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Concurrent Effect of Social Factors and Maturity Status on Height and BMI of Adolescent Girls

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ABSTRACT Concurrent effect of social factors (parental education, level of urbanisation and family size) and maturity status (menarche - status quo method) on height and BMI of 1569 girls aged 13-15 years was assessed by two-way analysis of variance and path analysis. Before analysis the effect of age was removed by mean of the LMS method. Height was significantly influenced by parental education, allowing for maturation rate. Urbanisation and father's education significantly influenced BMI, allowing for maturation rate. Path coefficients revealed that mother's education and father's education were the most important factors influencing girls' height and BMI, respectively.

INTRODUCTION

Height and the body mass index are both good indicators of social inequalities in post-industrial societies. The statural variation that is observed among groups of people differing in socio-economic conditions manifests itself with varying intensity. In Poland such social factors as urbanisation, parental education and/or occupation, and sibship size each have significant effects *per se* on stature of children and conscripts (Bielicki et al. 1981; Hulanicka et al. 1990; Bielicki and Waliszko 1991; Bielicki et al. 1992; Bielicki et al. 1997). The average height of subjects decreases across from upper to lower social class. However, defined gradient is especially noticeable in adolescence, particularly at the ages of 11-15 years, where the contrasts are most pronounced (Charzewski and Bielicki 1990; Hulanicka 1991). The World Health Organisation has acknowledged stature as a one of the best indices of health and nutrition status (WHO 1976).

Similarly, the BMI highly correlated with body fatness gives an information about nutritional status (Rolland-Cachera 1995). Adults and adolescents from various social groups show different level of fatness (Lipowicz 1999; Rogucka and Bielicki 1999; Lipowicz et al. 2002). In many developed countries obesity is more frequent in lower strata (Garn et al. 1977), whereas in developing countries exists rather in groups with higher SES (Georges et al. 1993).

The body fatness is dependent on a level of sexual maturation (Daniels et al. 1997). During adolescence, the BMI values of girls increase gradually and the early maturers are more frequent obese in spite of late ones (Tanner 1962). Garn et al. (1986) found that part of differences between two extremes of fatness is related to maturity status. Additionally, rate of maturation is influenced not only by heredity but also by environment. The influence of social differences on rate of menstruation is obvious. e.g. girls from better socio-economic conditions reveal lower mean age of menarche in spite of girls from worse ones (Bielicki et al. 1986).

Poland is one of the most ethnically homogeneous countries in Europe (because of high rate of inner social migration and insignificant rate of immigration), therefore social-class differences in growth are unlikely to be distorted by between-class genetic differences (Gronkiewicz 2001).

These two facts: (1) sensitivity of the adolescence to the influence of the social environment, and (2) the high degree of ethnic homogeneity of the Polish population, offers a unique opportunity to study the magnitude of the *net* effect of specific social factors on variation in growth of stature and relative weight.

The aim of the present investigation is to estimate the *net* effect of social factors and maturity status on height and the BMI of adolescent girls in the WrocBaw region of Poland.

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MATERIAL AND METHODS

1569 girls were measured during the medical examination in the Silesian Centre for Preventive Medicine (DOLMED) within the framework of the project of the Schoolchild Health Certificate. This cross-sectional survey was carried out between January and December 1997. All subjects were attendees of the seventh grade of randomly selected primary schools of WrocBaw, four small towns within a 50 kilometers radius of WrocBaw with populations below 25,000 and with urban administrative status, and villages settled in 8 communes of former voivodship of WrocBaw. All participants were between 13 and 15 years of age.

Based on social information obtained from questionnaires filled in by the parents, four social variables were used and scored as follows: *Urbanisation*: WrocBaw, towns, rural areas; *Education of mother and father, separately*: university, secondary school, trade school, elementary school; *Number of children in family*: one or two, three, four or more.

The girls' maturity status was assessed on the basis of the exact recalled date of menarche. In case of uncertainty or difficulties in giving exact date of menarche the subjects were excluded from analysis. All girls were divided into four groups, representing maturity status: no menstruated girls, having onset of menstruation within last year, having onset of menstruation between one and two years and having onset of menstruation at least two years before the date of examination.

Height and weight were measured at the health examination and the body mass index (BMI, weight/height^2) was calculated. Values of the BMI were normalised, and height and BMI were separately standardised on the basis of the LMS method described by Cole (1988). This method allows estimation, for each tabulated age and sex, L, M and S smooth curves, which represent respectively a power of the Box-Cox conversion to normality, the mean and the coefficient of variation. Then, given the values of L, M and S at each age the conversion of actual height (or the BMI) of each individual child into SD scores can be obtained using the formula (Cole 1989):

$$Z = \frac{(H / M)^L - 1}{LS}$$

The use of SDS removed the effect of age on height and BMI and avoided the problem of increasing means with age. Four two-way analyses of variance (ANOVA) were separately performed for each feature, where dependent variables were maturity status and proper social variable. Such design of analysis allowed to assess which social factor exerts significant influence on the stature and BMI of girls, controlling maturity status, and to test significance of interaction between them. The factors, which showed non-significant impact on analysed traits, were excluded from further analysis. Then, in order to estimate the magnitude of the *net* effect of meaningful factors, independent of the influence of other factors, the path analysis was used (Wright 1934). The model assumed that the dependent variable was fully determined by the included independent variables and uncontrolled factor *U*. Path coefficients, which were the standardised regression coefficients (betas), reflected the variation in the standard deviation of the dependent variable caused by variations in the given independent variables.

The basis for calculating the path coefficients was a matrix correlation for all features. In this case, the correlation coefficient r_p was used, expressed by the following formula (Góralski 1974):

$$r_p = \sqrt{\frac{K}{K-1}\frac{\chi^2}{\chi^2 + N}}$$

where N is a number of subjects, and K is the least number of scores of two given variables. For implementing the presumptions of this formula, the Z values for height and BMI were scored on the basis of tertiles..

RESULTS

Table 1 summarises the descriptive statistics of height and the BMI of girls, expressed in SD scores in all separated groups of four social factors. The results of the analyses of variance, showed in Table 2, revealed apparent effect of maturation rate on stature and overall fatness. No menstruated and early-matured girls significantly differed in stature and the BMI. From among all analysed socio-demographic variables, father's ($F = 3.79$, $p<0.01$) and mother's ($F = 9.56$, $p<0.001$) education significantly differentiated the stature of girls. Level of urbanisation ($F = 6.59$, $p<0.01$) and father's education ($F = 2.67$, $p<0.05$) significantly influenced on the BMI. Family size did not influenced on height and the relative weight. For each social factor interactions

between maturity status did not reach significant level. It means that influence of social factors was independent from maturation rate.

Although, great impact of the tempo of maturation on stature, the mean stature of girls still decreased monotonically with the downward shift in the level of mother's education within each category of maturity status (Table 1). The mean stature of girls having mothers with high education level towered over their schoolmates with less educated mothers, especially in early matures group.

Table 1: Average values of height and the BMI expressed in SD scores of each level of social factors (number of subjects in parentheses)

Social factors	*Means in SD scores*	
	Height	*BMI*
Urbanisation		
Wroclaw	0.008 (1031)	-0.009
Towns	0.024 (223)	-0.017
Rural areas	-0.031 (456)	0.03
Father's Education		
University	0.169 (328)	-0.008
Secondary school	-0.001 (527)	-0.032
Trade school	0.004 (720)	0.074
Elementary school	-0.182 (196)	-0.145
Mother's Education		
University	0.200 (240)	0.014
Secondary school	0.073 (798)	0.023
Trade school	-0.147 (471)	0.016
Elementary school	-0.177 (194)	-0.115
Number of Children		
1 or 2	0.032 (1057)	0.015
3	-0.070 (424)	0.025
4 or more	-0.027 (232)	-0.112

Tempo of maturation had a much stronger effect on girls' BMI variation, and the effect of social factors was less apparent. Not regular pattern appeared along categories within four groups of maturity status for urbanisation and father's education (Table 2). It is noteworthy that among menstruated subjects, girls from Wroclaw and rural area reached two opposite extreme means.

The path analysis was embraced only these factors which had a statistically significant effect on features assessed by means of the ANOVA. Table 3 shows the values of path coefficients (p_i) and the percentage of relative strength of influence of each factor. After partialling-out the effect of maturation rate the results indicated that mother's education has the strongest effect on stature variation of girls, accounting for 35.4 % of the variation in relation to maturity status. It

Table 2: Two-way Analyses of Variance, where maturity status and appropriate social factors were grouping variables and height or BMI was independent variable

Social factors	*F - ratio*	
	Height	*BMI*
Urbanisation	2,30	6,59**
Maturity status	18,62***	62,91***
Interactions	1,07	1,45
Father's education	3,79**	2,67*
Maturity status	25,98***	63,47***
Interactions	1,15	0,64
Mother's education	9,56***	1,49
Maturity status	21,96***	66,77***
Interactions	0,70	1,02
Number of children	0,52	2,15
Maturity status	20,21***	63,74***
Interactions	0,67	1,06

* $p < 0.05$; ** $p < 0.01$; ***$p < 0.001$

confirmed the great importance of the maternal education acting independently, and in *net* manner. Parental education and maturity status explained about 7.5 % variation in stature in girls. Father's education gave the greatest strength on girls' relative weight variation (22.4 %), in relation to maturity status. Percent variation of BMI in girls explained by used factors reached about 20 %, and was much greater then for height.

Table 3: The values of path coefficients p_i and relative strength of influence of each social factors, expressed as percentage of contribution of path coefficient of given factor to sum of all path coefficients.

	Height		*BMI*	
Social factors	*pi*	*%*	*pi*	*%*
Urbanisation	-	-	-0,156	-
Father's education	-0,011	-	0,132	22,41
Mother's education	0,127	35,38	-	-
Family size	-	-	-	-
Maturity status	0,232	64,62	0,457	77,59
Coeff. of determination	7,45%	100%	20,15%	100%

DISCUSSION

The present set of observation gives new evidence to the well-documented occurrence of stature variation across social strata in Poland (Charzewski 1981; Bielicki and Welon 1982; Piasecki and Panek 1982; JedliDska 1985; Charzewski and Bielicki 1990; Hulanicka et al. 1990, Hulanicka 1991). Girls' height is influenced by level of both parents' education, and girls' relative weight is influenced by level of urbanisation and level of father's education.

The value of *F* statistics indicates that mother's education had greater discriminate strength of stature variation of girls than father's education. There are few data comparing the relative strength of influence on growth of particular social factors. The stronger statistical effect of the education of the mother on growth and maturity of children, showed by that of education of father were previously reported by Charzewski (1981) and Piasecki and Panek (1982). In a more recent extensive study, on the basis of the enormous study of data on heights of conscripts from surveys in 1965, 1986 and in 1995, Bielicki et al. (1997) showed the increasing importance of maternal education on growth in height of boys.

It is obvious that there is no causal relationship between maternal education and girls' growth, and there may be some other mediating environmental factors that highly correlate with the level of mother's education. Bielicki and Welon (1982) suggested that education probably act by way of nutrition and morbidity during infancy and early childhood. Desai and Alva (1998) gave some confirmation of such relationship. The authors have found a strong correlation between maternal education and indices of child health and immunisation status in surveys of 22 developing countries. It could be assumed that similar phenomenon also exists in Polish population. Alternatively, it is possible that the effect of maternal education on stature may reflect differential utilisation of available income, by way of satisfying all the child's needs followed by those of the father, rather then the actual amount of money available per member of family (Bielicki and Welon 1982).

It is noteworthy that in this study the degree of urbanisation, as an autonomously acting social factor, did not show any importance for height of girls. In earlier studies the size of the place of residence was the second important factor among boys, showing stable strong significance through thirty years, from 1965 to 1995 (Bielicki et al.1997). In these studies urbanisation was an independent factor stimulating growth. The authors concluded that the privilege of big cities unremittingly still exists. Similar findings come from the work of Jedlinska (1985), who utilised the data of the III Anthropological Survey of Poland. This comprised of the data from three big cities (Warszawa, Lódz, and Wroclaw), five small towns of up to 10,000 inhabitants and villages settled around towns, conducted in 1977/78. Based on respective F-ratios of three-way analysis of variance the author showed the variable of the great relative importance on stature variation of 14 years old boys and girls, to be degree of urbanisation. The results of this study are in sharp contrast to the earlier findings and might be explained in two ways. 1) The voivodship of Wroclaw could have some unique interactions between the social environment and growth of children, compared to other regions included in previous investigations. 2) Being in the close neighbourhood of a big city (with population above 500,000 people, like Wroclaw) might have a *buffering effect* on the growth of children. Inhabitants of small towns or villages surrounding Wroclaw could be in some way benefited, possibly because of easier access to health-care centres and other resources in city. However, there is no data to support either possibility.

Surprisingly, in contrast to earlier studies, we found no significant effect of family size on height and relative weight of girls. It is possible that variable *number of children in family* showed too small diversity in analysed population or family size deprived growth of children only in much bigger families, e.g. it got a powerful meaning only in these families. Amount of food and quality of nutrition significantly dropped in families with four or more children, some kind of malnutrition might appear and, in consequence, it caused limitations of growth. In 1997 average monthly food expenditures of households with 4 and more children came to104.61 PLN per capita, which poses only 64 % of such food expenditures of households with one child (Statistical Yearbook of the Republic of Poland 2000). Additionally it can not be excluded that girls from small size families might modify their appearance by restricted slimming. In that case, girls all look alike.

In recent years, in affluent societies such as Sweden or Norway majority of social inequalities in height and relative weight of children and youth successively levelled out. Mother's occupational level and sibship size run out of importance, especially among girls (Lissau-Lund-Sorensen and Sorensen 1992; Cernerud 1994). It is postulated that such lack of social disparities in height and relative weight may be explained by an improvement in living conditions among less privileged children and reaching the optimal conditions of growth in these countries (Brundtland et al. 1980). That is not certain, has

lack of majority of social differences in height and relative weight among Polish girls resulted from similar reasons as in wealthy countries. This problem needs further research.

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