given (this test is a component of muscular endurance in the Eurofit battery);
3. flexibility – sit and reach, with the palms facing downwards and hands on top of each other, the subject reached forward as far as possible along the measuring line (15 cm was added to each result to eliminate negative values (this test a measure of flexibility of the lower back and upper thighs) ; one trial was performed;
4. explosive power – standing long jump, measured as the distance from the front edge of the take-off line to the heel nearest to the take-off line with a maximal jumping effort, the better of two attempts was retained for analysis;
5. running speed – agility – 10 × 5 m shuttle run, time (0.1 sec) elapsed to complete 5 cycles running as fast as possible from line to line placed 5 meters apart, one trial (lower time is a better performance);
6. speed of upper limb movement – plate tapping, time (0.1 sec) to complete 25 cycles moving the preferred arm as rapidly as possible from disc to disc placed 80 cm apart, better of two trials was used for analysis (lower time is a better performance).

Statistical Analysis

Subjects were grouped into single year age groups for descriptive purposes; the whole year was the mid-point, i.e., 7 = 6.5 to 7.49 years, etc. Sex-specific means and standard deviations were calculated by single year age groups for age, height, weight, BMI and each fitness test in the two surveys.

For comparisons of body size and fitness across the two surveys, the sample was divided into three age groups, 7 through 9, 10 through 12 and 13 through 15 years. The first, 7–9 years, approximates late childhood in the majority of children of both sexes, although some girls may be in early puberty. The second, 10–12 years, approximates the interval of the growth spurt in many girls and the pubertal transition in boys. And the third, 13–15 years, approximates the interval of the growth spurt in boys and post-peak height velocity and attainment of menarche in most girls. Estimated median ages at menarche of girls in the Copper Basin were 13.2±1.1 and 12.8±1.1 years in 2001 and 2007, respectively (Sławinska et al. 2012). Nevertheless, given individual differences in growth and maturation and sex difference in pubertal timing and the growth spurt, the labels for the age groups are only approximate.

Comparisons of age, height, weight and BMI between the two surveys in the three age groups were done with MANOVA. To control for secular changes in body size, comparisons of fitness items between surveys were done with MANCOVA controlling for chronological age, height and weight (covariates). Given the relationship between body size and chronological age, the latter was included as a covariate.

Results

Descriptive statistics for age, body size and the six fitness items are summarized in Appendix Tables 1 through 3, while means±95% confidence intervals for heights, weights and BMIs in the two surveys are illustrated for boys and girls in Figures 1 through 3. On average, boys and girls in 2010–2011 are slightly tall-

er than peers in 2001–2002 from nine years of age on (Fig. 1) and heavier from 8 years of age on (Fig. 2). Proportionally greater gains in weight than in height are reflected in large increases in the BMI between the 2001–2002 and 2010–2011 surveys, more so in boys than in girls (Fig. 3). Note, however, secular change in the BMI of adolescent girls 13–15 years is negligible.

Static strength shows the same trend as body weight and the BMI in both boys and girls, i.e., gains across the entire age range in boys and between 7 and 12 years in girls (Fig. 4). In contrast, trunk strength (sit-ups, Fig. 5) and flexibility (sit and reach, Fig. 6) were both reduced, on average, in the 2010–2011 compared to the 2001–2002 surveys. Explosive power (standing long jump, Fig. 7) shows, on average, negligible change between surveys across 7–15 years in boys and 7–12 years in girls; however, jumping performance is less in the 2010–2011 than in the 2001–2002 survey among girls 13–15 years. Running speed – agility (shuttle run, Fig. 8) improved, on average, from 2001–2002 to 2010–2011, while speed of upper limb movement (plate tapping, Fig. 9) decline, on average, between surveys.

Comparisons of age, height, weight and BMI in the three age groups (7–9, 10–12 and 13–15 years) across surveys are summarized in Table 1, while estimated secular gains are summarized in Table 2. Except among girls 13–15 years, chronological age does not differ between surveys. Youth in each age group in 2010–2011 are significantly taller and heavier and have a higher BMI than youth in 2001–2002. Estimated secular gains in height are larger in boys than in girls in the three age groups. Corresponding gains in weight and the BMI are similar in both sexes among children 7–9 and 10–12 years of age, but are greater in boys than in girls 13–15 years.

Estimated changes in physical fitness after adjusting for age, height and weight in the two surveys are summarized in Table 3 for girls and Table 4 for boys. Allowing for secular gains in height and weight, only the hand grip and shuttle run show significant secular improvements in the three age groups of girls and boys. The standing long jump shows significant secular improvement among girls 7–9 and 10–12 years and boys 10–12 years; the secular gain in jumping performance of boys 7–9 and 13–15 years is not significant, while the jumping performance of girls 13–15 years declines significantly between surveys. In contrast, performances of girls and boys of the three age groups in sit-ups, the sit and reach, and plate tapping decline between the 2001–2 and 2011–2012 surveys. All differences in the three fitness items between surveys are significant except that for sit-ups in boys 13–15 years of age.

Discussion

Height, weight and the BMI increased, on average, between surveys conducted in 2001–2002 and 2010–2011. The positive secular changes in body size likely reflect continued improvement in socioeconomic conditions which began after the political transformation in Poland (Kozieł 2014). Changes in diet and lifestyle (specifically, increased levels of physical inactivity) associated with socioeconomic improvements may have contributed to the relative larger secular increments in body weight and the BMI. Note, however, the estimated short term secular increase in the BMI of adolescent girls 13–15 years was small, 0.42 kg/m^2,

Table 1. Sample sizes, means (M) and standard deviations (SD) for height, weight and BMI in three age groups of girls and of boys in surveys conducted in 2001–2002 and in 2010–2011, and results of the MANOVAs

Age group (years)	Height (cm)							Weight (kg)					BMI (kg/m^2)				
	2001–2002			2010–2011				2001–2002		2010–2011			2001–2002		2010–2011		
	n	Mean	SD	n	Mean	SD	*F*	Mean	SD	Mean	SD	*F*	Mean	SD	Mean	SD	F
Girls																	
7–9	650	128.5	7.2	436	130.3	7.8	14.52*	27.1	5.9	28.9	6.9	21.09*	16.3	2.3	16.8	2.7	14.09*
10–12	738	145.2	9.1	435	147.7	9.1	19.63*	37.7	9.4	41.2	11.3	31.09*	17.7	3.0	18.6	3.5	22.71*
13–15	604	159.5	6.7	365	161.5	6.9	20.39*	50.8	9.3	53.3	11.1	14.14*	19.9	2.9	20.3	3.3	4.30**
Boys																	
7–9	596	129.7	7.7	390	130.7	7.5	4.70**	27.6	6.0	29.2	7.6	13.07*	16.3	2.3	16.9	3.0	12.60*
10–12	666	144.0	8.1	471	146.9	8.6	34.25*	36.8	8.9	40.1	10.2	34.99*	17.6	2.9	18.4	3.2	19.71*
13–15	630	163.1	10.4	376	166.3	9.4	24.12*	51.8	11.6	57.2	13.1	46.26*	19.3	3.0	20.5	3.7	34.49*

*$p<0.01$; **$p<0.05$

Table 2. Estimated secular differences (means and standard errors) in height, weight and BMI between surveys conducted in 2001–2002 and 2010–2011

Age group (years)	Height (cm)		Weight (kg)		BMI (kg/m²)	
	Mean	SE	Mean	SE	Mean	SE
			Girls			
7–9	1.75	0.46*	1.80	0.39*	0.57	0.15*
10–12	2.43	0.55*	3.42	0.61*	0.92	0. 19*
13–15	2.03	0.45*	2.50	0.67*	0.42	0. 20**
			Boys			
7–9	2.94	0.50*	3.37	0.57*	0.82	0.18*
10–12	2.94	0.50*	3.37	0.57*	0.82	0.18*
13–15	3.22	0.66*	5.39	0.79*	1.25	0.21*

*$p<0.01$; **$p<0.05$

compared to that noted in adolescent boys, 1.25 kg/m² (Table 2).

Although not directly related to the health of youth in the Copper Basin *per se*, the observations reinforce the conclusion of Przewęda (2009) that the health of Polish youth was dependent upon their levels of habitual physical activity. This conclusion was based on a comparison of body size and fitness of Polish youth between 1979 and 1999. Positive gains in size were noted, while levels of fitness and movement proficiency were reduced over time (Przewęda 2009). The positive somatic secular gains and corresponding reductions in youth fitness were described a serious health hazard for younger generations of Poles in the future.

Mean heights and weights of youth from the Copper Basin in 2010–2011 fluctuated around the 50 percentiles for

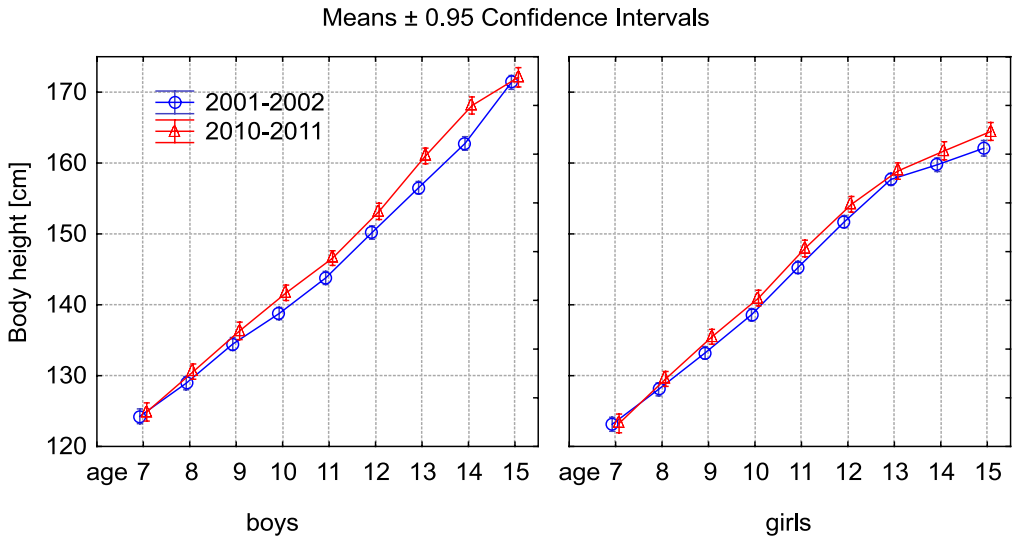

Fig. 1. Age-specific means (±95% CI) for the height of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

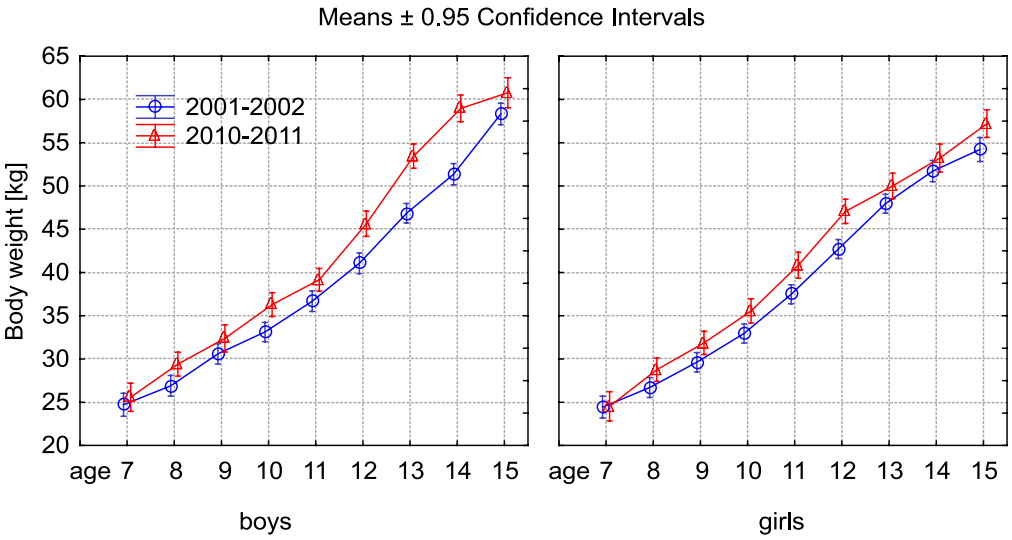

Fig. 2. Age-specific means (±95% CI) for the body weight of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

a nationally representative sample of Polish youth surveyed in 2009–2010 (Dobosz 2012). The increase in the BMI in both sexes in 2010–2011 suggested a slightly greater increment in body weight relative to height in youth from Copper Basin compared to the earlier survey in 2000–2001. The increase in the BMI over the short term may reflect the economically favorable living conditions (www.

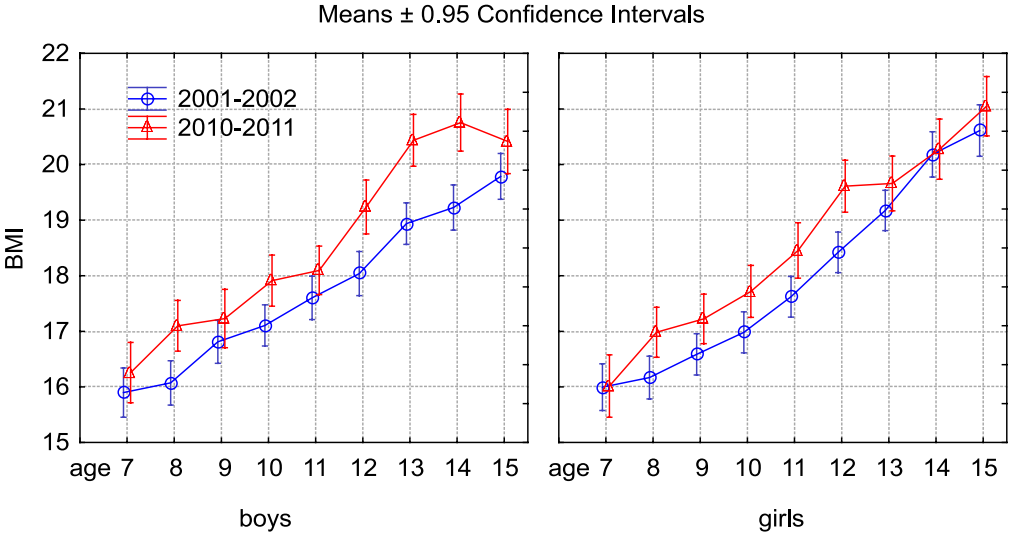

Fig. 3. Age-specific means (±95% CI) for the body mass index (BMI) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

pup.polkowice.one.pl), and perhaps changes in nutrition, specifically a high fat diet and excess calorie consumption which began at the end of the twentieth century in Poland (Posłuszny et al. 2011; Cieślińska-Świder and Lewera 2015, Lipowicz et al. 2015). An additional factor is reduced levels of physical activity and/or increased levels of physical inactivity; unfortunately, data addressing activity and inactivity among youth in the region are not available.

Earlier secular comparisons of the fitness of Polish children spanned broader time intervals, 1965–1995 among children and adolescents in Upper Silesia (Raczek 1997; 2002) and 1979 through 2009–2010 in national samples (Przewęda and Dobosz 2003; Dobosz 2012). The present study of school children in the Copper Basin of Poland, in contrast, noted variable secular changes in fitness over an interval of approximately one decade. Hand grip improved, on average, across the decade except in girls 13–15 years (Fig. 4), while performances on sit-ups, (Fig. 5) and sit and reach (Fig. 6) declined. The differences between surveys were significant in most age groups. Improvement in the standing long jump was negligible between surveys in both sexes except for girls 13–15 years in whom performance declined between surveys (Fig. 7). In contrast, performance in the shuttle run improved across the decade in both boys and girls (Fig. 8). Performance in the plate tapping task (speed of limb movement), on the other hand, declined between surveys (Fig. 9). Thus, short term secular changes were not uniform among indicators of physical fitness of school youth over the interval spanning 2001–2002 and 2010–2011.

As noted in the introduction, most comparisons of youth fitness across time have largely focused on changes in specific fitness items independent of secular changes in body size. This was also true of two secular comparisons of youth fitness in Poland (Raczek 1997; 2002; Przewęda 2009). It is important to consider secular changes in fitness in the context of changes in body size as performances on many fitness tests are related to body size (Malina 1978; 2004; Malina et al. 2004). Do changes in fitness over time reflect changes in fitness per se independent of body size, or do they reflect in part secular changes in body size? This issue was addressed in the present analysis by statistically controlling for age, height and weight when comparing fitness scores of three age groups in the two surveys (Tables 3 and 4). After controlling for age and body size, the secular decline in two indicators of health-related physical fitness, sit-ups and sit and reach, persisted. Although boys and girls in 2010–2011 were taller and heavier, they had significantly reduced trunk strength (sit-ups) and flexibility (sit and reach) compared to peers in 2001–2002.

Corresponding changes in indicators of performance-related fitness were variable. After controlling for age and body size, hand grip strength and running speed – agility (shuttle run) improved significantly across surveys (except hand grip in girls 13–15 years, no difference). In contrast, speed of upper limb movement (plate tapping) declined significantly between surveys in both sexes. In contrast, secular changes in the explosive power (standing long jump) were variable. Performances were significantly improved among girls 7–9 and 10–12 years, but were significantly and markedly poorer among adolescent girls 13–15 years of age (Table 3). The age, height and weight adjusted jumping performance of girls

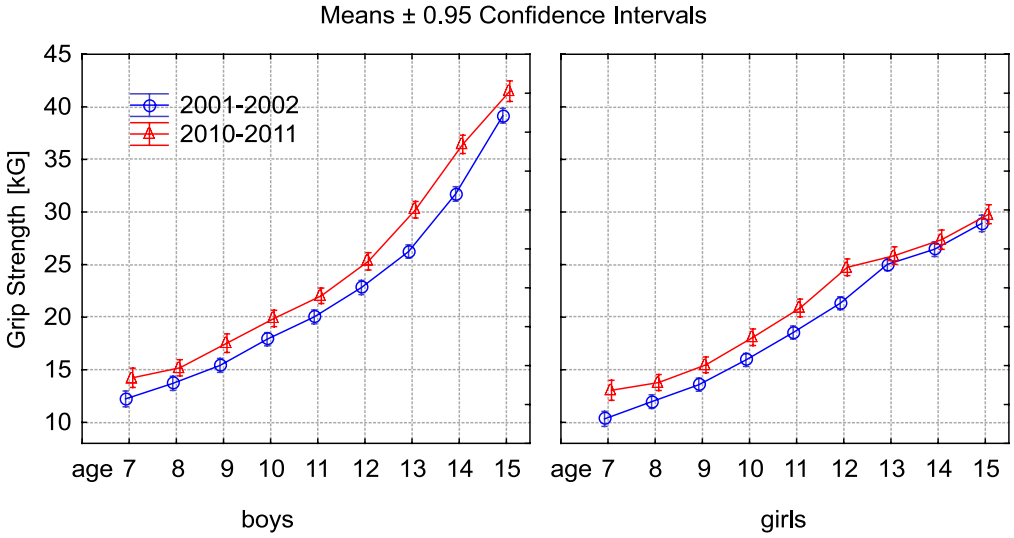

Fig. 4. Age-specific means (±95% CI) for hand grip (static strength) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

13–15 years was about 12 cm less than girls the same age in 2001–2002. This may reflect secular changes in sexual maturation (earlier puberty, Sławinska et al. 2012) and associated changes in lifestyle among adolescent girls, perhaps interacting with changing interests in physical activity and fitness associated with biological maturation (Osiński 1988; Malina 2004; Ignasiak et al 2007; Malina et al

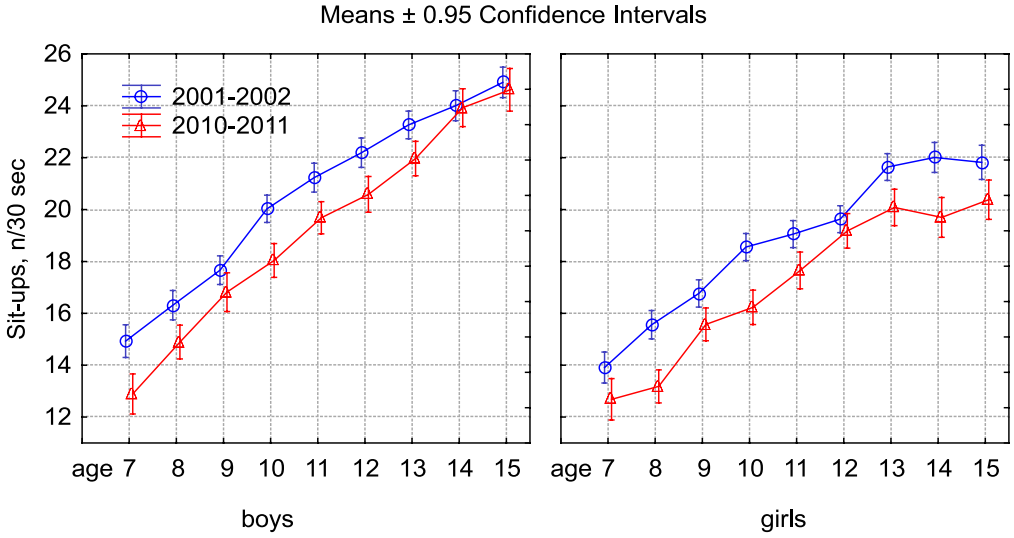

Fig 5. Age-specific means (±95% CI) for sit-ups (trunk strength) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

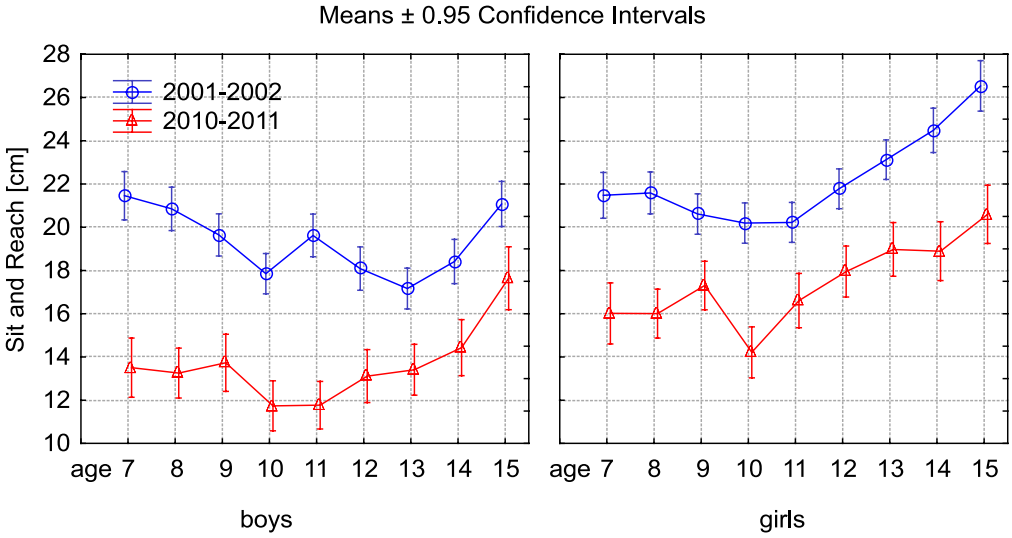

Fig. 6. Age-specific means (±95% CI) for the sit and reach (flexibility) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

2016). The trend for explosive power was somewhat similar in boys. Performances in the jump improved across surveys in boys 7–9 and 10–12 years, though the improvement was significant only in the latter age group. On the other hand, after controlling for body size, mean jumping performances in boys 13–15 years were identical in both surveys (Table 4).

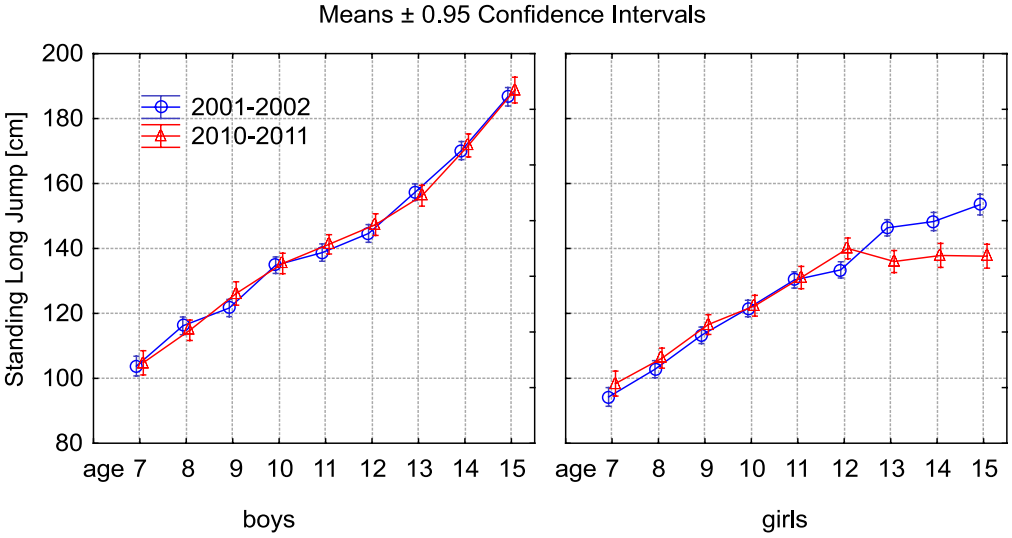

Fig. 7. Age-specific means (±95% CI) for the standing long jump (explosive power) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011

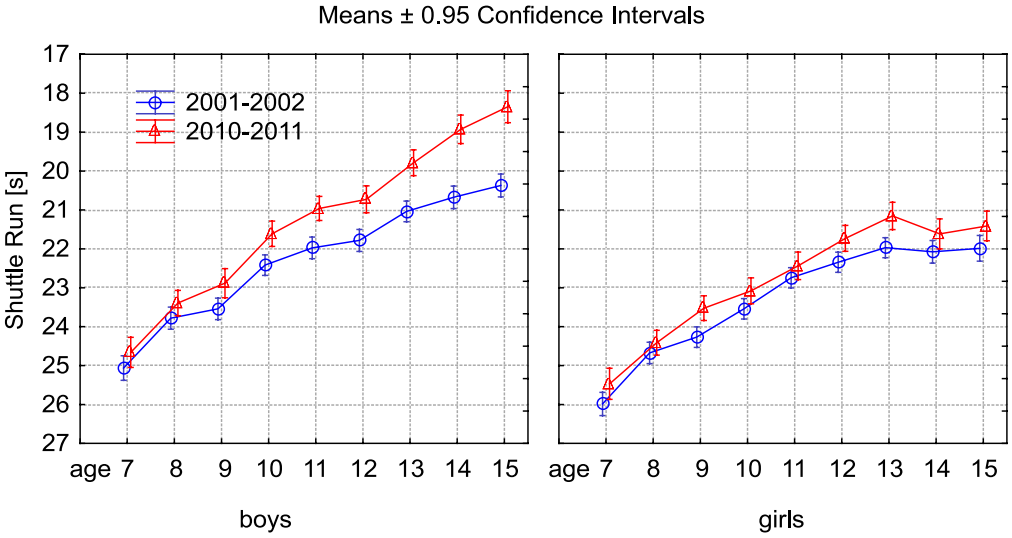

Fig. 8. Age-specific means (±95% CI) for the shuttle run (running speed – agility) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011. Note, the y-axis has been inverted since a lower time is a better performance

In summary, the study was limited to a single region of Poland, the Copper Basin in the southwest, which experienced significant economic progress over the decade surveyed. Comparisons across one decade showed a secular increase in

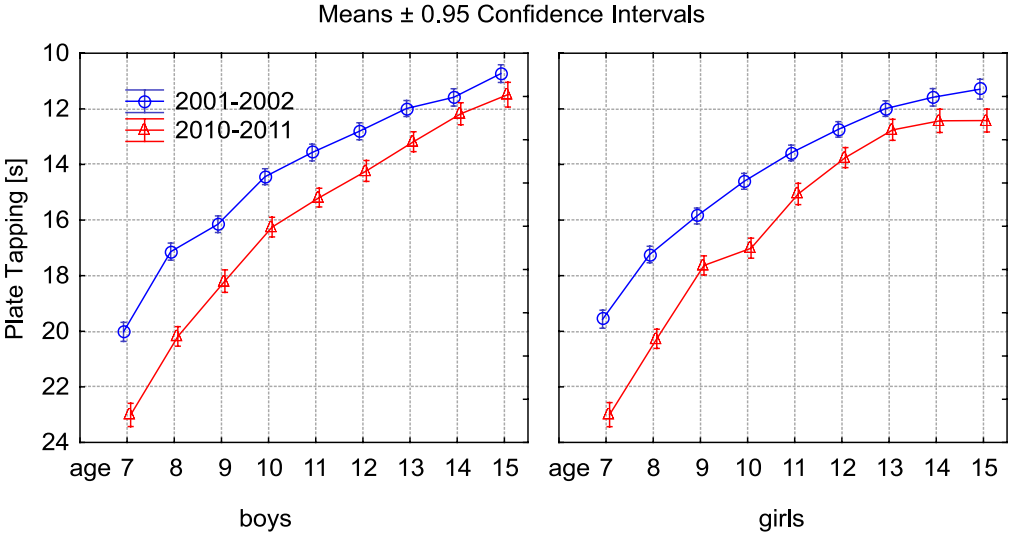

Fig. 9. Age-specific means (±95% CI) for plate tapping (speed of upper limb movement) of boys (left) and girls (right) surveyed in 2001–2002 and in 2010–2011. Note, the y-axis has been inverted since a lower time is a better performance

Table 3. Age-, height- and weight-adjusted performances on the fitness tests in the 2001–2002 and 2010–2011 surveys, and differences between surveys (means and standard errors) in three age groups of girls based on MANCOVA

Age group (years)	Hand Grip (kg)						Sit-ups (n/30 sec)						Sit-and-Reach (cm)					
	2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
7–9	12.3	0.1	14.0	0.1	1.72	0.18*	15.6	0.2	14.2	0.2	–1.45	0.25*	22.4	0.3	16.6	0.3	–5.78	0.31*
10–12	19.0	0.1	20.7	0.2	1.75	0.21*	19.0	0.2	17.9	0.2	–1.14	0.25*	22.3	0.2	16.7	0.3	–5.66	0.36*
13–15	26.8	0.2	27.0	0.2	0.21	0.29	21.8	0.1	20.1	0.2	–1.65	0.24*	25.7	0.3	19.6	0.3	–6.15	0.43*
	Standing Long Jump (cm)						Shuttle Run (sec†)						Plate Tapping (sec†)					
	2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
7–9	104.2	0.6	108.3	0.7	4.10	0.97*	24.9	0.1	24.3	0.1	0.59	0.14*	17.3	0.1	20.0	0.1	–2.70	0.18*
10–12	128.0	0.7	131.9	0.9	3.93	1.15*	22.9	0.1	22.4	0.1	0.51	0.12*	13.6	0.1	15.3	0.1	–1.66	0.12*
13–15	148.9	0.8	137.0	1.0	–11.93	1.32*	22.0	0.1	21.4	0.1	0.67	0.13*	11.7	0.1	12.6	0.1	–0.92	0.10*

†Signs were inverted as a lower time is a better performance
*$p<0.01$; **$p<0.05$

Table 4. Age-, height- and weight-adjusted performances on the fitness tests in the 2001–2002 and 2010–2011 surveys, and differences between surveys (means and standard errors) in three age groups of boys based on MANCOVA

Age group (years)	Hand Grip (kg)						Sit-ups (n/30 sec)						Sit-and-Reach (cm)					
	2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
7–9	14.0	0.1	15.5	0.2	1.42	0.21*	16.4	0.2	15.2	0.2	–1.14	0.27*	21.9	0.2	13.9	0.2	–8.02	0.31*
10–12	20.6	0.1	21.6	0.2	1.05	0.22**	21.0	0.2	19.7	0.2	–1.30	0.25*	21.1	0.2	13.1	0.2	–7.95	0.32*
13–15	32.8	0.2	33.9	0.3	1.15	0.40*	23.9	0.2	23.6	0.2	–0.31	0.27	22.5	0.3	15.8	0.3	–6.75	0.41*
	Standing Long Jump (cm)						Shuttle Run (sec†)						Plate Tapping (sec†)					
	2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference		2001–2002		2010–2011		Difference	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
7–9	114.1	0.7	116.3	0.9	2.14	1.15	24.1	0.1	23.5	0.1	0.60	0.15*	17.6	0.1	20.3	0.2	–2.68	0.21*
10–12	138.9	0.8	141.5	0.9	2.67	1.21**	22.1	0.1	21.0	0.1	1.09	0.12*	13.6	0.1	15.3	0.1	–1.63	0.12*
13–15	170.2	0.9	170.3	1.2	0.08	1.49	20.8	0.1	19.0	0.1	1.73	0.13*	11.5	0.1	12.4	0.1	–0.90	0.09*

†Signs were inverted as a lower time is a better performance
*$p<0.01$; **$p<0.05$

body size, but variable changes in several physical fitness items. The variable changes in fitness persisted after statistically controlling for age, height and weight in each survey. The changes in fitness were likely associated with concomitant changes in lifestyle and behavior, even though the schools in which the fitness surveys were conducted have extremely well-equipped sports and recreational facilities. The results emphasize a need for more detailed study of specific aspects of lifestyle and behavior among youth that may contribute to changes in fitness.

Authors' contributions

All authors equally contributed to this paper.

Conflict of interest

The Authors declare that there is no conflict of interests.

Corresponding author

Zofia Ignasiak, Department of Biostructure, University School of Physical Education in Wrocław, J. Paderewskiego Street 35, 51-612 Wrocław, Poland, e-mail address: zofia.ignasiak@awf.wroc.pl

References

Cieślińska-Świder J, Lewera M. 2015. Odżywianie oraz aktywność fizyczna a nieprawidłowa masa ciała u dzieci w wieku 10–13 lat. In: R Stemplewski, R Szeklicki and J Maciaszek, editors. Aktywność fizyczna i żywienie w trosce o zdrowie i jakość życia. Wydawnictwo Naukowe Bogucki. 171– 85.

Dobosz J. 2012. Kondycja fizyczna dzieci i młodzieży w wieku szkolnym: siatki centylowe. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie.

Dollman J. 2003. Trends and sociodemographic distribution of children's health-related fitness and behaviours. Doctoral dissertation, University of South Australia, Mawson Lakes Campus.

Domaradzki J. 2013. Środowiskowe uwarunkowania krótkookresowych przemian morfologicznych i funkcjonalnych 10–15-letniej młodzieży polkowickiej. Studia i Monografie 110.

EUROFIT 1991. European Fitness Test. Europejski Test Sprawności Fizycznej translated by Grabowski H and Szopa J. Akademia Wychowania Fizycznego w Krakowie.

Godina EZ. 1998. Secular changes in Russia and the former Soviet Union. In: EB Bodzsar and C Susanne, editors. Secular Growth Changes in Europe. Budapest: Eötvös Loránd University Press. 351–67.

Heebøll-Nielsen K. 1982. Muscle strength of boys and girls, 1981 compared to 1956. Scand J Sports Sci 4:37–43.

Ignasiak Z, Domaradzki J, Sławińska T, Żurek G. 2002. Rozwój morfofunkcjonalny dzieci z terenów przemysłowych. Studia i Monografie AWF we Wrocławiu 61.

Ignasiak Z, Sławińska T, Domaradzki J, Fugiel J, Krynicka-Pieleszek I, Rożek-Piechura K, Żurek G. 2007. Rozwój funkcjonalny dzieci i młodzieży z legnicko-głogowskiego okręgu miedziowego w ujęciu wieku morfologicznego. Studia i Monografie AWF we Wrocławiu 85.

Ignasiak Z, Sławińska T, Rożek K, Little BB, Malina RM. 2006. Lead and growth status of school children living in the copper basin of south-western Poland: differential effects on bone growth. Ann Hum Biol 33(4):401–14.

Ignasiak Z, Sławińska T, Rożek K, Malina RM, Little BB. 2007. Blood lead level and physical fitness of schoolchildren in the copper basin of south-western Poland: indirect effects through growth stunting. Ann Hum Biol 34(3):329–43.

Kozieł S. 2014. Charakterystyka przemian społeczno-ekonomicznych w latach 1966–

2012. In: S Kozieł, N Nowak-Szczepańska and A Gomuła, editors. Antropologiczne badania dzieci i młodzieży w Polsce w latach 1966–2012. Zmiany sekularne i zróżnicowanie społeczne. Wrocław: Wydawnictwo Arboretum. 13–20.

Lipowicz A, Łopuszańska M, Kołodziej H, Szklarska A, Bielicki T. 2015.Secular trends in BMI and the prevalence of obesity in young Polish males from 1965 to 2010. Eur J Public Health 25(2):279–82.

Raport o stanie środowiska w województwie dolnośląskim w 2001. Wrocław: WIOŚ. Available at: http://www.wroclaw.pios.gov.pl/index.php/publikacje/raporty-o--stanie-srodowiska/.

Raport o stanie środowiska w województwie dolnośląskim w 2011. Wrocław: WIOŚ. Available at: http://www.wroclaw.pios.gov.pl/index.php/publikacje/raporty-o--stanie-srodowiska/.

Malina RM. 1978. Secular changes in growth, maturation, and physical performance. Exerc Sport Sci Rev 6: 203–55.

Malina RM. 2004. Secular trends in growth, maturation and physical performance: A review. Anthropol Rev 67:3–31.

Malina RM. 2007. Physical fitness of children and adolescents in the United States: status and secular change. Med Sports Sci 50:67–90.

Malina RM, Bouchard C, Bar-Or O. 2004. Growth, Maturation, and Physical Activity. 2nd edition. Champaign, IL: Human Kinetics.

Malina RM, Cumming SP, Coelho e Silva MJ. 2016. Physical activity and movement proficiency: The need for a biocultural approach. Pediatr Exerc Sci 28:233–9.

Matton L, Duvigneaud N, Wijndaele K, Philippaerts R, Duquet W, Beunen G, Claessens AL, Thomis M, Lefevre J. 2007. Secular trends in anthropometric characteristics, physical fitness, physical activity, and biological maturation in Flemish adolescents between 1969 and 2005. Am J Hum Biol 19:345–57.

Nishijima T, Kokudo S, Ohsawa S. 2003a. Changes over the years in physical and motor ability in Japanese youth in 1964–97. International Journal of Sport and Health Science 1:164–70.

Nishijima T, Nakano T, Takahashi S, Suzuki K, Yamada H, Kokudo S, Obsawa, S. 2003b. Relationship between changes over the years in physical ability and exercise and sports activity in Japanese youth. International Journal of Sport and Health Science 1:110–8.

Osiński W. 1988. Wielokierunkowe związki zdolności motorycznych i parametrów morfologicznych. Badania dzieci i młodzieży wielkomiejskiej z uwzględnieniem poziomu stratyfikacji społecznej. Monografie Akademii Wychowania Fizycznego w Poznaniu 261.

Posłuszny P, Fugiel J, Pokrywka J. 2011. Tendencje zmian w obrębie masy ciała 7-letnich chłopców z różnych środowisk zagłębia miedziowego. Med Środow 14(4):49–57.

Przewęda R. 2009. Zmiany kondycji fizycznej polskiej młodzieży w ciągu ostatnich dekad. Studia Ecologiae et Bioethicae 7(1):57–71.

Przewęda R, Dobosz, J. 2003. Kondycja fizyczna Polskiej młodzieży. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie, Studia i Monografie 98.

Przewęda R, Trześniowski R. 1996. Sprawność fizyczna polskiej młodzieży w świetle badań z roku 1989. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie, Studia i Monografie.

Raczek J. 1997. Change in motor fitness in the Polish school population (1965– 1995). Kinesiologia Slovenica 3:30–34.

Raczek J. 2002. Entwicklungsveranderungen der motorischen Leistungsfahigkeit der Schuljugend in drei Jahrzehnten (1965–1995). Sportwissenschaft 32: 201–16.

Shingo N, Takeo M. 2002. The educational experiments of school health promotion for the youth of Japan: Analysis of the 'sport test' over the past 34 years. Health Promot Int 17: 147–60.

Sławinska T, Ignasiak Z, Little BB, Malina RM. 2012. Short-term secular variation

in menarche and blood lead concentration in school girls in the Copper Basin of Southwestern Poland: 1995 and 2007. Am J Hum Biol 24:587–94.

Strugała-Stawik H, Pietraszkiewicz T. 2000. Profilaktyka i leczenie mikrointoksykacji ołowiowej u dzieci legnickich. Nowa Med 12:63–4.

Stupnicki R, Przewęda R, Milde K. 2003. Centylowe siatki sprawności fizycznej polskiej młodzieży wg testów EUROFIT. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie.

Tompkinson GR. 2007. Global changes in anaerobic fitness test performance of children and adolescents(1958–2003). Scand J Med Sci Spor 17:497–507.

Tompkinson GR, Olds TS. 2007. Secular changes in pediatric aerobic fitness test performance: The global picture. Med Sport Sci 50:46–66.

Trześniowski R. 1996. Rozwój fizyczny i sprawność fizyczna młodzieży szkolnej w Polsce. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie, Z warsztatów Badawczych.

Westerstahl M, Barnekow-Bergkvist M, Hedberg G, Jansson E. 2003. Secular trends in body dimensions and physical fitness among adolescents in Sweden from 1974 to 1995. Scand J Med Sci Spor 13:128–37.

Appendix

Table 1. Descriptive statistics for height, weight and BMI by survey

Age (years)	Height (cm)						Weight (kg)				BMI (kg/m²)			
	2001–2002			2010–2011			2001–2002		2010–2011		2001–2002		2010–2011	
	n	Mean	SD	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Girls														
7	187	123.1	5.6	105	123.3	5.8	24.4	4.9	24.5	5.1	16.0	2.2	16.0	2.3
8	223	128.1	6.1	164	129.5	6.0	26.7	5.3	28.8	6.6	16.2	2.2	17.0	2.8
9	240	133.2	6.1	167	135.5	6.6	29.6	6.1	31.9	6.8	16.6	2.5	17.2	2.7
10	243	138.6	6.7	151	140.9	7.4	32.9	7.9	35.6	8.2	17.0	2.9	17.7	2.9
11	246	145.3	7.6	133	148.0	6.9	37.5	8.2	40.8	10.3	17.6	2.8	18.5	3.4
12	249	151.7	7.6	151	154.2	7.4	42.7	9.5	47.1	11.8	18.4	3.2	19.6	3.8
13	251	157.7	6.7	136	158.9	6.9	48.0	9.1	50.0	11.3	19.2	2.8	19.7	3.5
14	199	159.8	6.5	113	161.7	5.8	51.7	9.4	53.2	10.1	20.2	3.0	20.3	3.2
15	154	162.1	6.1	116	164.5	6.8	54.2	8.2	57.2	10.6	20.6	2.8	21.1	2.9
Boys														
7	168	124.3	5.5	112	124.9	6.0	24.7	4.8	25.6	5.8	15.9	2.1	16.3	2.6
8	208	128.9	6.2	158	130.6	5.9	26.9	5.4	29.4	6.4	16.1	2.3	17.1	2.6
9	2 20	134.5	6.3	1 20	136.3	6.4	30.6	6.2	32.4	8.8	16.8	2.5	17.2	3.6
10	241	138.8	6.3	157	141.7	6.6	33.1	6.4	36.3	8.5	17.1	2.5	17.9	3.1
11	216	143.8	6.5	174	146.6	6.7	36.7	8.1	39.2	8.9	17.6	2.9	18.1	3.1
12	209	150.2	7.3	140	153.2	8.6	41.1	10.0	45.6	11.3	18.0	3.3	19.2	3.4
13	236	156.5	8.3	152	161.0	8.0	46.9	11.5	53.4	13.9	18.9	3.5	20.4	4.3
14	200	162.8	9.2	125	168.1	8.6	51.4	10.9	59.0	12.7	19.2	2.8	20.8	3.7
15	194	171.4	7.8	99	172.1	8.2	58.3	9.2	60.8	10.5	19.8	2.3	20.4	2.5

Appendix

Table 2. Descriptive statistics for hand grip, sit-ups and sit-and-reach by survey

Age (years)	Hand Grip (kg)				Sit-ups (n/30 sec)				Sit-and-Reach (cm)			
	2001–2002		2010–2011		2001–2002		2010–2011		2001–2002		2010–2011	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
						Girls						
7	10.3	2.7	13.1	4.9	13.9	3.8	12.7	4.9	13.9	3.8	12.7	4.9
8	12.0	2.6	13.8	3.2	15.6	4.0	13.2	4.4	15.6	3.9	13.2	4.4
9	13.6	3.1	15.5	3.1	16.8	4.6	15.6	4.4	16.8	4.5	15.6	4.4
10	15.9	3.3	18.1	4.0	18.6	4.4	16.2	3.5	18.6	4.4	16.2	3.5
11	18.5	3.9	20.9	3.9	19.1	4.4	17.7	4.1	19.0	4.4	17.6	4.1
12	21.3	4.3	24.8	5.4	19.6	4.7	19.2	4.2	19.6	4.7	19.2	4.2
13	25.0	4.7	25.9	5.6	21.6	3.6	20.1	3.9	21.6	3.6	20.1	3.8
14	26.5	4.0	27.4	5.7	22.0	3.3	19.7	3.9	22.0	3.3	19.7	3.9
15	28.9	4.4	29.8	6.4	21.8	3.5	20.4	3.7	21.8	3.5	20.4	3.7
						Boys						
7	12.2	2.5	14.2	5.4	14.9	4.2	12.9	4.2	14.9	4.2	12.9	4.2
8	13.7	2.7	15.2	4.1	16.3	4.4	14.9	4.5	16.3	4.4	14.9	4.4
9	15.4	3.5	17.5	3.7	17.7	4.0	16.8	4.5	17.7	4.0	16.8	4.5
10	17.9	3.4	19.9	4.2	20.0	4.4	18.0	4.6	20.0	4.3	18.0	4.6
11	20.0	3.6	22.0	4.3	21.2	4.1	19.7	3.9	21.2	4.1	19.7	3.9
12	22.8	5.0	25.3	5.9	22.2	4.2	20.6	4.3	22.2	4.2	20.6	4.3
13	26.2	5.9	30.2	7.9	23.3	4.1	22.0	4.8	23.3	4.0	21.9	4.8
14	31.7	7.8	36.4	9.6	24.0	3.7	23.9	4.8	24.0	3.7	23.9	4.8
15	39.2	8.0	41.5	9.2	24.9	3.5	24.6	4.7	24.9	3.5	24.6	4.7

Appendix

Table 3. Descriptive statistics for the standing long jump, huttle run and plate tapping by survey

Age (years)	Standing Long Jump (cm)				Shuttle Run (sec)				Plate Tapping (sec)			
	2001–2002		2010–2011		2001–2002		2010–2011		2001–2002		2010–2011	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
						Girls						
7	94.3	14.6	98.4	15.8	26.0	2.4	25.5	2.8	19.6	3.2	23.0	3.5
8	102.8	15.7	106.2	17.7	24.7	2.1	24.4	2.3	17.2	2.8	20.3	3.8
9	113.3	16.1	116.6	16.8	24.3	2.1	23.5	2.2	15.9	2.4	17.6	2.6
10	121.5	18.2	122.4	20.4	23.5	1.9	23.1	2.1	14.6	2.1	17.0	2.7
11	130.3	19.0	131.1	18.9	22.7	2.0	22.4	2.1	13.6	1.5	15.1	2.2
12	133.4	20.5	140.0	21.5	22.3	2.0	21.7	2.2	12.7	1.4	13.8	1.8
13	146.4	19.6	136.0	20.1	22.0	2.0	21.2	2.0	12.0	1.4	12.8	1.5
14	148.3	19.9	137.9	20.4	22.1	2.1	21.6	2.3	11.6	1.4	12.4	1.5
15	153.5	21.1	137.6	22.2	22.0	1.9	21.4	2.2	11.3	1.2	12.4	1.7
						Boys						
7	103.8	17.3	104.8	17.0	25.1	2.1	24.7	2.6	20.0	3.8	23.0	3.9
8	116.2	17.8	114.8	18.8	23.8	1.9	23.4	2.5	17.1	2.9	20.3	3.6
9	121.7	17.7	126.1	22.1	23.5	2.0	22.9	2.7	16.2	2.5	18.2	3.6
10	134.9	18.7	135.4	20.6	22.4	2.1	21.6	2.0	14.4	2.0	16.3	2.5
11	138.7	21.9	141.3	20.6	22.0	1.8	21.0	1.9	13.6	1.7	15.2	2.0
12	144.6	20.9	147.3	24.9	21.8	1.9	20.7	2.1	12.8	1.4	14.2	2.0
13	157.3	22.2	156.2	23.9	21.0	2.0	19.8	1.9	12.0	1.4	13.2	1.9
14	170.2	21.3	171.7	26.2	20.7	1.9	18.9	1.7	11.6	1.3	12.2	1.3
15	186.7	23.8	188.8	28.0	20.4	2.1	18.4	1.7	10.7	1.0	11.5	1.5