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Body height differentiation by season of birth: Girls from Cracow, Poland

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ABSTRACT Published studies world wide demonstrate that measures of human development and health status vary depending on the month of birth but these patterns are not always consistent and sometimes even conflict. Direct factors related to the birth season that may significantly differentiate morphological and functional traits and mechanisms causing these relations have not been found so far. On the basis of cross-sectional material, gathered in the years 1983 and 2000 by the Department of Anthropology of the Academy of Physical Education in Cracow, two main hypotheses have been verified: (1) average body height differences by month of birth are statistically insignificant, (2) the magnitude of these differences does not change with time. Metric data of 4672 girls aged 5-18 years, born in 1965-1978 and 1982-1995, were used. The total sample was also subdivided into prepubertal (5-9 years) and adolescent (10-18 years) groups. The age of the individuals was calculated to the nearest day and the procedure of standardization on the interpolated values of regional norms was applied. A highly significant relationship between the birth month and average values of height was revealed in preadolescent girls. The results obtained for the entire material proved insignificant. The patterns of the month-of-birth effect on body height for girls born in 60./70. and 80./90. show high similarity, though the effect seems weaker in the latter sample. Winter proved to be the most favorable birth season for later body height.

KEY WORDS: seasonality, month-of-birth effect, stature of girls, growth

Living organisms respond to astronomical and climatic seasonal changes in the annual cycle and this reactivity is observed at all levels of species organization from the individual level through local groups and populations to species scale, including humans. Seasonal effects have been reported worldwide for conceptions, births and deaths, rates of illness and intensification of illness, growth

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rates [PANEK 1960; BOGIN 1978, 1979; MIRWALD and BAILEY 1997; XU *et al.* 2001], levels of physical activity and psychophysical abilities.

The effect of factors related to birth season/month on individual biology in various periods of ontogeny has been observed. Epidemiological studies show such influence on morphological and functional development and health status in the perinatal period, reflected for example in birth weight [FALLIS and HILDITCH 1989, BOŻIŁOW *et al.* 1992, KINABO 1993, MATSUDA and HIROSHIGE 1995, WELLS and COLE 2002, ELTER *et al.* 2004, MURRAY *et al.* 2000, TUSTIN *et al.* 2004, LAWLOR *et al.* 2005, MCGRATH *et al.* 2005, CHODICK *et al.* 2007]. Similar effects are apparent at older ages that affect physical development, risk of occurrence of some diseases, psychophysical ability, reproductive potential and longevity [e.g., NILSSON *et al.* 1997, TORREY *et al.* 1997, LUMMA 2003, HUBER *et al.* 2004, CAGNACCI *et al.* 2005, DOBLHAMMER *et al.* 2005, WJST *et al.* 2005]. The effect of month of birth on body size, both final and at particular developmental periods, has also been shown. Body size is measured as height and/or weight, two factors which differ considerably in heritability. It is expected that body height, as a feature less susceptible to environmental modifications would be less likely to demonstrate a relationship between seasonality and body size. Heritability estimates for human body height are higher than in most other human complex traits [PEROLA *et al.* 2007] and range between 75 and 90%, with the remaining approximately 20% of variation due to environmental effects [PFÄFFLE 2006]. Nutrition and disease are the most important nongenetic factors affecting growth velocity of body height and final stature but additional factors include workload, health care, parents' educational level, SES [BIELICKI *et al.* 1981, 1988, 1992, 2005].

Many studies have shown differentiation of average body heights depending on season of birth in human populations from various world regions, but apparently there is still no consensus on the significance of this effect. European studies on male adults showed that taller Austrian conscripts were born in February to July [WEBER *et al.* 1998], taller Swedish conscripts – in March to May, particularly in the low SES group [KIHLBOM and JOHANSSON 2004] and taller Spanish males (aged 35-64) in June and July [BANEGAS *et al.* 2001].

The effect of birth month on later body height in children has been revealed in several studies. SHEPHARD *et al.* [1979] found that Canadian children from a local sample born in July to March were significantly taller and heavier than those born in other months. HENNEBERG and LOUW [1990] revealed that coloured preadolescent children from urban areas of South Africa born in August to February were taller and heavier compared with those born in March to July. In the study on rural African children [HENNEBERG and LOUW 1993], the birth periods of taller and heavier subjects versus shorter and lighter ones were shifted forward by 2-3 months. WALDI *et al.* [2000] found a positive correlation between the mean number of sunshine hours in the third trimester of gestation and later stature throughout childhood and early adolescence in their longitudinal study of growth and development in Dunedin, New Zealand. The inference from this research is that the most beneficial months of birth for increased body height during an individual's period of rapid growth should be these which follow the period of maximal sunlight duration. MCGRATH *et al.* [2006] demonstrated that 7-year old white and non-white US children born in winter and spring were taller and heavier than their counterparts born in the summer and autumn. The correlation between birth season and body height is also supported by data from Asia. TANAKA *et al.* [2007] found that the tallest and heaviest rural 6-15 year old Japanese children were born in spring months. There was an apparent gradual decrease in body size during subsequent seasons with the least growth during the winter.

There are two studies of month-of-birth effect on body size in Polish children. Rural children were significantly taller if they were born in October through to March in the village of Barciany in north-eastern Poland [KOŚCIŃSKI *et al.* 2004]. The effect was stronger in the children of high socioeconomic status, a finding consistent with the efforts of HENNEBERG and LOUW [1993] and BANEGAS *et al.* [2001]. PUCH and KOZŁOWSKA-RAJEWICZ (2004) found that month of birth influenced body height prior to puberty (similar to HENNEBERG and LOUW [1990]) but not in the total sample, in urban children from Katowice, the largest city in an industrial region of southern Poland. The month of birth effect may have been suppressed by a strongly polluted environment and specific socio-economic stratification of the urban population from Upper Silesia in the 1980s. However, rural and urban Polish individuals born during the autumn and winter months were more likely to grow taller than individuals born during the summer and spring months.

In all the above mentioned studies differentiation of average body heights by season of birth, although statistically significant, was rather low, ranging from 2 mm to 7 mm, except for the research of BANEGAS *et al.* [2001] and TANAKA *et al.* [2007]. However, it seems that their results of 2 cm differences might have resulted from the material selection and statistical methods. The extensive literature on the impact of season of birth relative to growth status and adult height has not led to resolution of all issues including: (a) variation in the impact of month-of-birth relative to geographical locale and time period, (b) identification of factors directly related to the birth month/season that affect body size, and (c) the mechanisms that explain how birth season influences body size variation.

The objective here is to document month of birth effects on height in two samples of Polish schoolgirls from the same region representing two different birth cohorts in order to test the following hypotheses:

– average body height differences by month of birth are statistically insignificant

– the magnitude of these differences does not change with time.

Materials

The assumed research aims could have been realized only on the basis of the empirical material meeting the following criteria: unity of place, distance in time, range of the age structure of at least several years and sample size that fulfills statistical requirements. These criteria were met by the data from cross-sectional surveys of children and adolescents from

April to June in 1983 and 2000 in randomly chosen schools and kindergartens representing all types of school institutions from the entire area of the city of Cracow (southern Poland, 50° 03' N latitude and 19° 56' E longitude, the third largest city in Poland), gathered by research teams from the Department of Anthropology of the Academy of Physical Education in Cracow. The samples included only those girls for whom there was complete information on body height, and the exact date of examination and birth date. The individual's anthropometric measures were stored in the measurement forms or databases in the Department of Anthropology of the Academy of Physical Education in Cracow. Various analyses of physical development in these samples have been reported previously [e.g., CHRZANOWSKA 1993, CHRZANOWSKA *et al.* 2002*b*, CICHOCKA and ŻARÓW 2002, GOŁĄB *et al.* 2002], including two extensive collective works: *Dziecko krakowskie* [CHRZANOWSKA *et al.* 1988] and *Dziecko krakowskie 2000* [CHRZANOWSKA *et al.* 2002*a*].

The timing of ontogenetic developmental events differs between the sexes [e.g., HÄGG and TARANGER 1991, HULANICKA *et al.* 2001, GREIL and LANGE 2007]. There are also sex differences in heritability of body height [SILVENTOINEN *et al.* 2000, 2001, 2003; SILVENTOINEN 2003] and in the degree of response to environmental changes [STINSON 1985, RUDOLF and HOCHBERG 1990, BENEFICE and MALINA 1996, SICHIERI *et al.* 2000, ROHLEDER *et al.* 2001, ZVEREV and GONDAWE 2001, KOMLOS and LAUDERDALE 2007, SEMPROLI and GUALDI-RUSSO 2007]. Moreover, in an only study on month-of-birth effect relative to adult height in females (BANEGAS *et al.* [2001]), no statistically significant relationship was found. Thus, the present analysis is confined to girls aged 5-18 years. Data on boys will be elaborated upon separately. The sample proved to be representative of the Cracow population – means and standard deviations in particular age categories did not deviate from the values of the reference standards [CHRZANOWSKA *et al.* 1988, 2002*a*].

Methods

Age of individuals on the day of examination was calculated to the nearest day and then assigned to one of fourteen annual categories (5-18). The categorization was made as follows: in the category of x-year old were included all individuals aged from x-1 years, six months and one day to x years and 6 months. Measurements of body height were performed according to the Martin-Saller technique. Individual body heights of girls surveyed in the years 1983 and 2000 were standardized on means and standard deviations by age categories from these years respectively [CHRZANOWSKA *et al.* 1988, 2002*a*]. K. Kościński's [KOŚCIŃSKI *et al.* 2004] standardization program was applied to the individual's age in days in order to convert the height by age data to values reflecting where each individual is on a theoretical linear growth trajectory for that year for that sample. Classical standardization produces an error resulting for two reasons: (1) cross-sectionality – all subjects are examined at the same moment independent of their chronological age, (2) defining the age of the examined subjects in years. Therefore the children investigated in spring and born in the second half of the year will be on average shorter than the ones born in the first months of the same year. Thus, the standardization procedure of Kościński [Kościński *et al*. 2004] allowed grouping of individuals born in the same month irrespective of their age at examination.

Girls with z-scores greater than 3 or (-3) were excluded from analyses. This, together with including only individuals aged 5 to 18 years, reduced the size of subsamples to 2747 in the year 1983 and 1925 in 2000. Pubertal changes suppress the birth-of-month effect on later height [Cameron and Demerath 2002] and the impact of month birth on height declines with age [Henneberg and Louw 1990, 1993; Puch and Kozłowska-Rajewicz 2004], thus analyses were performed separately for girls aged 5-9 years versus 10-18 years.

Z-scores for height were compared between birth months, seasons and semi-annual birth periods using a one-way ANOVA of Statistica 7.0 software package and a multifactor ANOVA was applied in order to determine whether time influences the relationship between month of birth and subjects' height. Girls from Cracow were compared to girls from another Polish urban population – Katowice [Puch and Kozłowska-Rajewicz 2004].

Results

Number of subjects, average heights and standard deviations for each of the two subsamples of girls from Cracow are presented in Table 1. As expected, the girls examined in 1983 were shorter than girls examined in 2000 in all age categories by about one half of a standard deviation. Differences between mean values of body height in particular age categories range from 1.8 to 3.6 cm. The average growth increment for the total sample during the 17-year period is about 1.5 cm.

Table 1. Number of subjects, average heights and standard deviations by annual age categories in 1983 and 2000 – girls from Cracow

1983			**age**	**2000**		
N	**SD**	**mean**		**mean**	**SD**	**N**
148	4,4	109,0	**5**	111,1	4,9	79
138	4,6	115,3	**6**	117,3	5,0	98
202	5,6	120,6	**7**	122,2	5,7	86
182	5,3	127,3	**8**	129,5	6,1	139
190	6,0	131,6	**9**	134,1	5,2	142
196	6,6	137,2	**10**	139,9	6,8	115
195	6,6	143,1	**11**	145,5	6,7	154
221	7,3	150,3	**12**	152,7	6,8	198
194	6,4	155,0	**13**	158,9	6,1	173
188	5,6	159,3	**14**	161,5	5,9	237
234	5,4	161,1	**15**	163,8	6,0	166
220	5,5	161,0	**16**	164,6	5,7	132
207	5,9	162,1	**17**	164,0	5,7	106
232	5,7	161,1	**18**	164,4	5,8	100
2747			**5 – 18**			**1925**

Table 2 presents sample sizes, ages, average height z-scores and standard deviations for the two subsamples collected in 1983 and 2000 subdivided by total sample versus preadolescent group. There were no statistically significant effects of month of birth on height for the total sample (1983: F=1.38*;* p=0.18, 2000: F=0.71*;* p=0.73), season of birth on height (1983: F=2.82*,* p=0.04; 2000: F=0.28, p=0.84) or semi-annual periods of birth (April-September and October-March) versus height (1983: F=1.63, p=0.20; 2000: F=0.77, p=0.38).

For preadolescent girls (5-9 years of age) from both birth cohorts significant differences between height values by month of birth were obtained. Figures 1A and 1B illustrate that the magnitude of these differences is greater for the subjects examined in 1983 compared to subjects measured in 2000. The pattern of changes during the year is regular, from a height maximum during winter months (expressed as deviations of monthly z-scores from the annual average) that decreases during the summer months followed by an increase in autumn. These differences are statistically significant in both subsamples using the one-way ANOVA, in 1983 (F=2.76; p=0.0016) and in 2000 (F=1.89; p=0.03). Individuals born in April to September are the shortest. The month-of-birth-effect is more pronounced in the girls measured in 1983 although the patterns are similar. Body height increments are lowest if individuals are born during spring to summer months and height increments are lowest for girls examined in 2000 during June to September.

Table 2. Number of subjects, average height z-scores and standard deviations by month of birth in 1983 and 2000 for preadolescent girls and total sample from Cracow

1983						**Month of birth**	**2000**					
Total sample (5-18 years)			Preadolescent girls (5-9 years)				Total sample (5-18 years)			Preadolescent girls (5-9 years)		
N	z	SD	N	z	SD		N	z	SD	N	z	SD
239	0.047	0.947	67	-0.006	0.766	**Jan**	158	-0.009	0.955	41	0.095	0.869
217	0.008	0.960	65	0.163	0.885	**Feb**	150	-0.022	0.879	40	-0.093	0.933
272	0.013	0.949	84	-0.061	0.821	**Mar**	153	0.066	0.985	47	-0.118	1.034
280	0.008	0.995	85	-0.272	0.974	**Apr**	161	-0.055	0.913	44	-0.029	0.804
262	-0.036	0.950	79	-0.343	1.090	**May**	158	0.070	0.943	50	0.184	0.876
212	-0.014	0.948	57	-0.173	0.904	**Jun**	181	-0.066	1.008	58	-0.188	1.167
233	-0.025	0.985	82	-0.292	0.965	**Jul**	168	-0.152	0.988	53	-0.536	1.105
232	-0.213	0.927	65	-0.336	0.905	**Apr**	182	0.052	0.959	64	0.139	0.917
221	-0.113	0.959	74	-0.438	0.977	**Sep**	159	-0.015	0.974	40	-0.078	1.176
172	-0.144	1.005	38	-0.183	0.955	**Oct**	168	-0.008	0.931	46	-0.202	0.898
194	-0.044	0.979	79	0.059	0.924	**Nov**	132	0.000	1.082	24	-0.085	1.131
213	-0.020	0.922	85	-0.131	0.856	**Dec**	155	0.039	1.004	37	-0.122	0.965
2747	**-0.040**	**0.961**	**860**	**-0.170**	**0.933**	**Jan-Dec**	**1925**	**-0.009**	**0.968**	**544**	**-0.087**	**1.004**

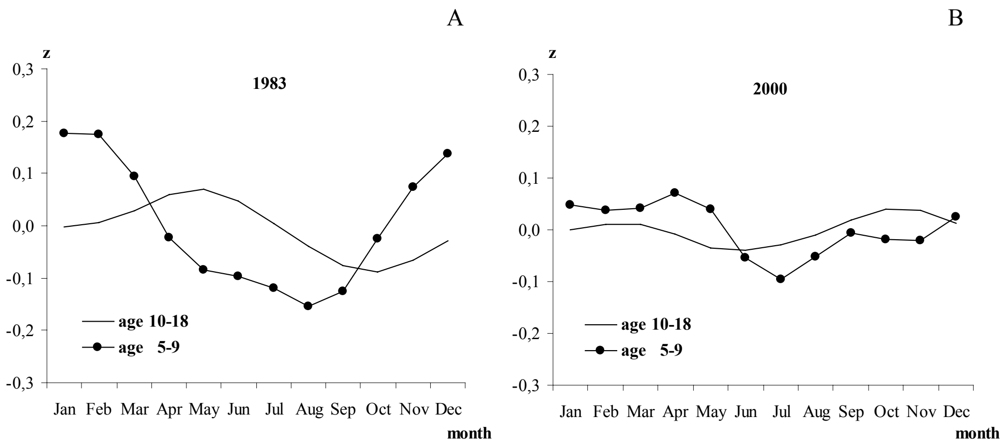

Fig. 1. Deviations of average height z-scores by month of birth from annual mean in girls from Cracow, aged 5-9 vs. 10-18 years: A – 1983, B – 2000. Data smoothed by moving averages of three values.

Discussion

There are two trends evident in the comparison of average body heights between two birth cohorts separated by 17 years: (1) secular changes towards greater heights, and (2) decreases in the magnitude of average height differences by month of birth. The reasons for both phenomena are likely due to fluctuating, but anyway improving, living conditions, which affected the physical development of the girls from Cracow between the years 1960 and 1990 [CHRZANOWSKA *et al.* 1988, 2002*a*; GOŁĄB 1992]. Nutritional status, physical activity and disease load are regarded as the most important nongenetic factors influencing the course of growth and development and, consequently, final stature is dependent on the natural environment and standard of living of children and their families [BOGIN 1999, SCHELL and KNUTSEN 2002]. Transformation of the Polish political system – transition from a state-controlled economy to a free market economy, and changes in the social structure with opening up of Poland to the world's influences led to considerable improvement in living conditions measured by increased consumption, improved health status, increased education and professional promotions [WNUK-LIPIŃSKI 1990; DOMAŃSKI 1998, 2005; CHRZANOWSKA *et al.* 2002*b*; NOLTE *et al.* 2002; BIELICKI *et al.* 2003, 2005; STILLMAN 2006; DOMAŃSKi *et al.* 2007]. There have been consistent improvements in child health as evidenced by a constant tendency toward increasing body size despite periodic economic crises.

The raise in the standard of living, particularly in urban areas, gradually made people less dependent on unfavorable seasonal changes in climate (outdoor temperature, solar intensity, air humidity), access to some kinds of food (winter deficits of fresh fruits and vegetables) or physical activity (low number of sport centers). Child health can also be affected by global warming, changes in seasonal variation, and there is also less variation in the conditions for child physical development during the year due to better medical care and dietary supplements. These improvements may have reduced the impact of month-of-birth effect on body height.

The analysis here does not support an influence of month-of-birth on body height in Polish urban populations. However, the influence of the month of birth on stature is significant in younger girls who did not reach adolescent age, consistent with the studies of children from Katowice [PUCH and KOZŁOWSKA-RAJEWICZ 2004] and coloured, urban and rural children from South Africa [HENNEBERG and LOUW 1990, 1993]. The relationship in both subsamples of girls from Cracow diminishes with attainment of pubertal age, becoming insignificant during adolescence and after growth ceases (1983: F=1.72; p=0.07, 2000: F=0.47; p=0.92). Therefore the month-of-birth effect in Polish urban populations is limited to the younger child groups. The adjustment procedure does not remove all bias because growth rates are not constant, but it improves reliability and comparability among the individuals of both subsamples. Average body heights are greatest for individuals born in the winter months and lowest for those born in the summer months, similar to other Polish samples, as illustrated in Figure 2.

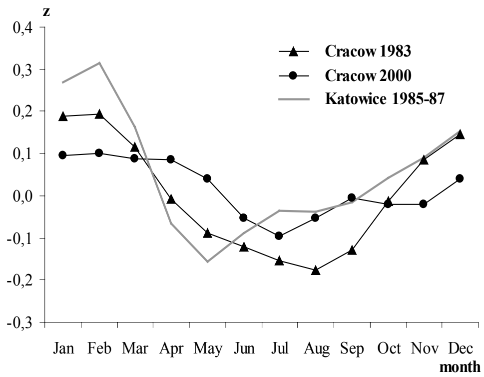

Fig. 2. Comparison of standardized average heights by month of birth for urban preadolescent girls from Cracow and Katowice. Data smoothed by moving averages of three values.

It was also demonstrated that the month-of-birth effect on body height decreased during the 17 years separating the two data collections of 1983 and 2000. The magnitude of any factor (either biological or cultural or both) underlying the effect must have declined or the individual response of the examined subjects became weaker. A number of mechanisms may explain this change including: global factors (e.g., total amount of energy reaching the Earth acting through UV-dependent production of vitamin D, changes in electromagnetic field or in the force of gravity), hemisphere-related climatic conditions and local factors, for example climatic (day length, hours of insolation, solar radiation, rainfall, temperature), other environmental characteristics (e.g., nutrition or physical activity) or cultural influences. It is clear from the first paragraph of this section that some of the above mentioned factors changed over the examined time range. More importantly, exposure of children to seasonal influences was much greater in previously born individuals than in the group younger than c. 17 years. A summary of the results from various world regions on the relationship between the most and least favorable birth seasons for average body height values is presented in Table 3. This allowed the authors to

Table 3. Worldwide patterns of month-of-birth effect on body height

	NORTHEN HEMISPERE →		**Spring**			**Summer**			**Autumn**			**Winter**			
PLACE	SAMPLE	SEX & AGE	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	SOURCE
Sweden, all country	general	men (18-19)	+	+						–	–			+	Kihlbom & Johansson [2004]
Austria, all country	general	men (18-21)	+	+	+	–	–	–	–	–	–	+	+	+	Weber *et al.* [1998]
Spain, all country	random	men (34-65)			+	+					–	–			Banegas *et al.* [2001]
Canada, Quebec	local	boys & girls (5-9)	–	–	–	+	+	+	+	+	+	+	+	+	Shephard *et al.* [1979]
Poland, Barciany	local	boys & girls (6-20)	–	–	–	–	–	–	+	+	+	+	+	+	Kościński *et al.* [2004]
Poland, Katowice	local	boys & girls (5-9)	+	–	–	–	–	–	–	+	+	+	+	+	Puch & Kozłowska-Rajewicz [2004]
Poland, Cracow 1983	local	girls (5-9)	+	–	–	–	–	–	–	+	+	+	+	+	this study
Poland, Cracow 2000	local	girls (5-9)	+	+	+	–	–	–	–	+	+	+	+	+	this study
USA, East Coast	regional	boys & girls (7)	+	+	–	–	–	–	–	–	+	+	+	+	McGrath *et al.* [2006]
Japan, Tokushima	regional	boys & girls (6-15)	+	+	+	+	+	+	–	–	–	–	–	–	Tanaka *et al.* [2007]
South Africa, Cape Town	local	boys & girls (6-10)	–	–	–	–	+	+	+	+	+	+	+	–	Henneberg & Louw [1993]
South Africa, Little Karoo	local	boys & girls (6-10)	+	–	–	–	–	–	–	+	+	+	+	+	Henneberg & Louw [1990]
New Zealand, Dunedin	local	boys & girls (3-18)	+	+	+	–	–	–	–	–	–	+	+	+	Waldi *et al.* [2000] *
	SOUTHERN HEMISPHERE →		**Autumn**			**Winter**			**Spring**			**Summer**			

–	+	no data

EQUATOR

*„good" (+) and „bad" (–) months were assessed by the authors of the present paper on the basis of original data

infer some regularity underlying the observed phenomenon. European studies of adult populations: conscripts from Sweden [KIHLBOM and JOHANSSON 2004] and Austria [WEBER *et al.* 1998] as well as adult males from Spain [BANEGAS *et al.* 2001], showed that the least advantageous are the autumn months. However, methodical differences preclude direct comparisons of these studies. The results of examination of children from the northern hemisphere: Canada [SHEPHARD *et al.* 1979], USA [MCGRATH *et al.* 2006], Poland [PUCH and KOZŁOWSKA-RAJEWICZ 2004, KOŚCIŃSKI *et al.* 2004, this study] and excepting Japan [TANAKA *et al.* 2007] show that the most favorable period for height development are winter months of birth and least – the spring/ summer months. Moreover, there is a gradual shift along the North-West/South-East axis of the least advantageous months from spring/ summer to autumn/winter.

In the studies from the southern hemisphere: coloured urban and rural children from South Africa [HENNEBERG and LOUW 1990, 1993] and urban subjects from New Zealand [WALDI *et al.* 2000] it was found that on average taller children were born in months of the year corresponding to those of the northern hemisphere (Table 3). However, the same months are climatically and astronomically different in the two hemispheres. There appears to be a shift in the best months for growth for the southern hemisphere from autumn-winter to winter-spring being similar to the northern hemisphere. Cultural and behavioral differences may alter the expression of these geographical differences but one plausible explanation for these month-of-birth effects is that sunlight affects rates of conceptions leading to seasonal birth effects, a hypothesis suggested and partially confirmed empirically by CUMMINGS [2002, 2003]. The increased environmental light intensity or length of photoperiod together with decreased daily cloud cover exerts a positive effect on human conceptions. This mechanism may partly explain how month of birth affects growth rates but to confirm this hypothesis will require analysis of environmental light intensity and photoperiod together with cloud cover during the period of growth for the examined samples. Nevertheless, it seems that this hypothesis may prove to be correct, particularly when the periods of maximum growth are contrasted between the northern and southern hemispheres, e.g. longitudinal study of children from New Zealand [WALDI *et al.* 2000].

Conclusions

The analysis of the month-of-birth effect on body height in two temporally distant subsamples of schoolgirls from Cracow and previous results of similar studies on Polish children allowed the authors to infer the following:

– the influence of birth season/month on body height was significant only in prepubertal girls

– the birth season most favorable for average values of body height is winter and the least – summer

– the magnitude of the effect decreased with time

– local groups from Polish areas show similar patterns of the effect of birth month on body height.

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Streszczenie

Wyniki badań populacji i grup lokalnych z różnych kontynentów wskazują na istnienie związku między sezonem urodzenia a stanem zdrowia i kondycją biologiczną człowieka oraz stanem i dynamiką rozwoju fizycznego. Dotychczas jednak nie rozstrzygnięto ostatecznie: (a) czy efekt sezonu urodzenia jest zjawiskiem rzeczywistym czy artefaktem i jakie jest zróżnicowanie zjawiska w czasie i w przestrzeni, (b) jakie bezpośrednie czynniki związane z sezonem urodzenia istotnie różnicują wartości cech metrycznych, (c) jaki jest mechanizm różnicującego wpływu czynników związanych z sezonem urodzenia na wielkość ciała.

Sformułowano następujące hipotezy badawcze: (1) różnice średnich wysokości ciała według miesiąca urodzenia są statystycznie nieistotne, a (2) wielkość tych różnic nie zmienia się w czasie. Weryfikacji dokonywano na podstawie materiałów antropometrycznych z Katedry Antropologii AWF w Krakowie, z badań przekrojowych dzieci krakowskich w 1983 i 2000 roku, wykorzystując dane o wysokości ciała łącznie dla 4672 dziewcząt w wieku 5-18 lat (Tab. 1). Indywidualne wartości wysokości ciała standaryzowano na wiek w odniesieniu do norm regionalnych [CHRZANOWSKA i in. 1988, 2002], co umożliwiło ich grupowanie wg miesiąca urodzenia. Procedurą standaryzacji na wartości interpolowane, uwzględniającą dokładny (do jednego dnia) wiek osobników w chwili badania, zniwelowano różnice między osobnikami zaliczonymi do tej samej rocznej grupy wiekowej (Tab. 2).

Istotne statystycznie zróżnicowanie przeciętnej wysokości ciała, w zależności od sezonu urodzenia, ujawniło się tylko w wieku przedpokwitaniowym (Fig. 1A i 1B). Wzorce badanego zjawiska dla obu kohort wiekowych wykazują znaczne podobieństwo, choć wpływ miesiąca urodzenia jest mniejszy u dziewcząt badanych w 2000 roku. Wyniki porównań badanych grup między sobą oraz na tle innych populacji lokalnych z terenu Polski pokazują podobieństwo wzorców badanej zależności (Fig. 2). Podobnie jak w przypadku dzieci miejskich z Katowic [PUCH i KOZŁOWSKA-RAJEWICZ 2004] i dzieci wiejskich z Barcian [KOŚCIŃSKI *et al.* 2004] najwyższe średnie wartości wysokości ciała stwierdzono u dziewcząt urodzonych w miesiącach grudzień – marzec, najniższe czerwiec – wrzesień. Wyniki badań wpływu sezonu urodzenia na wysokość ciała z różnych rejonów świata, pomimo braku jednolitego wzorca, wykazują pewne uporządkowanie miesięcy mniej i bardziej korzystnych dla przeciętnych wartości cechy i w świetle badań WALDI *et al.* [2000] i CUMMINGSA [2002, 2003] mogą przemawiać za koncepcją usłonecznienia jako czynnika wywołującego obserwowane zróżnicowanie (Tab. 3).

Niezależnie od tego, jakie bezpośrednie czynniki i mechanizmy leżą u podstawy badanego zjawiska, wyniki dotychczasowych badań różnych grup lokalnych z terenu Polski upoważniają do sformułowania następujących wniosków: istnieje istotny związek między miesiącem (sezonem) urodzenia a wysokością ciała; związek ten ujawnia się w wieku przedpokwitaniowym i zmniejsza się w czasie, a przeciętne wartości cechy są wyższe u urodzonych zimą i niższe u urodzonych latem.