



# Secular trends in body weight and length of children aged 0–2 years. Longitudinal study of five consecutive birth cohorts between 1964–2003 from Wrocław, Poland

Krzysztof Boryśławski<sup>1</sup>, Sławomir Kozieł<sup>2</sup>

<sup>1</sup>Department of Anthropology, Wrocław University of Environmental and Life Sciences, Poland

<sup>2</sup>Polish Academy of Sciences, Anthropology Unit in Wrocław, Poland

**ABSTRACT:** The aim of this work is to evaluate the intensity of possible secular trends among the five subsequent cohorts of Wrocław (Poland) children aged 0, 6, 12 and 24 months. This document describes secular changes in the body length, weight and the Rohrer's index.

**Material:** Research material represent the longitudinal studies of five consecutive birth cohorts. The first study involved children born during 1963–1965, and the last in 2003–2005. All of the studies were related to the same social group and were conducted using the same methodology.

There are differences in the intensity and direction of the secular trends in children depending on their age. In both sexes the body length of newborns kept increasing until the end of the nineties and decreased in the last decade. The body weight did not change during the 40-year period. This suggests an important role of maternal regulator in fetal development and therefore no clear response to external environmental factors. Secular changes such as the body length and weight, which are the most adequate to the economic changes in Poland, were observed in children aged 6 and 12 months. It may be a result of their highest ecosensitivity during this period. However, there have not been any clear trends observed in the 24 months age group. This may be due to the increasing participation of genetic factors in the development of the child.

**KEY WORDS:** physical development, longitudinal data, children aged 0–2, GDP in Poland

## Introduction

The tendency for intergenerational changes (*in +* or *in-*) of biological indicators is an expression of phenotypic plasticity rather than modification of the genetic program (Meredith 1964). Changes in the positive direction (acceleration)

are indicative of a fuller realization of the developmental potential of individuals due to the emergence of favorable conditions in which this development takes place (Bielicki 1986; van Wieringen 1986; Tanner 1987; Rosenberg 1988; Kuh et al. 1991; Prebeg 1998). In turn, reducing the values of anthropometric

traits indicates deterioration of these conditions. There are also reports of the gradual expiration of the secular trend in countries with the satisfying, optimal standard of living (e.g. Ward and Ward 1984; Lindgren et al. 1991; Cole 2000).

It has been reported that political and socio-economical transition in Poland induced the changes in nutrition, resulting in increase of BMI of population. For example, prevalence of obesity between 1986 and 2001 in 19-year-old males increased three folds from 0.8 to 2.4%. Moreover significant effect was observed in increase variation of BMI in all social strata across the entire period (Kozieł et al. 2004).

Therefore, secular changes are largely the result of changes in environmental factors modifying the ontogenesis. In the postnatal period, this concerns mainly the socio-economic status. However, prenatal period is mainly determined by factors associated with mother's body (maternal regulator), and only partly related to the SES. Karn and Penrose (1961) have estimated the impact of the above factors on fetal development at 62%. Other factors e.g. the genotype of the fetus (20%) and somatic measurements of mother's body are not related to the environmental conditions such as maternal age or number of previous pregnancies (Prochorow et al. 1976; Piasecki 1983; Cieślík and Waszak 1992; Kornafel 1995, Ekonjo et al. 2003; Kubiak-Fortecka and Wilczyński 2009).

The phenomenon of secular trends in neonate and in children under 2 age is relatively little known because of the difficulty in gathering data for subsequent birth cohorts within the same social group. Most of the work addressing this issue relates to the development of school-age children and the elderly and

only a few apply to children under 2 years old. In Poland such studies were, among others, conducted by Bałasz and Bocheńska 1968; Kaliszewska-Drozdowska 1971; Prochorow et al. 1976; Borysławski 1994; Töppich 2001.

The first studies of Wrocław children aged 0–2 years, born in 1964–1965 (Borysławski 1985; 1988) were conducted in the sixties of the last century. The material consist of data related to children living in the city center. Over the following four decades children born in 1973–1975, 1983–1985, 1993–1995 and 2003–2005 (Borysławski 1994) were assessed. All studies were conducted in the same medical clinics and using the same measurement techniques. Also, the same were the characteristics of the survey during the collection of the material. Therefore, both the methodology and the continuity of observation of the same socio-demographic environment were preserved. This reduced the risk of a wrong estimation of the changes between generations and allowed an attempt to assess them (Bocheńska 1978; Kromayer 1997; Haładaj et al. 2003; Żaczek 2004) in relation to the changing economic and social situation as well as political system during this period in Poland.

The aim of this work is to evaluate the intensity of possible secular trends in birth weight, length and Rohrer's index among the five subsequent cohorts of children. It is known that after birth the sensitivity of the organism to the influence of the environmental factors increases (e.g. Bałasz and Bocheńska 1968; Bocheńska 1978; Borysławski, Kurlej 1984; Wolański 2006). Therefore, an assessment of secular changes was conducted in four age categories: at birth, 6, 12 and 24 months.

## Materials and methods

The material comes from three clinics for healthy children in the district of Old Town in Wrocław (over 600 thousands of inhabitants). The size of the material in a recent survey is smaller because of the difficulty in gathering information caused by the recently introduced Privacy Law and protection of personal data. It takes into account the length, the body weight and Rohrer's index [body weight (g) × 100/body length<sup>3</sup> (cm)], and also characteristics of the survey: birth order of children, the age and the occupation of mother and father. The birth weight and length were measured within two hours after birth by professional obstetrics using weightmeter and Epstain's length board. Body weight and length were next measured by occasion of the visit in clinic for healthy children at the age of 6, 12 and 24 months by trained nurses.

In order to assess the significance of the trend the weighted linear regression was fitted to the means of body weight and length, separately for sex. Significant positive or negative value of Betas indicated existence and direction of trends.

## Results

The order of birth across birth cohorts seems to be very similar, with the first born children dominating (58–66%) and 29–35% of children born as a second in order (Table 1). To ensure comparability with the earliest studies, the age of parents was considered in three age categories. In all of the studies the highest percentage was of parents, especially mothers, between 22 and 30 years of age. The percentage of young parents was the smallest and that has not significantly changes in the observed 40-year period. By contrast, from the 60s the percentage of parents aged over 30 years reduced, but increased in the 22–30 years age group. For mothers, this trend is particularly pronounced since the 90s. Professional activity in the first three studies dealt only with two categories, because due to ideological reasons there was no official unemployed at the time. There is a significant trend, particularly noticeable in mothers, of rising percentage of white-collar workers at the expense of physical labour.

The analysis includes the estimation of intensity and direction of secu-

Table 1. Percentages of children in categories of birth order, mothers (M) and fathers (F) age and mothers (M) and fathers (F) occupational status in the examined birth cohorts.

Birth cohort [years]	Birth order <sup>1</sup>			Parents' age [years] <sup>2</sup>						Parents' occupational status <sup>3</sup>					
				x–21		22–30		31–x		White-collar		Manual		Unemployed	
	1	2	3+	M	F	M	F	M	F	M	F	M	F	M	F
1964–1965	58	35	7	9	3	64	51	27	46	50	48	50	52	–	–
1973–1975	66	29	5	14	7	63	54	23	39	48	43	52	57	–	–
1983–1985	64	29	7	12	7	64	57	24	36	51	47	49	53	–	–
1993–1995	59	31	10	11	5	69	60	20	35	52	45	36	47	12	8
2003–2005	64	30	6	9	3	73	62	18	35	62	52	28	45	10	3

<sup>1</sup> $\chi^2=8.134$ ;  $p=0.421$

<sup>2</sup>for mothers  $\chi^2=9.28$ ;  $p=0.319$ ; for fathers  $\chi^2=13.05$ ;  $p=0.110$

<sup>3</sup>for mothers  $\chi^2=18.37$ ;  $p=0.001$ ; for fathers  $\chi^2=3.72$ ;  $p=0.445$

Table 2. Means and standard deviations of investigated anthropometric traits in age categories of boys and girls in five examined birth cohorts.

Birth cohort (years)	BOYS					GIRLS								
	Body length [cm]		Body weight [kg]		Rohrer's index	Body length [cm]		Body weight [kg]		Rohrer's index				
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD			
	N					N								
		At birth												
1964–1965	100	52.20	2.31	3.45	0.43	2.42	0.25	100	51.03	2.43	3.22	0.48	2.45	0.24
1973–1975	100	52.72	2.79	3.33	0.52	2.27	0.20	100	52.52	2.21	3.28	0.43	2.26	0.20
1983–1985	100	53.97	3.04	3.38	0.48	2.15	0.23	100	53.57	2.55	3.24	0.41	2.12	0.19
1993–1995	131	54.62	3.07	3.44	0.52	2.11	0.23	117	54.01	2.94	3.18	0.51	2.13	0.25
2003–2005	61	53.90	2.59	3.36	0.53	2.14	0.33	74	53.16	2.82	3.29	0.44	2.22	0.23
		At 6 months												
1964–1965	100	68.78	2.15	8.36	0.77	2.58	0.27	100	66.68	2.35	7.60	0.76	2.57	0.24
1973–1975	100	69.03	2.42	8.33	0.77	2.53	0.22	100	68.03	1.89	7.82	0.78	2.48	0.20
1983–1985	100	69.23	2.05	8.32	0.83	2.51	0.23	100	67.32	1.93	7.48	0.77	2.45	0.21
1993–1995	131	67.24	2.92	7.96	0.73	2.62	0.22	117	65.90	2.78	7.36	0.82	2.57	0.23
2003–2005	61	65.30	2.59	7.57	1.03	2.73	0.41	74	64.61	2.33	7.26	0.82	2.70	0.36
		At 12 months												
1964–1965	100	76.73	2.28	10.72	0.99	2.38	0.24	100	74.46	2.50	9.84	0.93	2.39	0.22
1973–1975	100	77.01	2.44	10.56	1.06	2.31	0.19	100	75.60	2.21	10.01	1.03	2.32	0.20
1983–1985	100	77.42	2.16	10.63	1.11	2.29	0.19	100	75.66	2.22	9.65	1.04	2.23	0.21
1993–1995	131	76.53	2.88	10.65	0.94	2.38	0.20	117	75.57	2.45	9.75	1.23	2.30	0.24
2003–2005	61	75.82	2.49	9.92	1.19	2.27	0.27	74	75.46	2.87	9.60	1.17	2.24	0.26
		At 24 months												
1964–1965	100	87.71	2.80	13.04	1.08	1.94	0.16	100	85.82	3.23	12.05	1.05	1.90	0.17
1973–1975	100	88.37	2.69	12.89	1.25	1.87	0.14	100	88.63	2.83	12.51	1.14	1.80	0.14
1983–1985	100	89.29	2.62	13.30	1.34	1.87	0.13	100	87.54	2.84	12.29	1.29	1.83	0.16
1993–1995	131	89.00	3.61	13.27	1.62	1.88	0.17	117	87.53	3.50	12.33	1.70	1.86	0.20
2003–2005	61	89.47	3.51	12.43	1.80	1.73	0.20	74	88.98	3.83	12.53	1.63	1.78	0.22

lar changes during the observed 40-year period.

Table 2 shows the descriptive statistics of three analyzed features for successive cohorts by sex. Body length (Fig. 1) at birth in both sexes, from the 60s up to 90s shows positive secular trend (beta = 0.88;  $p < 0.001$ , and beta = 0.82;  $p < 0.001$ , for boys and girls respectively). Body length at 6 months of age in boys and girls increased from 60s to 80s and 70s and then rapidly decreases, resulting in negative secular trend for both sexes (beta = -0.80 and -0.72;  $p < 0.001$ , for boys and girls respectively). At 12 months the body length shows some sex differences, in boys increased up to 80s and then decreased, while in girls reaches a peak in the 70s and for four decades has remained virtually at the same level (beta = -0.53 and 0.64;  $p < 0.001$ , for boys and girls respectively). Starting from the 60s observed a growing trend in boys body length of 24 month of life (beta = 0.90;  $p < 0.001$ ). In girls from the 60s to 70 observed a significant increase in average body length (more than 3cm, beta = 0.63;  $p < 0.001$ ). Then its value decreases, and in the 80s and 90s is similar. In the last decade, followed by a renewed increase in the average length of the body.

The values of body weight in boys and girls (Table 2, Fig. 2) at birth are very close in five examined cohorts and show no clear trends over time (beta = -0.09;  $p < 0.05$ , and beta = 0.01; n.s., for boys and girls respectively). At 6 months of age in boys during the first three decades the body weight is maintained at a similar level and then in the subsequent two clearly decreases. In girls the body weight was higher only in the 70s compared with the 60s. Since the 70s this feature has been decreasing, as well as in boys,

resulting in genitive secular trend in both sexes (beta = -0.88, and -0.81;  $p < 0.001$ , for boys and girls respectively). At 12 months of age changes in body weight in boys and girls in the first decade run in different directions – decreased in boys and increased in girls. In the second and third decade these values in boys remained at a similar level and only in the fourth decade clearly decline. The body weight in girls decreased from the 70s to 80s, and no clear secular changes were observed in the decades that followed. Fitted weighted linear regression showed negative trend (beta = -0.62, and -0.69;  $p < 0.001$ , for boys and girls respectively). At the age of 24 months in the first decade you can observe a negative secular trend in boys and a positive in girls (beta

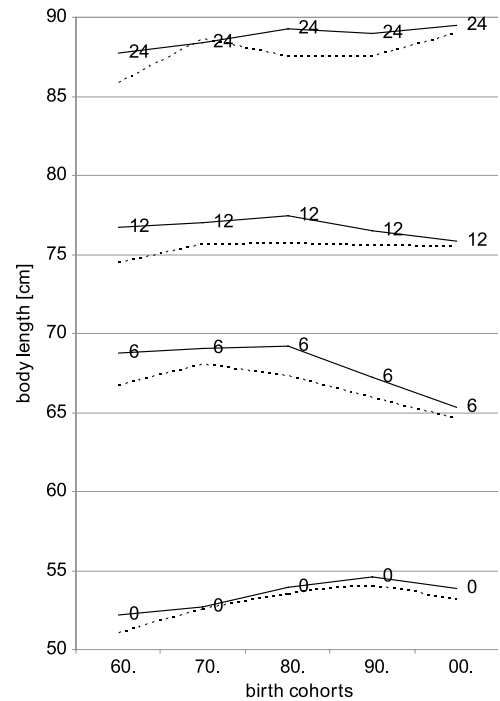


Fig. 1. Secular changes in body length of boys (—) and girls (-----) aged 0, 6, 12 and 24 months in five examined birth cohorts

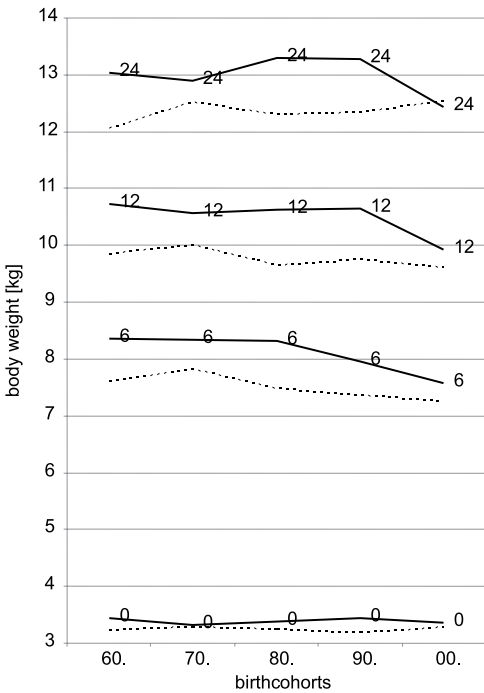


Fig. 2. Secular changes in body weight of boys (—) and girls (-----) aged 0, 6, 12 and 24 months in five examined birth cohorts

= -0.61, and 0.59;  $p < 0.001$ , for boys and girls respectively). In the 70s the body weight increased in boys; in the 80s remained at the same level and only in the last decade it clearly reduced. In girls in the 80s and 90s the body weight slightly declined and in the last decade rose again, reaching levels from the 70s and even surpassing the 24 monthly body weight in boys.

Rohrer's index (Table 2, Fig. 3) is usually higher in boys and, except in children 6 months of age, it was the highest in 60s. In the analyzed period it changes similarly in both sexes. In the newborns it's values clearly decrease until 80s in girls and 90s in boys and then increase again - more so in girls, resulting in significant negative secular trend (beta =

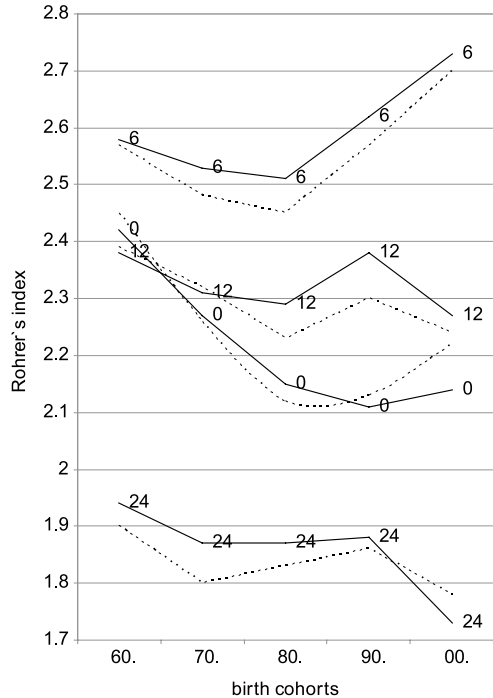


Fig. 3. Secular changes in Rohrer's index of boys (—) and girls (-----) aged 0, 6, 12 and 24 months in five examined birth cohorts

-0.91 and -0.74;  $p < 0.001$ , for boys and girls respectively). At 6 months of life, same as at birth, it declines in the first two decades reaching the lowest value in the 80s, then it increases to the highest level throughout all of the period (beta = 0.64 and 0.51;  $p < 0.001$ , for boys and girls respectively). At 12 months of age the Rohrer's index decreases in the first two decades, then up to the 90s it increases but then decreases again (beta = -0.29 and -0.76;  $p < 0.001$ , for boys and girls respectively). Similarly, at 24 months of life in the first decade you can observe the decrease, then the increase in the value until the 90s and in the last decade decrease again (beta = -0.77 and -0.53;  $p < 0.001$ , for boys and girls respectively). The rate of reduction is more pro-

nounced in boys which results in boys being slimmer than girls.

### Discussion

As shown above, maternal factors (age and occupation of parents, birth order) have not changed in the last 40-years. Therefore, one can assume that the observed secular trends are mainly due to changes in economic status at that time. One can also expect that these changes are more pronounced in older children. The body length (height) is a trait of the more genetically determined and hence less susceptible to the environmental changes than the body weight. The body weight is therefore a good indicator for assessing changes in short-term living standard of the population and the body height can better reflect the long-term trends.

It seems that the described secular trends correspond to changes of social and economic situation in Poland during the last 40-year (Figs 4 and 5). The 60s and 70s was a period of relative stability

and even an improvement in the economic situation. The economic crisis which occurred at the end of the 70s, with food rationing, the associated social unrest, and the introduction of martial law lasting almost 2 years (December 1981–July 1983), resulted in further deterioration of the economic situation. In turn, the beginning of the 90s was a period of intense social changes associated with regime changes. The introduction of the capitalist economy has been associated with many reforms of the state and its administration, the elimination of many factories and rising unemployment. The result was a marked reduction in living standards, particularly in the lower strata of society. Since 1992 followed by a slow, gradual improvement of the macroeconomic indicators and growth in living standards but this does not apply equally throughout society. There are significant disparities appearing in living standards of families from different social strata. The rate of unemployment among low-skilled or unskilled workers increased

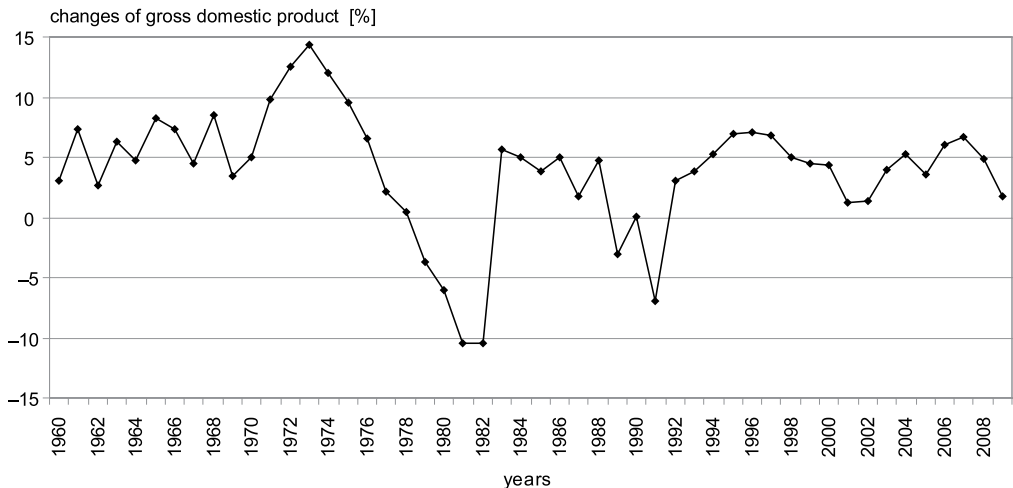


Fig. 4. Annual changes (%) in the value of Gross Domestic Product in Poland in the years 1960–2009 (based on publications of the Central Statistical Office of Poland)

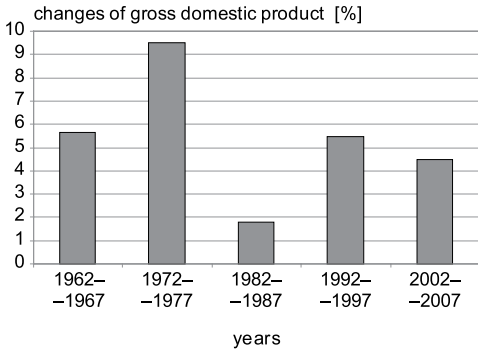


Fig. 5. Average changes in the value of gross domestic product in Poland in the periods of development of examined children from conception to 2 years

significantly. The test population of Wrocław district ranks rather low on the social ladder (Bergman et al. 1988), so it can be assumed that the improved economic situation in Poland in the years 1995–2007 did not improve significantly their economic situation (Zienkowski 2000).

As expected, in the first decade (60.–70.) body length increased in both sexes in all age categories; in the second decade (70.–80.) it increased among boys and only in girls aged 0 and 12 months (Fig. 1). In subsequent decades the body length either reduced (children 6 month and 12 month boys) or was not significantly affected. Slight acceleration of the body length of newborns of both sexes until the 90s and a small decrease in the last decade indicate the influence of factors other than economic on the development of this trait. Similarly, the absence of clear trends in the age of 24 months might indicate the increasing with age role of genotypic control over the speed of the development (Wilson 1979). It should be noted that the early childhood is the period of special parental care, so

even unfavorable environmental conditions can to a lesser extent affect the development of children at this age.

It seems that secular changes most adequate to economic trends can be observed in children aged 6 and 12 months. This is probably due to the transitional nature of this period. Lack of the effect of maternal regulator and not quite full activity of own genes may justify the strong influence of environmental factors on the formation of the body length in this period (Cole 2003). Similar, but somewhat less marked trends relate to the body weight although this feature is practically not changing in newborns of both sexes (Fig. 2). Based on the study of Wrocław infants born in the years 1949–1989 Kornafel (1985; 1995) also found that there are slight variations in body weight between successive birth cohorts. These differences proved insignificant even if the influence of mother age and order of birth were not considered.

All of those observations apply to infants born in the years 1972, 1982 and 1992 in Kluczbork (Töppich 2001).

Changes in Rohrer's index in newborns indicate that they are getting slimmer (Fig. 3). Only in the last decade its value increased slightly. A similar trend in Wrocław newborns in the years 1949–1989 noted Kornafel (1985; 1995) and Töppich (2001) in Kluczbork newborns in the years 1972–1992. Becoming slimmer children aged 6 month one can observe only until the 80s and in the subsequent two decades they are more corpulent. In children aged 12 and 24 months you can note generally tendency to decline Rohrer's index value. Only in the 90s it's value in both sexes were higher than in the previous decade.



## Conclusions

1. Based on the available information it can be concluded that during the examined 40-year period there were no significant changes in the socio-demographic profile of the studied residents of The Old Town in Wrocław but their economic status probably did change.
2. In both sexes of newborns the body length gradually but regularly increased until the 90s and slightly decreased in the last decade. The body weight did not change during 40-year period. This seems to confirm the important role of the maternal regulator in fetal development and therefore no clear response to external environmental factors.
3. Secular changes, both in the body length and the weight, which are the most adequate to the economic changes in Poland, occurred in children 6 and 12 months, which may indicate the highest ecosensitivity during this period.
4. There were no clear, directional trends observed in the investigated traits at 24 months of age. This may be due to the increasing participation of the genetic factors in the development of the child.

## Authors' contributions

KB collected the data and conducted the statistical analysis, interpreted the results, prepared the first draft of the manuscript and approved the final version of the manuscript. SK expanded statistical analysis, supervised and reviewed the article and co-wrote the final version of the article.

## Conflict of interest

The Authors declare that they have no conflict of interests.

## Corresponding author

Krzysztof Boryslawski, Department of Anthropology, Wrocław University of Environmental and Life Sciences, Koźuchowska 5, 51-631 Wrocław, Poland, e-mail address: krzysztof.boryslawski@up.wroc.pl

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