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THE EFFECT OF SOCIO-DEMOGRAPHIC AND GENETIC FACTORS ON HEAD INDICES

ABSTRACT: A representative sample of Hungarian conscripts were taken from the cohorts of the 18-year-old young males in 1998 (n=8,000). Anthropometric, medical and socio-demographic data were collected in the sample. In this study only the effects of some socio-demographic factors on the cephalic and the morphological facial indices were analysed, but the effects of genetic factors were also observed. A rapid debrachycephalisation and the tendency of the face to become narrower and higher were also found in the sample.

KEY WORDS: Cephalic index – Debrachycephalisation – Socio-demographic factors – Genetic factors – Hungarian conscripts – Morphological facial index

INTRODUCTION

The human head form has been environmentally conditioned or under genic control. However, it was shown by twin studies that both these assumptions are valid, i. e. the variance of head form contains environmental and genetic components, too (Clark 1956, Osborne, DeGeorge 1959). Socio-demographic factors are also in the groups of the environmental factors. Contrary to the effect of the socio-demographic factors on the body measurements, there are much less data regarding the head measurements. Pálsson and Schwidetzky (1973) found relationship between the urbanisation and the head form, while Gyenis and Gonda (1991) between the head and facial measurements and indices and the place of birth and parental educational level of Hungarian university students.

The aim of this study is to show the effect of some socio-demographic and genetic factors on the shape of the head – expressed by the cephalic and morphological facial index – by different statistical methods.

MATERIAL AND METHODS

A national representative sample of Hungarian conscripts was taken from the cohorts of the 18-year-old males born in 1980 in six counties of the country; as well as in four large cities, and in Budapest. The counties represent industrially different regions of the country. The conscription was in 1998 and the sample size is over 8,000.

The present study is only a part of a more comprehensive project, which contains anthropometric, medical and socio-demographic data, too (Gyenis, Joubert 2002). Comparison was made with the data of conscripts surveyed by Nemeskéri *et al*. (1983) at the same places in 1973. In that study only the relationship between the cephalic and morphological facial indices and some demographic factors (place of residence grouped by counties and cities and place of residence classified by the degree of urbanization, birth order, number of the children in the family and the parental educational level) of the conscripts was analysed.

The place of residence grouped by counties involves six of the nineteen counties in Hungary, Budapest, the capital of Hungary and four large towns on county rank. The groups are as follows: Bács-Kiskun (B-K) county in the southern part of the Hungarian Great Plain, Borsod-Abauj-Zemplén (B-A-Z) county in the northern part of the country, Hajdú-Bihar (H-B) county in the north-east Hungarian Great Plain, Pest county as the central industrial region, Somogy county in southern Transdanubia, Veszprém county in central Transdanubia, Budapest, and four large cities: Miskolc, Debrecen, Szeged and Pécs.

The degree of urbanisation, expressed as the population size and the "quality" of the locality of the conscript's residence: 1. Budapest (population about 2 million); 2. large cities (population over 100,000); 3. medium cities (population between 100,000–25,000); 4. small towns (population under 25,000, urban administrative status); 5. rural settlements (villages, farms).

The family size, defined as the number of children in the family, including the conscript: 1. one, 2. two, 3. three, 4. four and more.

The birth order of conscript: 1. first, 2. second, 3. third, 4. fourth and more.

Educational level of father: 1. 0–7 classes, 2. 8 classes, 3. 8 classes+vocational school, 4. 9–12 classes, 5. 13–18 classes.

Educational level of mother: scale same as in the case of the father.

Statistical analyses were made by ANOVA, Scheffé-test and regression analysis.

The regression analysis was carried out in the light of five independent variables per two dependent variables.

The dependent variables: 1. the cephalic index, 2. the morphological facial index.

The independent variables: 1. the educational level of the mother, 2. the educational level of the father, 3. the degree of urbanisation of the place of residence, 4. the birth order of the conscript, 5. the family size (total number of the conscript and of his brothers and sisters). The educational level of the parents was grouped by the same way mentioned above.

Since there is a strict correlation between the father's and the mother's educational level and often there are no data concerning the father, we developed two models. In the one only the mother's educational attainment is included, in the other one we developed one variable from the both parents' educational attainment: we took into consideration all the possible pairings.

In case of the regression analysis made with the combined educational level, it must be taken into consideration that those omitted from the analysis because of the lack of the father's data (205 cases) do not concern the sample in an even distribution, i.e. we omit a relatively homogeneous group. In 78% of cases, the mothers completed at most 8 forms, while 47% is valid for the sample as a whole. Therefore the results obtained must be interpreted with the restriction that they are true only concerning those where the father's data were known at the births of the conscript.

The mother's educational level was included in the model as an ordinal variable, the combined educational attainment as a factor variable, i.e. they were transformed into dichotomous (two-digit) variable in a number corresponding to the number of the categories.[1)]

[1)] If the parents' educational attainment belongs to the given category, then the value of the new variable is 1, in other cases 0.

In case of the categories of the population size (or urbanisation degree) of the place of residence at the study of the cephalic index, the two most populous categories of the towns were contracted because the average values of the index show a good conformity. With the values of the variable of the place of residence transformed in this way, the average of the index shows a linear correlation. Besides it can be supposed that the general social conditions of the population of the individual settlements differ by groups of population size, therefore at the study of the cephalic index it was included as an ordinal variable in the model. The average values of the facial index by categories of population size do not show the above tendential correlation, therefore it was treated as a factor in the regression analysis effectuated regarding the indicator.

In the analysis concerning both indexes, we treated the birth order as a factor variable. The family size – with the inclusion of the other three variables – was significant for none of the indicators.

The regression analysis was carried out with SPSS 8.0 PC software, on basis of GLM (General Linear Model). The significant variables were included in the model manually taking into consideration the results obtained at the individual steps.

RESULTS

The mean values of the cephalic index of the conscripts differ according to the place of residence in the 1998 survey (*Figure 1*). The lowest value was found in Budapest, while the highest one in Hajdú-Bihar county, in the eastern part of Hungary and the differences were significant (*Table 1*). In comparison with the mean values of the 1973 survey, a decrease appeared with 6–7 units in all counties and cities.

TABLE 1. The significance levels of the socio-demographic factors by ANOVA in the survey in 1998.

Cephalic index	**p***
Place of residence	.0001
Number of the children in the family	.0001
Educational level of the father	.0001
Educational level of the mother	.0001
Birth order	n. s.
Morphological facial index	.0001
Place of residence	.0001
Number of the children in the family	.0001
Educational level of the father	.0001
Educational level of the mother	.0001
Birth order	n. s.

*The large majority of the paired comparison with Scheffé-test showed significant differences in cases of the place of residence and the parental educational level. In the case of the number of children in the family, less significant differences were found.

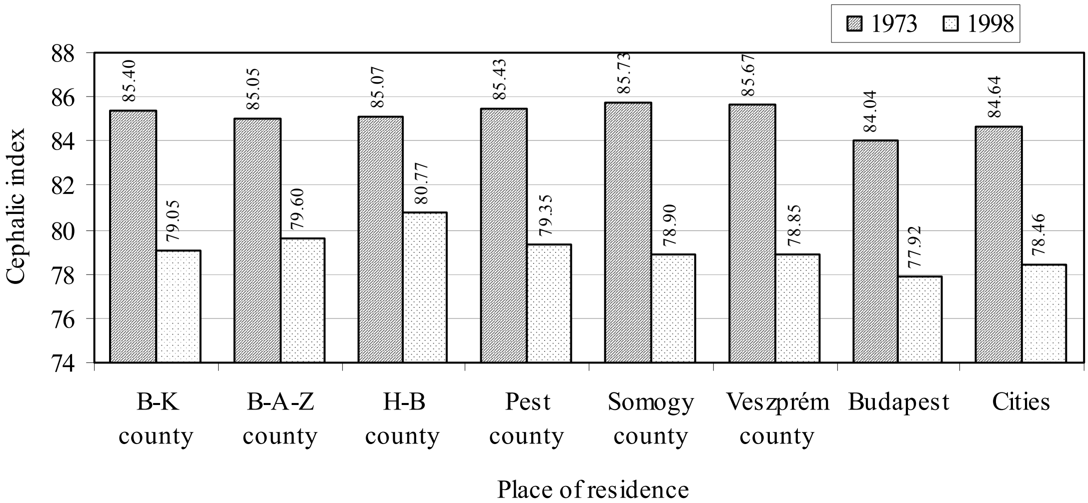

FIGURE 1. The cephalic index of the conscripts according to the place of residence in 1973 and 1998.

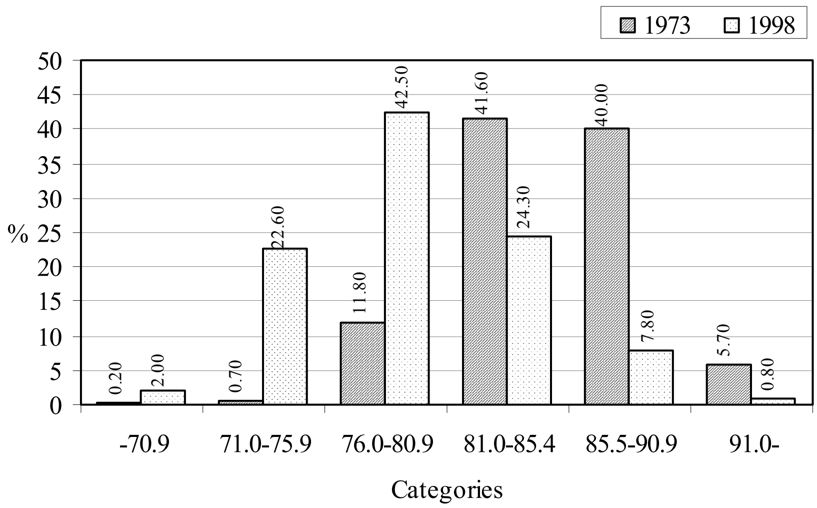

FIGURE 2. The categories of the cephalic index of the conscripts in 1973 and 1998.

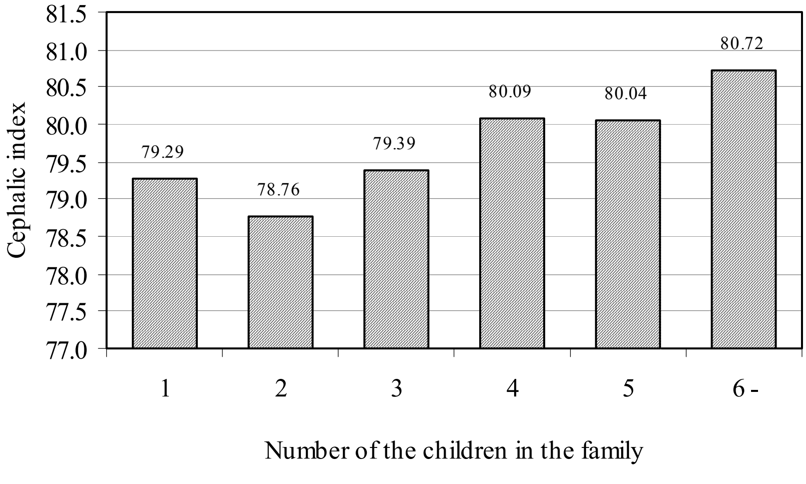

FIGURE 3. The cephalic index of the conscripts according to the number of the children in the family in 1998.

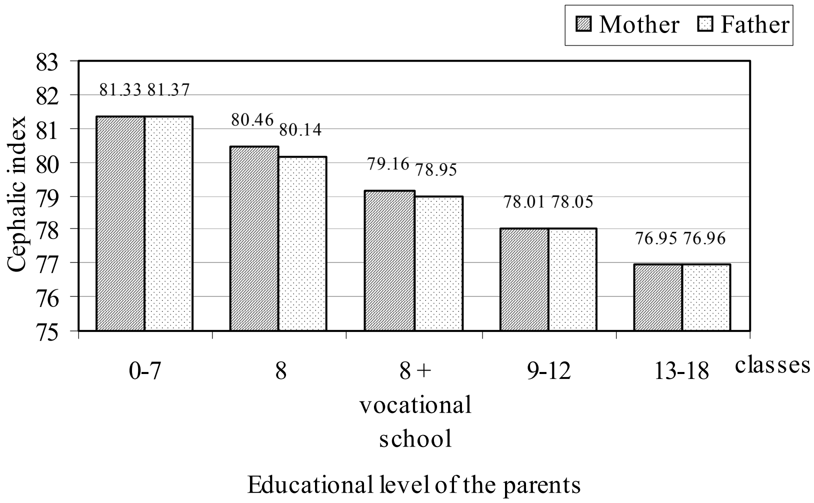

FIGURE 4. The cephalic index of the conscripts according to the educational level of the parents in 1998.

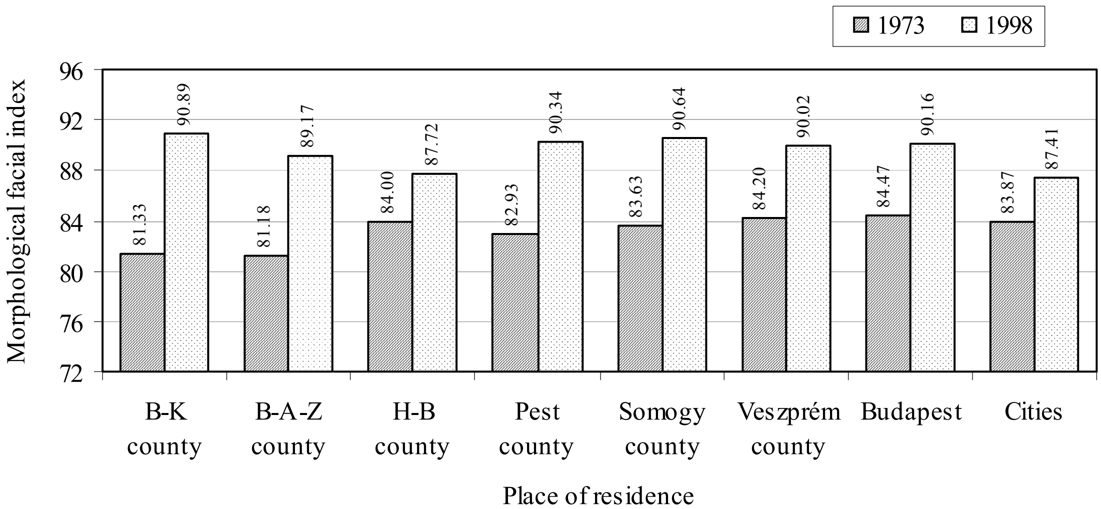

FIGURE 5. The morphological facial index of the conscripts according to the place of residence in 1973 and 1998.

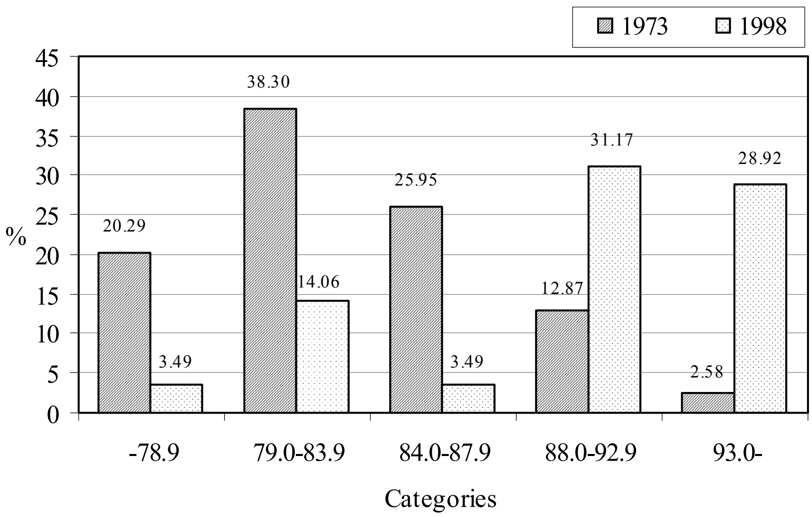

FIGURE 6. The categories of the morphological facial index of the conscripts in 1973 and 1998.

Among the categories of the cephalic index the mesocephalic ones showed the highest frequency (42.5 per cent) followed by the brachycephalic (24.3 per cent) ones in 1998 (*Figure 2*). 25 years earlier, in 1973, the brahycephalic category was the most frequent one (41.6 per cent), followed by the hyperbrachycephalic one (40.0 per cent). In 1973, 87.3 per cent of the conscripts belonged to the three brachycephalic categories (brachycephalic, hyperbrachycephalic and ultrabrachycephalic), while in 1998, 65.1 per cent of them belonged to the meso- and dolichocephalic categories. In consequence of the decrease of the values of the cephalic index during the time, the majority of the brachycephalic categories moved to the meso- and dolichocephalic ones.

In the different categories of the birth order of the conscripts, the differences were only between 0.23–1.48 units in 1998 and 0.14–0.23 units in 1973. Therefore they did not show any influence on the cephalic index, either in 1998 (*Table 1*), or in 1973. Therefore these values are also not presented here.

Contrary to the birth order, the cephalic index according to the number of the children in the family showed a linear increasing tendency in the conscripts from the category of two children in the family to the six or more children in the family in 1998 (*Figure 3*). The differences were significant (*Table 1*). Unfortunately, we did not have the same data from 1973 for comparison.

The parental educational level also showed a linear connection with the cephalic index (*Figure 4*). The higher the educational level of the parents was, the lower the value of the index was. The differences were significant both in the case of the mother and father (*Table 1*). Because of the lack of such kind of data from 1973, it was not possible to make any comparison between the two samples in 1973 and 1998.

The morphological facial index according to the place of residence showed similar tendency as the cephalic index (*Figure 5*). The mean values of the conscripts also differed significantly (*Table 1*). The lowest values were found in Hajdú-Bihar county and in the cities, while the higher values of other places were close to each other. In comparison with the mean values of the survey in 1973, an increase appeared with 4–7 units in all counties and cities.

Among the categories of the morphological facial index, the leptoprosopic ones showed the highest frequency (31.17 per cent) followed by the hyperleptoprosopic (28.92 percent) in 1998 (*Figure 6*). 25 years earlier, in 1973, the euryprosopic category was the most frequent (38.3 per cent), followed by the mesoprosopic (25.95 per cent). In consequence of the increase of the values during the time, the categories moved from the euryprospic and mesoprosopic category into the leptoprosopic and hyperleptoprosopic categories.

In the birth order of the conscripts there were only 0.74–1.36 units in 1998 and 0.14–0.23 units differences between the mean values of the categories, therefore they did not show any influence on the morphological facial index, either in 1998 (*Table 1*), or in 1973. Therefore these values are also not presented here.

Contrary to the birth order, the morphological facial index according to the number of the children in the family also showed a linear connection in the conscripts from the category of two children in the family to the six or more children in the family in 1998 (*Figure 7*) and the differences were significant (*Table 1*). Comparison was not made with the survey in 1973, because of the lack of such kind of data.

The parental educational level also showed a linear connection with the morphological facial index (*Figure 8*). The higher the educational level of the parents was, the higher of the value of the index was. The differences were significant (*Table 1*).

According to the socio-demographical factors, all the differences were significant by the ANOVA, except for the birth order of the conscripts (*Table 1*). The large majority of the paired comparison with Scheffé-test showed also significant differences in case of the place of residence and the parental educational level. In the case of the number of children in the family significant differences were rare.

The regression analysis showed not only the effect of the socio-demographic factors, but the genetic factors, too.

The value of the cephalic index was influenced significantly by the category of the population size of the place of residence, by the mother's educational level and by the birth as a second child. The variables included 9 per cent of the variance, it can be stated that the role of the

TABLE 2. The coefficients of the multivariate linear regression equation for the cephalic index of the conscripts.

Variable	B	Standard error	t	Significance level	The 95% reliability interval of B95 lower limit	upper limit
Settlement	0.477	0.047	10.177	0.000	0.385	0.569
The mother's educational attainment	–0.951	0.047	–20.323	0.000	–1.042	–0.859
Birth order						
2	–0.426	0.109	–3.911	0.000	–0.639	–0.212
3	–0.037	0.174	–0.215	0.830	–0.378	0.303
4 and more	0.010	0.266	0.039	0.969	–0.511	0.531
Constant	80.714	0.229	352.946	0.000	80.266	81.162

$R^2 = 0.090$; $F = 144.940$; df = 5; $p = 0.000$

TABLE 3. The coefficients of the multivariate linear equation for the cephalic index of the conscripts in 1998.

Variable	Number of cases	B	Std. Error	t	p	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Place of residence	7062	0.419	0.048	8.742	0.000	0.325	0.512
Mother's and father's educational level							
≤7, ≤7	203	4.377	0.385	11.363	0.000	3.622	5.132
≤7, 8	115	4.247	0.459	9.254	0.000	3.347	5.147
≤7, 8+vocational	15	2.939	1.119	2.627	0.009	0.746	5.133
≤7, 9–12	4	5.631	2.133	2.640	0.008	1.450	9.812
8, ≤7	194	4.340	0.383	11.336	0.000	3.590	5.091
8, 8	1087	3.461	0.261	13.262	0.000	2.950	3.973
8, 8+vocational	218	3.141	0.364	8.633	0.000	2.428	3.855
8, 9–12	145	1.992	0.416	4.784	0.000	1.176	2.809
8, 13–18	5	0.493	1.910	0.258	0.796	–3.251	4.238
8+vocational, ≤7	45	4.640	0.672	6.907	0.000	3.323	5.956
8+vocational, 8	1341	2.718	0.253	10.721	0.000	2.221	3.215
8+vocational, 8+vocational	763	1.769	0.271	6.527	0.000	1.238	2.300
8+vocational, 9–12	817	1.411	0.267	5.283	0.000	0.888	1.935
8+vocational, 13–18	90	1.432	0.499	2.867	0.004	0.453	2.411
9–12, ≤7	1	1.358	4.247	0.320	0.749	–6.967	9.684
9–12, 8	219	2.087	0.363	5.746	0.000	1.375	2.798
9–12, 8+vocational	174	1.537	0.391	3.934	0.000	0.771	2.303
9–12, 9–12	736	1.041	0.270	3.850	0.000	0.511	1.571
9–12, 13–18	171	0.112	0.392	0.287	0.774	–0.656	0.881
13–18, ≤7	1	7.661	4.248	1.804	0.071	–0.666	15.988
13–18, 8	32	0.906	0.782	1.159	0.247	–0.627	2.438
13–18, 8+vocational	24	1.674	0.893	1.874	0.061	–0.077	3.425
13–18, 9–12	291	0.479	0.332	1.442	0.149	–0.172	1.130
Birth order							
2	2739	–0.390	0.110	–3.546	0.000	–0.606	–0.174
3	735	–0.063	0.176	–0.355	0.723	–0.408	0.283
4 and more	279	–0.272	0.277	–0.981	0.327	–0.815	0.271
Constant		75.914	0.246	308.350	0.000	75.432	76.397

R^2= 0.097; F = 29.087; df = 27; p = 0.000

TABLE 4. Coefficients of the multivariate linear regression equation for the morphological facial index of conscripts in 1998.

Variable	B	Standard error	t	Significance level	The 95% reliability interval of B95 lower limit	upper limit
The mother's educational level	0.466	0.064	7.263	0.000	0.340	0.592
Place of residence						
Budapest	0.088	0.217	0.404	0.686	–0.338	0.513
City 1	–1.944	0.224	–8.667	0.000	–2.384	–1.504
City 2	0.859	0.239	3.601	0.000	0.391	1.326
Small town	0.068	0.193	0.350	0.727	–0.311	0.447
Constant	88.519	0.200	441.767	0.000	88.126	88.912

R^2 = 0.022; F = 33.37; df = 5; p = 0.000

social background determined by these three factors is moderate. So it can be supposed that the cephalic index, which is the ratio of the width and length of the head, is formed basically by genetic factors (*Table 2*).

On basis of the value of the B parameters indicated in the table we can say that going lower by a unit on the descent of settlement types, the average value of the index grows by 0.477. Besides, the mother's educational level higher by 1 level reduces the ratio of the width of the head to its length on the average nearly by 1% (0.951%). In case of second-born at the age of 18 years the width of the head compared to its length is by 0.43% lower compared to the others. The birth order and the family size are not independent from one another. The higher is the birth order, the surer the conscript comes of a family with many children. Thus the variable indicated in the model connects practically these two effects, and therefore the variable of the number of brothers/sisters was not significant, while controlling for the others.

The model in which instead of the mother's educational attainment the combined indicator of the educational level of both parents was included, explains a greater part of the variance (9.7%). It must not be forgotten then, however, that this model refers only to those conscripts where the educational attainment of both parents is known. Consequently, in respect of the educational attainment the sample is more homogeneous than the original one. If we adapt to this narrower sample the model in which only the mother's educational attainment is indicated, the explained variance decreases to 0.087. We do not present the table of this respect because the parameters are very similar to those above presented. Anyhow from the foregoing we can conclude that also the father's educational attainment is an important explaining variable concerning the cephalic index (*Table 3*).

The model developed with the inclusion of the variable concerning the educational attainment of both parents' shows that the lower are the parents' educational

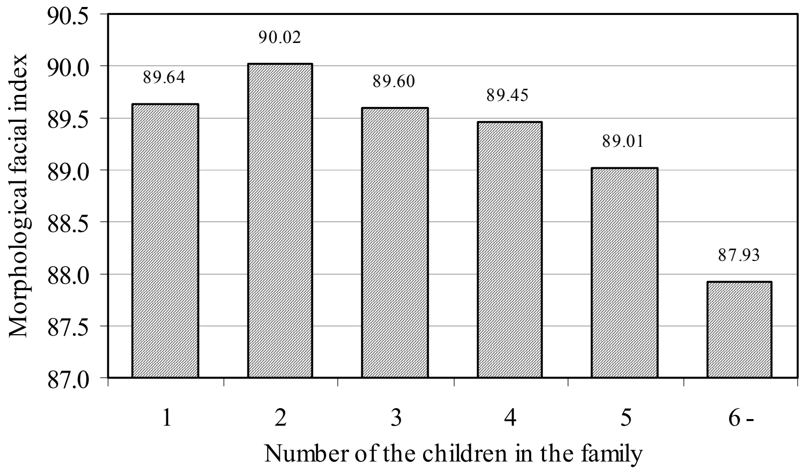

FIGURE 7. The morphological facial index of the conscripts according to the number of the children in 1998.

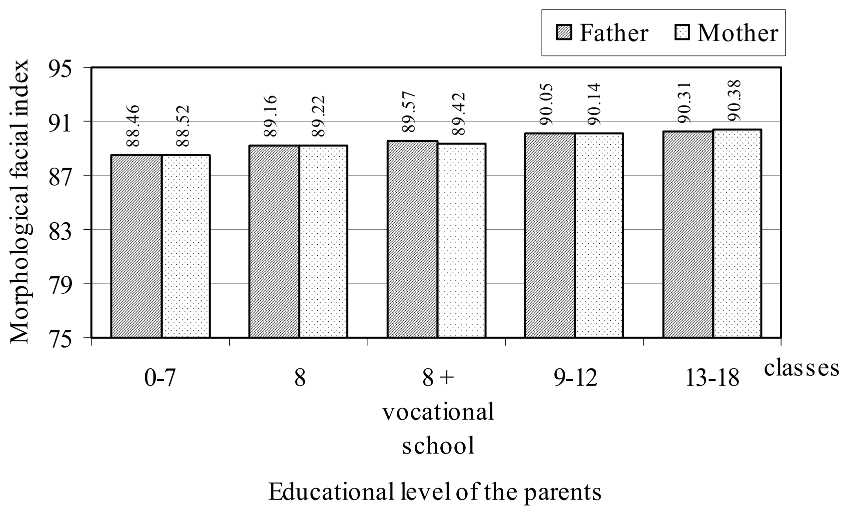

FIGURE 8. The morphological facial index of the conscripts according to the educational level of the parents in 1998.

attainments together, the higher is the value of the cephalic index. To facilitate the interpretation of the data, we also indicate number of cases, because the variable of 25 possible values cuts up the sample significantly, and there are pairings that occur very seldom.

The cephalic index – as we saw it above – is relatively less influenced by the social conditions because the variables included in the analysis explain scarcely 10% of the variance. In case of the morphological facial index the ratio is even much lower than this value, only 2%. After the inclusion of the mother's educational attainment and the population size group of the place of residence, the birth order was not significant.

Parallelly with the increase in the mother's educational attainment, also the value of the indicator grows. In case of a growth by a unit, the morphological facial index will be higher by 0.466 on the average. The face of the inhabitants of the most populous towns outside Budapest is significantly narrower compared to its height. The situation is inverse in the urbanised areas with a less high population number (*Table 4*).

The explaining power of the detailed model containing the educational attainment of both parents is the same as that of the former one. So we can say that the father's educational attainment gives no further information concerning the factors affecting the value of the facial index.

DISCUSSION

Giot (1949) was the first who observed the process of the debrachycephalisation in males of five populations of Brittany (France) over a 57 year period (1889–1946). The decrease of the cephalic index was between 0.3–2.1 in those populations. Büchi (1950) obtained similar results in a sample of Switzerland. Marquer and Chamla (1961) found the debrachycephalisation in a sample of 2,091 individuals from France aged between 20–91 years. Billy (1966) described the same phenomenon in the data of different populations of Switzerland, Brittany and Northern-France at the end of the 19th century. Vercauteren *et al.* (1983) were the first who showed the debrachycephalisation process in children from Belgium between 1960–1980. Zellner *et al.* (1998) analysed the changes of head dimensions in school children from Jena (Germany) between 1944 and 1995. The head length increased, while the head breadth and the value of the cephalic index decreased, the latter one with 8 units during the investigated period. In an other Middle-European country, the Czech Republic, the mean value of the cephalic index of the children decreased by 4 units between 1976–78 and 1995–96 (Bláha *et al.* 1999). Bunak (1969) also showed the debrachycephalisation in children from Kazakhstan and the U. S. A. However, in Japan, the brachycephalisation has recently only ceased, but did not turn yet to the opposite direction, the debrachycephalisation. Moreover, in Grönland, in an Eskimo-Danish hybrid population of Augpilagtok and Kraulshavn, the brachycephalisation has continued between 1885–88 and 1968–69 and the mean value of the cephalic index increased by 5 units during this period (Jorgensen *et al.* 1974).

In Hungary Eiben and Pantó (1984) were the first who recognised the debrachycephalisation in Hungarian schoolchildren. They repeated Ballai's 1913–14 investigations on the head dimensions of Hungarian school children in six villages. Seventy years later they found that the mean value of the cephalic index in the same villages decreased by about 5 units. Gyenis (1994) reported very rapid changes of head dimensions in a sample of Hungarian university students consisting of ten successive classes of first year students at the Technical University Budapest between 1976–1985. The values of the head length and morphological facial height increased, while the values of the head breadth and bizygomatic diameter decreased. Therefore the mean value of the cephalic index decreased by 2.0 units in males and 1.7 units in females, while the mean value of the morphological facial index increased in males by 3.6 units and 4.2 units in females. Thus the tendency to a longer and narrower head shape seems to be closely connected to the tendency of the face to be higher and narrower in this period.

Several factors have been thought to be responsible for the variations and changes in the head form. They include the climate (Coon 1955, Beals *et al.* 1983), heterosis (Billy 1975), nutrition or diets (Lasker 1946), allometry related to increases in height (Susanne *et al.* 1988), migration (Kobylianski 1983), urbanisation (Pálsson, Schwidetzky 1973) and socio-economic status (Pálsson, Schwidetzky 1983, Gyenis, Gonda 1991). In spite of the several factors suggested as the reasons of the changes in head form during the last centuries, the real causes are still unknown.

Recently, Jaeger *et al.* (1998) emphasised that brachycephalisation and debrachycephalisation are part of the secular trend. They based their hypothesis on the data of different populations from the Neolithic till the end of the 20th century in Germany, where they found the decrease of body height connected with brachycephalisation, while the increase of the body height was connected with debrachycephalisation.

Another tendency was observed by Kouchi (2000), who found that increases in height over the last 100 years have been accompanied by brachycephalisation in Japanese and Korean populations.

The authors studied earlier the effect of the secular trend on the stature in the Hungarian conscripts (Gyenis, Joubert 2002) and they found that the positive secular trend has continued in the conscripts. Therefore, the results presented here agreed well with the statement of Jaeger *et al.* (1998), that the secular trend of the stature is connected with a debrachycephalisation process in Europe. It was also observed that the debrachycephalisation is connected with the tendency of the face to become narrower and higher. The debrachycephalisation trend of the Hungarian conscripts is as rapid as in the case of the university students (Gyenis 1994).

It was also found that effects of the environmental and genetic factors on the shape of the head have different expressions. Among the socio-demographic factors, the combined educational level of the parents explained the greatest part of the variance. The influence of the genetic factors was higher in the case of the cephalic index than in the morphological facial index.

CONCLUSIONS

The following phenomena were found in Hungarian conscripts surveyed in 1998 in terms of the cephalic and morphological facial indices:

1. Rapid debrachycephalisation appeared between 1973–1998. The mean value of the cephalic index decreased by 6 units during the 25 years.
2. At the same time, the tendency to a narrower head shape seemed to be closely connected to the tendency of the face to become narrower and higher. The mean value of the morphological facial index increased by 6.5 units during the 25 years.
3. The majority of the investigated socio-demographic factors (place of residence, parental educational level and family size) influenced significantly the shape of the head of the Hungarian conscripts.
4. The regression analysis showed the different power of the socio-demographic and genetic factors on the shape of the head.

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