Anthropological Review • Vol. 77 (1), 77–86 (2014)
Available online at: https://doi.org/10.2478/anre-2014-0007

Is the secular trend reflected in early stages of human ontogenesis?

Zygmunt Domagała, Paweł Dąbrowski, Michał Porwolik, Krystian Porwolik, Bohdan Gworys

Department of Anatomy, Wrocław Medical University

Abstract: There are a limited number of studies on secular changes in the neonatal period, and the majority of them concern research related to childhood and puberty
The objective of our study was to carry out a comparative analysis of body weight and length at birth in neonates born in Wrocław in subsequent decades since 1950 to find out if these parameters are subject to secular trend, and what values they attained during the studied period of 50 years.
The study was carried out in the 1950s, 1960s, 1970s, 1980s, 1990s and in 2000 to analyse changes in body length, body weight and Rohrer index over time. The sample studied consisted of 7510 neonates, 3882 males and 3628 females, born in Wroclaw. Secular changes were tested using one-way variance analysis. The values of *F* statistics were compared to the critical values of the *F* Snedecor distribution. Changes in the features of neonates in subsequent study years were analysed using the modified z-score. Data were normalised for standard deviation in decade increments.
Results demonstrated very slight, though statistically insignificant increase in body weight at birth. Over the 50-year period the mean body weight of neonates was in the range of 3.3–3.4 kg, regardless of sex.
Results demonstrated very slight, though statistically insignificant increase in body weight at birth. Over the 50-year period the mean body weight of neonates was in the range of 3.3–3.4 kg, regardless of sex: The acceleration in the body length of neonates caused a gradual decrease in the mean values of the Rohrer index.
No secular trend in body weight was found in Wrocław neonates over the 50-year period between 1950 and 2000-With regard to body length at birth, four waves of deceleration and acceleration were found: period 1 (1950s): deceleration in the increase of the analysed body parameters of neonates; period 2 (1960s): acceleration in neonates' growth; period 3 (1970s and 1980s): economic crisis and political transformations in Poland; this is reflected by the stable mean values of body dimensions in neonates. The secular trend clearly decelerated, and period 4 (1990s and 2000) – very intense acceleration in both body weight and length and the Rohrer index.

Key words: neonates, neonatal body length, neonatal body weight, Rohrer index.

Original Article: Received: September 20, 2013 Accepted for publication: December 29, 2013
DOI: 10.2478/anre-2014-0007

Introduction

Acceleration in developmental processes and the timing of puberty, change in the sequence of developmental stages, and delay of involutive processes have been observed from the early 20th century. This process is more pronounced in populations which experience intensive progress and civilisation advance (Bielicki et al. 2005, Avila et al. 2013, Lisner et al. 2013).

Porwolik et al. (2005) demonstrate that environmental factors operating during the foetal period have a significant impact on diversity of body length in neonates. The growth rate is subject to change. In the second half of the 20th century it was identified four periods of changes in body length at birth. The results obtained has encouraged us to continue studies on neonates born in Wrocław, with a focus on their accelerated development. Another important reason for this study was the current debate on the significant role of intrauterine factors in the postnatal development. The last but not least is the knowledge gap on secular changes in prenatal and neonatal periods (Bożiłow et al. 1985, Boziłow et al. 1992, Ziółkowski et al. 1992, Andersen et al. 2010).

The objective of this study was to carry out a comparative analysis of body weight and length at birth in neonates born in Wrocław in subsequent decades since 1950 to find out if these parameters are subject to secular trend, and what values they attained during the studied period of 50 years.

Material and methods

The study was carried out in the 1950s, 1960s, 1970s, 1980s, 1990s and in 2000. Altogether, 7720 babies were born. Two hundred and ten cases (2.7%) were rejected because of evident mistakes in the documentation process, multiple pregnancies, confirmed growth anomalies, etc. For the purposes of this study, only neonates from single pregnancies, vaginal delivery, and to which there were no medical objections were taken into consideration. Measurements were taken at the 1st Department and Clinic of Gynaecology and Obstetrics, Medical University in Wrocław after delivery, by four nurses previously trained by anthropologists. Metric measurements were taken according to standard anthropometric techniques (Boziłow et al. 1985, 1992) using anthropometric tapes with accuracy up to 1 mm, approved by the Polish Central Office of Measures. Body weight was measured on hospital scales, accuracy up to 2 g, approved by the Polish Office of Measures. Each measurement was taken three times. Mean values from the measurements were used for analysis.

The Statistica 10 PL statistical software package was used to identify the compliance of individual absolute values with normal distribution using the Kolmogorov-Smirnov test. Male-female differences were analysed with the Morgan test. The one-way ANOVA was used to test secular changes in subsequent study years. The values of F statistics were compared to the critical values of the F Snedecor distribution at level $\alpha = 0.05$.

Changes in the neonates' traits in subsequent study years were analysed using the modified z-score. Data were normalised for standard deviation in decade increments.

Results

7510 neonates comprising 3882 males and 3628 females from Wrocław underwent analysis (Table 1)

Three characteristics of body size were analysed: body length and body weight of the neonate at birth, and the Rohrer index. The descriptive statistics of the study traits are presented in table 2, or each of these traits, different variability of mean values between 1950 and 2000 was found.

The body length at birth increased in male neonates by 2 cm during the analysed period. In the 1950s, the body length decreased significantly by almost 3 cm on average, to compensate for this decrease in the subsequent decade. Between 1970–1990, a relatively stable mean values for this trait was observed. For the 1990s it was found a significant increase in the mean values of body length at birth in male neonates.

Body length in female neonates increased in the second half of the 20th century by 1.7 cm. The variability of mean values in the subsequent decades followed similar trends as those identified for male neonates, but body lengths were always lower in newborn girls. However, the differences analysed with the Morgan test were found to be statistically insignificant. It should be pointed out that for the 1980s, a 0.6 cm reduction in the mean body length of female neonates was found, while in male neonates this value remained stable.

Table 1. Number of study male and female neonate subjects born in Wrocław in subsequent decades between 1950 and 2000

Study year	Male	Female	Total
1950	668	713	1381
1960	658	537	1195
1970	730	673	1403
1980	731	674	1405
1990	596	578	1174
2000	499	453	952
Total	3882	3628	7510

Between 1950 and 2000 the variability in body weight at birth was at a very low level. Changes in the mean values of body weight for both sexes analysed with the F Snedecor test were statistically insignificant. The analysis also demonstrated no statistical significance in dimorphic differences. It can be assumed that the mean body weight at birth was in the range of 3.3 kg–3.4 kg in the entire analysed period.

Mean values of the Rohrer index increased in both sexes only in the 1950s. In that period the increase in body weight at birth was greater than the increase in body length. In the other analysed decades the values for this index decreased, resulting in decreased mean Rohrer index in the entire study period by 17 units in male neonates and by 15 units in female neonates. Considering the relative stabilisation in mean values of body weight at birth, it can therefore be concluded that the increasing values of body length in neonates caused a gradual decrease in the mean values of the Rohrer index.

For the purpose of the comparative analysis of variability in the studied features in the second half of the 20th century mean values were normalized for standard deviation (z-score). This transformation enabled us the comparison of mean values for studied traits, irrespective of the sex, study decade or absolute values for the trait.

In the 1950s, body length at birth decreased in both sexes by 0.7–0.8 units (Figure 1). Male-female differences were found to be statistically insignificant.

Table 2. Descriptive statistics of body length, body weight and Rohrer index in male and female neonates born in Wrocław according to study year, between 1950 and 2000

Study Year No of subjects	Trait	Sex	Mean	SD	Range Min-Max
1950 Male neonates N=668 Female neonates N=713	Body length (cm)	Male	53.7	3.3	34–63
		Female	53.1	3.5	37–61
	Body weight (g)	Male	3323.3	566.7	1100–6300
		Female	3288.2	607.0	1200–5600
	Rohrer Index	Male	2.15	0.29	1.87–2.80
		Female	2.20	0.36	1.92–2.68
1960 Male neonates N=658 Female neonates N=537	Body length (cm)	Male	50.9	2.6	37–58
		Female	50.4	3.2	41–57
	Body weight (g)	Male	3378.31	599.53	1150–5520
		Female	3348.17	571.25	1200–5500
	Rohrer Index	Male	2.56	0.34	2.03–2.84
		Female	2.61	0.39	2.13–2.99
1970 Male neonates N=730 Female neonates N=673	Body length (cm)	Male	53.9	3.4	38–64
		Female	53.5	2.9	39–59
	Body weight (g)	Male	3338.64	566.61	800–5100
		Female	3341.21	541.10	950–5000
	Rohrer Index	Male	2.13	0.19	1.84–2.31
		Female	2.18	0.23	1.81–2.45
1980 Male neonates N=731 Female neonates N=674	Body length (cm)	Male	54.3	3.4	41–64
		Female	54.3	3.4	41–64
	Body weight (g)	Male	3358.32	573.34	1000–5000
		Female	3314.67	549.61	1000–4800
	Rohrer Index	Male	2.10	0.21	1.74–2.29
		Female	2.07	0.29	1.77–2.32
1990 Male neonates N=596 Female neonates N=578	Body length (cm)	Male	54.3	3.6	40–63
		Female	53.6	3.3	42–64
	Body weight (g)	Male	3341.63	591.38	1050–5350
		Female	3251.33	598.98	1100–5300
	Rohrer Index	Male	2.09	0.36	1.63–2.41
		Female	2.11	0.33	1.76–2.39
2000 Male neonates N=499 Female neonates N=453	Body length (cm)	Male	55.7	3.2	42–63
		Female	54.8	3.4	43–64
	Body weight (g)	Male	3414.72	578.04	1080–5300
		Female	3378.79	557.07	1150–5200
	Rohrer Index	Male	1.98	0.41	1.49–2.39
		Female	2.05	0.39	1.64–2.51

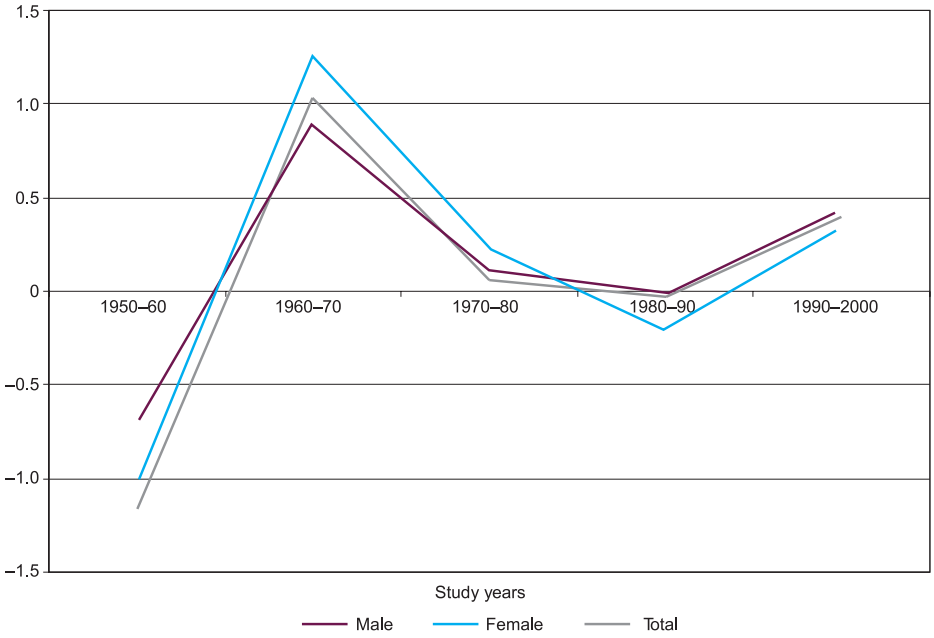

Fig. 1. Normalised increments in body length of neonates born in Wrocław in the second half of the 20th century

Between 1960 and 1980 the values of normalised increments were positive, but gradually decreased in subsequent decades. In the 1980s, the normalised values stabilised in male neonates but decreased in female neonates by 0.04 units. In the 1990s, the normalised values of body length increased significantly by about 0.35–0.45 units.

The normalised values of body weight at birth in neonates born in Wroclaw showed very little variability, regardless of sex (Figure 2). The greatest increase (by 0.22 units) was found in the 1990s in female neonates, while in the same decade the increase in male neonates was by 0.13 units. In the other decades of the 20th century the normalised values of body weight at birth did not exceed 0.1 units in both sexes. Regardless of being above or below zero, these values were too low to be important for the interpretation of changes in the mean body weight between 1950 and 2000.

The normalised values of the Rohrer index were above zero only in the 1950s, when they increased by about 1.2 units in both sexes. In the other decades the normalised values of the Rohrer index were below zero, except for female neonates born in the 1980s (increase by 0.12 units). In the 1990s, the normalised Rohrer index decreased rapidly and was –0.27 units in male neonates and –0.15 units in female neonates. The gradually decreasing index value, coinciding with a relatively stable mean body weight at birth indicate that the acceleration in body length is the main factor responsible for changes in the index value. The decrease in mean normalised index values was correlated with the increase in normalised values for body length at birth.

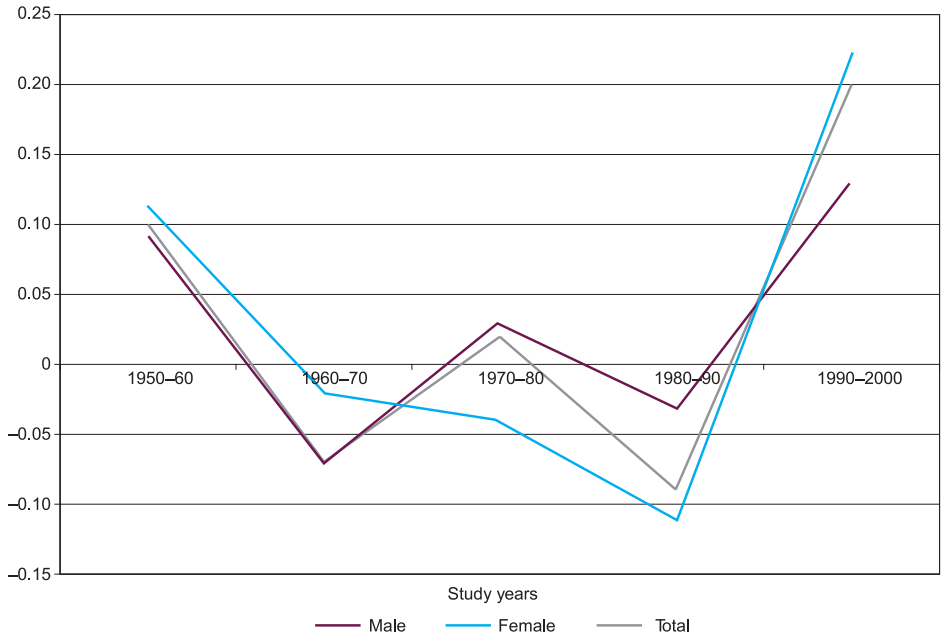

Fig. 2. Normalised increments in body weight of neonates born in Wrocław in the second half of the 20th century

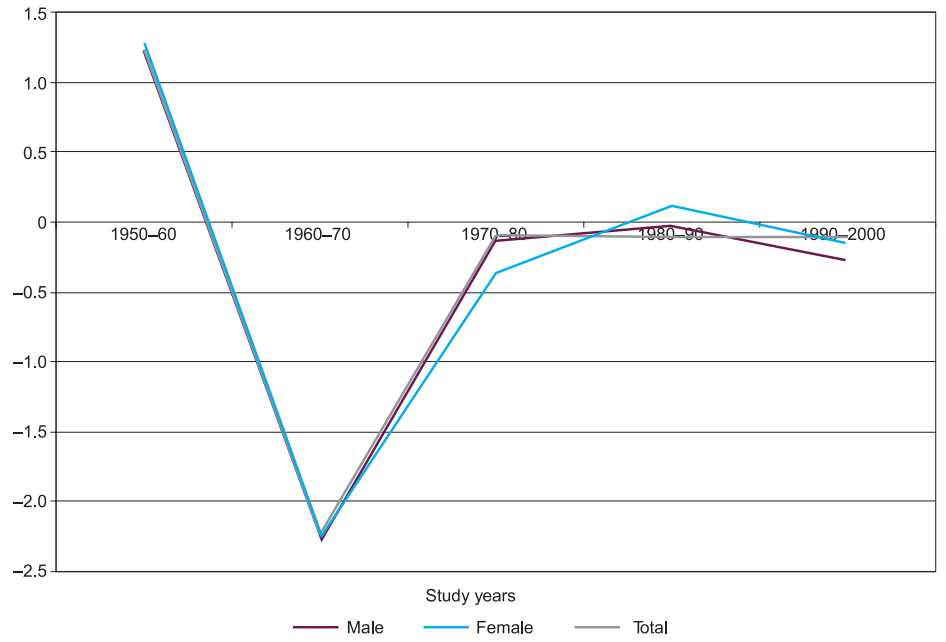

Fig. 3. Normalised increments in the Rohrer index for neonates born in Wrocław in the second half of the 20th century

Discussion

The choice of features analysed in our study was not accidental. Body height (body length in neonates) is a parameter which actively responds to long-term changes in socio-economic conditions, by both increase or decrease in mean values (Bożiłow et al. 1985, Ziółkowski et.al. 1992, Andersen and Osler 2004, Barker et al. 2005, Schack-Nielsen 2006, Kułaga et al. 2011, Avila et al. 2013, Mirmiran et al. 2013). Body weight is known for displaying the substantial plasticity and has been found to change most dynamically during periods of radical but also rapid changes that occur in the body. This particularly refers to embryo-foetal, perinatal and neonatal periods (Bożiłow et al. 1992, Koupilova et al. 2000, Andersen and Osler 2004, Brialić et al. 2006, Grandi and Dipierri 2008). Fluctuations in mean body weight indicate the short-term effects of changing environmental conditions on the human body, while long-term studies demonstrate that body weight adapts relatively quickly to the effects of changing environmental conditions. The Rohrer index is one of the weight- and height-related parameters characterising leanness or corpulence of the body in the most general terms. Rysiewski and Książyk (2009) wrote that "Results of formal analysis of indices may make researchers pessimistic. The reason for this is the fact that, according to studies, the interpretation of indices in terms of physicality is generally difficult, and for all indices provide more or less rescaled body weight. These results diverge from the objective, which was focused on finding new information on the studied individual through a measure which is the function of body weight and body height. At best, although still unsatisfactory, this objective can be reached by using the Rohrer index, which is to the lowest degree correlated with the body weight". For this reason we chose the Rohrer index for the analysis of secular changes in the studied population of neonates.

Many researchers have pointed out that secular trends are significantly diversified in the same time intervals for different populations, but also for the same population in different time intervals. Secular changes are much more pronounced in the social groups and populations that experience the strongest delay in socio-economic progress. For this reason secular changes are found to be the most intensive in developing countries, in lower social groups (Koupilova et al. 1998, Koupilova et al. 2000, Brialić et al. 2006, Schack-Nielsen et al. 2006, Grandi and Dipierri 2008, Avila et al. 2013, Hata et al. 2013, Lissner et al. 2013). In our study we found no secular changes in body weight between 1950 and 2000. Changes in the mean values of body weight, both absolute and normalised, were not statistically significant and did not show significant dimorphic differences. The analysis of the Rohrer index revealed two periods of change in the second half of the 20th century. In the first period (1950s) values of the index gradually increased, suggesting the increasing corpulence of neonates of both sexes. In the second period (1960–2000) index values decreased. This indicates changes towards leaner bodies in neonates born in Wrocław, despite minor fluctuations of the index values in single study years.

As was expected, the secular trend particularly concerns body length at birth. The changing socio-economic conditions in Poland caused by economic

crisis in the late 1970s and early 1980s, followed by political transformations, modified ontogenesis during both the prenatal and neonatal period (Bożiłow et al. 1985, Bożiłow et al. 1992, Ziółkowski at al. 1992). Similar conclusions were made from studies on (exotic for us) populations from Papua New Guinea (Ulijaszek 2001) and Argentina (Grandi and Dipierri 2008). During the studied 50 years we identified four periods characterised by diversified orientation and rate of secular changes. Period 1 (1950s): deceleration in the increase of the analysed body dimensions of neonates. Period 2 (1960s): acceleration in neonates' growth. Period 3 (1970s and 1980s): economic crisis in Poland, decrease in socio-economic level and radical political transformations. This was reflected in stable mean body dimensions of neonates, and the secular trend was clearly inhibited. Period 4 (1990s and 2000): very intense acceleration in all analysed features of neonates.

Unlike in Poland, in countries that did not experience radical socio-economic transformations or war, studies demonstrated stable, weak acceleration of mean values for body weight and length in neonates (Schack-Nielsen et al. 2006). Brazilian researchers (Silva et al. 2005) also demonstrated that in well-off populations that have easy access to health care services negative secular trends can occur temporarily.

In our studies we found no clear trend attenuating such changes in neonates born in Wrocław. On the contrary, in the 1990s we found a significant acceleration of growth and increase in the leanness of neonates. This may suggest that the expression of inherited potential for development in the studied period of ontogenesis, and with respect to analysed features, has not reached the level determined by the genetic makeup.

Conclusions

No secular changes in body weight of neonates between 1950 and 2000 was found.

The analysis of the Rohrer index revealed two periods of changes in the second half of the 20th century. In the first period (1950s) values of the index gradually increased, suggesting increasing corpulence in neonates of both sexes. In the second period (1960–2000) index values decreased, suggesting a gradual increase in the leanness of the neonates.

During the studied years, four periods of various direction and the rate of secular changes in the length of neonates born in Wrocław were identified: period 1 (1950s) with deceleration in the body length of neonates; period 2 (1960s) with acceleration in neonates' growth; period 3 (1970s and 1980s) most probably associated with economic crisis in Poland, decrease in socio-economic level and radical political transformations. This was reflected in stable mean body dimensions of neonates, and the secular trend was clearly inhibited, and period 4 (1990s and 2000): very intense acceleration in neonates' body weight and length and the Rohrer index.

Acknowledgements

The authors together with the anthropological-medical research team would like to thank to the employees from the obstetrician ward in the clinical hospital no. 1 in Wrocław.

Author Contribution:

ZD collected data and wrote final version of the article; PD perform statistical analysis and wrote initial version of the article; MP collected data and prepare required literature; KP collected data, analysis of all collected data; BG created general idea of the study, reviewed initial and final version of the article.

Conflict of interest

The Authors declare that there is no conflict of interests regarding the publication of this article.

Corresponding author

Zygmunt Domagala, Katedra i Zakład Anatomii Prawidłowej Uniwersytetu Medycznego we Wrocławiu, ul. Chałubińskiego 6a, 50–367 Wrocław
e-mail address:
zygmunt.domagala@am.wroc.pl

References

Andersen AM, Osler M. 2004. Birth dimensions, parental mortality, and mortality in early adult age: a cohort study of Danish men born in 1953. Int J Epidemiol. 33(1):92–9.

Andersen LG, Angquist L, Eriksson JG, Forsen T, Gamborg M, Osmond C, et al. 2010. Birth weight, childhood body mass index and risk of coronary disease in adults: combined historical cohort studies. PLoS One 5(11):e12126.

Avila JA, Avila RA, Gonçalves EM, Barbeta VJ, Morcillo AM, Guerra-Junior G. 2013. Secular trends of height, weight and BMI in young adult Brazilian military students in the 20th century. Ann Hum Biol. Jul 11. In press.

Barker DJ, Osmond C, Forsén TJ, Kajantie E, Eriksson JG. 2005. Trajectories of growth among children who have coronary events as adults. N Engl J Med 353(17):1802–09.

Bielicki T, Szklarska A, Kozieł S, Ulijaszek SJ. 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):427–34.

Bożiłow W., Gworys B., Kurlej W., Poradnik E. 1985. Długość ciała noworodków wrocławskich w świetle dokumentacji szpitalnej. MiPA 106:93–103.

Bożiłow W., Sawicki K., Poradnik E., Kurlej W., Gworys B. 1992. Zmienność masy ciała podczas rozwoju prenatalnego i okołoporodowego. Przegl Antrop 55:45–55.

Brialić I, Rodin U, Vrdoljak J, Plavec D, Capkun V. 2006. Secular birth weight changes in liveborn infants before, during, and after 1991–1995 homeland war in Croatia. Croat Med J 47(3):452–58.

Eriksson JG, Forsén T, Tuomilehto J, Jaddoe VW, Osmond C, Barker DJ. 2002. Effects of size at birth and childhood growth on the insulin resistance syndrome in elderly individuals. Diabetologia 45(3):342–48.

Grandi C, Dipierri JE. 2008. Secular trend of birth weight in Argentina (1992–2002): a population based study. Arch Argent Pediatr 106(3):219–25.

Hata J, Ninomiya T, Hirakawa Y, Nagata M, Mukai N, Gotoh S, et al. 2013. Secular Trends in Cardiovascular Disease and its Risk Factors in Japanese: Half Century Data from the Hisayama Study. Circulation. Jul 31. In press.

Koupilova I, Rahu K, Rahu M, Karro H, Leon DA. 2000. Social determinants of birthweight and length of gestation in Estonia during the transition to democracy. Int J Epidemiol 29(1):118–24.

Koupilová I, Vågerö D, Leon DA, Pikhart H, Príkazský V, Holcík J, et al. 1998. Social variation in size at birth and preterm delivery in the Czech Republic and Sweden, 1989–91. Paediatr Perinat Epidemiol 12(1):7–24.

Kułaga Z, Litwin M, Tkaczyk M, Palczewska I, Zajaczkowska M, Zwolinska D,et al. 2011. Polish 2010 growth references for school-aged children and adolescents. Eur J Pediatr 170:599–609.

Łaska-Mierzejewska T, Olszewska E. 2007. Anthropological assessment of changes in living conditions of the rural population in Poland in the period 1967–2001. Ann Hum Biol 34(3):362–76.

Lissner L, Mehlig K, Sjöberg A, Chaplin J, Niklasson A, Albertsson-Wikland K. 2013. Secular trends in weight, height and BMI in young Swedes: the 'Grow up Gothenburg' studies. Acta Paediatr 102(3):314–17.

Malina RM, Reyes ME, Little BB. 2010. Secular change in heights of indigenous adults from a Zapotec-speaking community in Oaxaca, southern Mexico. Am J Phys Anthropol 141(3):463–75.

Mirmiran P, Moslehi N, Asghari G, Jambarsang S, Mehrabi Y, Azizi F. 2013. Secular trends in size at birth of Iranian neonates: meta-analyses of published and unpublished studies. Ann Hum Biol 40(1):75–82.

Porwolik K, Gworys B, Porwolik M, Dudek K, Akinpelumi BF. 2005. Acceleration of body length growth in Wroclaw neonates in the second half of the XX century (1950–2000). Adv Clin Exp Med 14:197–201.

Risnes KR, Vatten LJ, Baker JL, Jameson K, Sovio U, Kajantie E, et al. 2011. Birthweight and mortality in adulthood: a systematic review and meta-analysis. Int J Epidemiol 40 (3):647–61.

Rysiewski H, Książyk J. 2009. Wskaźniki wagowo-wzrostowe: próba konfrontacji oczekiwań auksologicznych z rzeczywistością formalno-matematyczną. Pediatria Współczesna. Gastroenterologia, Hepatologia i Żywienie Dziecka 11:13–17.

Schack-Nielsen L, Molgaard C, Sorensen TI, Greisen G, Michaelsen KF. 2006. Secular change in size at birth from 1973 to 2003: national data from Denmark. Obesity 14: 1257–63.

Silva AA, Bettiol H, Barbieri MA, Pereira MM, Brito LG, Ribeiro VS, et al. 2005. Why are the low birthweight rates in Brazil higher in richer than in poorer municipalities? Exploring the epidemiological paradox of low birthweight. Paediatr Perinat Epidemiol 19(1):43–49.

Sławińska 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 2007.2012. Am J Hum Biol 24(5):587–94.

Talma H, Schönbeck Y, van Dommelen P, Bakker B, van Buuren S, Hirasing RA. 2013. Trends in menarcheal age between 1955 and 2009 in the Netherlands. PLoS One. In press.

Thomas NE, Jasper M, Williams DR, Rowe DA, Malina RM, Davies B, et al.2011. Secular trends in established and novel cardiovascular risk factors in Welsh 12–13 year olds: a comparison between 2002 and 2007. Ann Hum Biol 38(1):22–27.

Tretyak A., Godina E., Zadorozhnaya L. 2001. Secular Trends of Sizes at Birth in Russian Infants Born between 1987 and 2002, J Physiol Anthrop Appl Hum Sci, 24(4):403–06.

Ulijaszek SJ. 2001. Secular trend in birthweight among the Purari delta population, Papua New Guinea. Ann Hum Biol 28(3):246–55.

von Soest T, Wichstrøm L. 2013. Secular Trends in Depressive Symptoms Among Norwegian Adolescents from 1992 to 2010. J Abnorm Child Psychol. In press.

Zilberberg MD, Shorr AF. 2013. Secular Trends in Gram-Negative Resistance among Urinary Tract Infection Hospitalizations in the United States, 2000–2009. Infect Control Hosp Epidemiol. 34(9):940–46.

Ziółkowski M, Gworys B, Kurlej W. 1992. Secular changes in human fetuses normally aborted in years 1965–1985. Studies in Human Ecology 10:63–74.