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Original Research Article

Secular Change of Craniofacial Measures in Croatian Younger Adults

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ABSTRACT A secular change of body height and neurocranial variables was registered in the Croatian population during the last century. We investigated the continuity of this process, and introduced facial measurements into the study. The results cover a 13-year period, from the birth of the subjects in 1974–1986, with a gap in the period from 1977–1981. The subjects were first-year students of the University of Rijeka School of Medicine, aged 19–21 years. Secular changes were evaluated by analysis of variance and multivariate regression analysis. A statistically significant decrease was found in head breadth, and an increase in morphological face height values, in both sexes. A significant increase of head circumference was observed in female students. The height and length of the head in both sexes displayed a slight but insignificant increase, while face breadth revealed no notable change during the investigated period. The results allow an assumption of a trend of cranial vault and face shape remodeling in our younger adult population toward a narrower vault and more elongated face, consistent with ongoing dolichocephalization. The correlation analysis revealed a low to moderate relationship of vertical and longitudinal craniofacial measures and body height, while partial correlation analysis showed facial height changes in our sample to be independent of cranial breadth changes. Am. J. Hum. Biol. 18:668–675, 2006.

Over the past 100 years, significant secular changes of body height and different body and craniofacial proportions were noted in European and other populations (Hauspie et al., 1996; Kondo et al., 1999; Casado de Frias, 1999; Fredriks et al., 2000; Jantz and Meadows Jantz, 2000; Kouchi, 2000; Padez, 2003; Hossain et al., 2005; Gyenis and Joubert, 2004; Zellner et al., 1999; Hoppa and Garlie, 1998; Danubio et al., 2003; Sanna and Soro, 2000; Cole, 2000; Castilho and Lahr, 2001; Smith et al., 1986). These changes, associated with industrialization, improvement of living conditions, nutritional habits, and a good socioeconomic environment in the developed countries, failed to take place in industrially underdeveloped, rural regions (Prazuck et al., 1988). Body height showed a consistent increase in the developing world due to a secular change in the growth rate, which occurs mainly during early childhood. In contrast, head and face dimension changes followed different patterns in different populations. In the European-derived and American black population, the skull has become narrower, and the vault has increased in height and length (Wescott and Jantz, 2005). Head height showed greater secular change than any other head dimension. Face changes were less pronounced, but face breadth followed the head breadth pattern of change and decreased, while face height increased, i.e., the face became narrower and higher (Jantz and Meadows Jantz, 2000). Smith et al. (1986) reported craniofacial enlargement in adult Northern European-derived offspring compared to their parents. Facial morphology significantly differed between the two groups. Facial depth and height (mainly upper facial height) increased in the former, while facial breadth decreased. The pattern of secular changes differs between populations, and is thus population-specific. In a population of Zapotec-speaking Indian children from southern Mexico, for instance, a secular decrease of head length and an increase of head breadth (brachyceph-

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alization) were registered over several recent decades, accompanied by face-remodeling toward a narrower face (Little et al., 2006). In the Japanese population, head breadth, head length, and bizygomatic breadth showed a secular increase (Kouchi, 2000, 2004; Kondo et al., 1999). Because the rate of secular head breadth increase was extremely high relative to head length, individuals were becoming short-headed, with a relatively broad skull. Consequently, the cephalic index increased. This process of brachycephalization has ceased in the Japanese and Korean population during the second half of the past century (Kouchi 2000). However, a slight reversal of head dimension changes was also noted in Japanese males and females in recent decades (Hossain et al., 2004, 2005). The key factors in the process of head-dimension changes are small increases in the growth rate in a specific direction during infancy and childhood. These increases involve the posterior cranial base, and occur in a posterioinferior or lateral direction, resulting in significant changes of the vault shape (Kouchi, 2000; Wescott and Jantz, 2005). Secular changes of cranial dimensions also occurred in the Croatian population, as displayed in children and adults (Prebeg, 2002; Prebeg et al. 1995; Buretić-Tomljanović et al., 2004). In our previous study, in a sample of a student population (Buretić-Tomljanović et al., 2004), we compared head measures with those of similar studies from the mid-20th century, and demonstrated dramatic head length and breadth changes, resulting in a significant decrease of cephalic index values and a significant change in frequencies of all cephalic categories in both sexes. These results were consistent with dolichocephalization. Since head growth in length and height, and also an increase of body height, moderately correlate with vertical facial growth (Baume et al., 1983; Jantz and Meadows Jantz, 2000; Lieberman et al., 2000), in the present study, we introduced the investigation of the tendency to change into head height and face measurements in a population of younger adults. We expected head length and breadth changes to still be in progress in our population, and we were interested in following head height or facial dimension changes. According to a general trend, dolichocephalization is accompanied by facial measure changes leading to a narrowing of the midface and an increase of facial depth and height. We investigated the correlation between craniofacial measures, body height, and year of birth, and also the relationship between vertical, horizontal, and longitudinal craniofacial dimensions.

SUBJECTS AND METHODS

The study included 921 medical students (363 male and 558 female) from the University of Rijeka School of Medicine, aged 19–21 years, and born between 1974–1976 and 1982–1986. Anthropologic measurements were not conducted in students born between 1977–1981. All students were divided into groups according to year of birth. The mean age of the specified population correlates with the end of the physical body growth period in humans. We therefore selected the student population as a representative general population of younger adults. In this age group, the effects of several environmental and aging factors were excluded (Relethford and Lees, 1981; Vercauteren, 1990; Schousboe et al., 2004), and therefore, the phenotype of our subjects was closest to that genetically assigned. In addition, they are in the prereproductive age and, in most cases, up to their present life phase, there were no significant migrations.

Approximately 48% of our medical students are from northwest Croatia, representing the Rijeka, Istria, and Lika regions. About 17% come from central Croatia, mainly the wide area surrounding the capital city. From the south (the Dalmatian region) come 26%, and 9% come from the eastern part (Slavonia). Since our students come from all parts of Croatia, they represent a larger student population of the same age. Given that students from the central and eastern parts of Croatia gravitate mostly toward the University of Zagreb, their number in our sample is smaller. All students participated voluntarily in the research.

In this study, body height, head length (glabella-opisthocranion), head breadth (euryon-euryon), head circumference, head height (vertex-porion, while the head is in the Frankfurt horizontal), morphological face height (nasion-gnathion), and face breadth (zygion-zygion) were analyzed. Body height, head length, and head breadth were determined for all student groups, while head circumference, head height, and facial measures were assessed partially in groups born in 1982 and 1983, and completely in groups born between 1984–1986 (in total, 201 male and 340 female students). Craniofacial measures and body height were evaluated with the statistical software package for Windows 2001 by Stat Soft, Inc. The statistical analysis was performed using analysis of variance (ANOVA/MANOVA), with multiple dependent variables to assess significant differences among groups (degrees of freedom are 7 for body height, head length, head breadth, and cephalic index, and 4 for head height and all facial measures). Statistical significance was assumed at $P < 0.05$. A linear regression analysis using the least-squares method was used for determining the correlation of individual craniofacial measures with body height and year of birth. Multivariate regression analysis was used to test changes of the investigated variables in the course of time in male and female students. Partial correlation coefficients were calculated (while holding body height and birth year constant) to examine relationships among craniofacial dimensions.

RESULTS

Table 1 shows the mean and standard deviation values of head and face measurements in both sexes during the 13-year research period (birth years 1974–1986).

Table 2 shows the direction and statistical significance of changes obtained by multivariate regression analysis, in which the secular trend of cranial and facial variables was evaluated by regression of these variables to year of birth. We observed a significant decrease of head breadth and a significant increase of morphological face height in both sexes (Figs. 1, 2), and an increase of head circumference in female students (Tables 1 and 2). ANOVA also showed significance for head breadth and morphological face height in both sexes ($P < 0.001$ for both measures in males; in females, $P < 0.00001$ for head breadth, $P < 0.0001$ for head circumference, and $P < 0.02$ for morphological face height). The particular measurement changes of head and face are, therefore, significant in absolute values, and are pronounced in both sexes. Although highly significant in both sexes, facial changes, revealed by ANOVA, were more pronounced in males, while changes in cranial measures were greater in females. The present results clearly show a tendency of skull narrowing and of the face becoming longer in our younger adult males and females.

Absolute values of all craniofacial measurements are lower in female students than in males (Table 1), showing sexual dimorphism. Changing variables, but not at a level of statistical significance, are seen in body height, head length, and head height (showing a trend toward slight increase), while the slight trend of facial-breadth decrease, also insignificant, is found in females. The correlation coefficients of craniofacial measurements, body height, and year of birth are presented in Table 3. Table 3 shows that horizontal head and face measures do not correlate, or correlate weakly, with body height, while the correlation between body height and all other investigated characters is moderate but highly significant. The results of correlation analysis of craniofacial measures and year of birth are consistent with those obtained by regression analysis and ANOVA. In Table 3, a low but significant correlation between head length and year of birth is evident in males. To investigate the correlation between different craniofacial measures, we used partial correlation coefficients, controlling for body height and year of birth.

Partial correlation coefficient analysis (Table 4) revealed different patterns of interdependence of particular craniofacial measures between sexes. The consistent findings in both sexes are: 1) low or moderate correlation between all cranial measures, with the exceptions of head length and head breadth; 2) moderate correlation between horizontal (head breadth-face breadth) and vertical (head height-morphological facial height) cranial and facial measures; 3) low to moderate correlation of head circumference with all other craniofacial variables; and 4) lack of correlation between head breadth and morphological face height.

DISCUSSION

A secular increase in stature and changes in cranial dimensions in our population were observed in the mid-20th century. The low magnitude of body-height changes in the eight subject groups examined in this study is consistent with findings in other European populations during recent decades. The secular trend in adult height has slowed down, but is still continuing in most industrialized countries (Hauspie et al., 1996; Casado de Frias, 1999). Prebeg (2002) also anticipated a positive secular change in body height among Croatian schoolchildren in the following decades. Our population of schoolchildren and adults is among the tallest in Europe. In our subject sample (over a 13-year period), the mean body height and standard deviation of male stu-

TABLE 1. Mean craniofacial measures[1]

	Year of birth							
	1974	1975	1976	1982	1983	1984	1985	1986
Males	N = 45	N = 52	N = 38	N = 38	N = 65	N = 44	N = 39	N = 15
BH	182.56 ± 6.29	180.96 ± 6.7	182.90 ± 5.0	182.23 ± 6.5	183.18 ± 6.1	182.13 ± 6.4	181.72 ± 5.4	183.81 ± 6.9
HL	19.11 ± 0.78	19.06 ± 0.75	19.48 ± 0.71	19.24 ± 0.77	19.46 ± 0.75	19.35 ± 0.77	19.40 ± 0.79	19.30 ± 0.78
HB	14.97 ± 0.50	15.10 ± 0.62	15.13 ± 0.64	14.94 ± 0.77	14.88 ± 0.69	14.53 ± 0.85	14.63 ± 0.73	14.53 ± 0.56
HH				14.81 ± 0.49	14.70 ± 0.72	14.79 ± 0.73	14.75 ± 0.71	14.81 ± 0.66
HC				57.70 ± 1.14	57.69 ± 1.72	57.75 ± 1.82	58.08 ± 1.87	58.30 ± 1.98
MFH				11.59 ± 0.70	11.63 ± 0.70	11.72 ± 0.76	12.16 ± 0.64	12.08 ± 0.65
FB				11.02 ± 0.64	11.03 ± 0.68	10.86 ± 0.67	11.18 ± 0.59	10.83 ± 0.49
Females	N = 73	N = 93	N = 52	N = 41	N = 110	N = 84	N = 77	N = 28
BH	169.04 ± 5.48	168.64 ± 5.2	169.06 ± 7.9	168.04 ± 5.6	168.31 ± 6.2	170.03 ± 6.1	169.31 ± 5.6	168.47 ± 6.0
HL	18.30 ± 0.60	18.30 ± 0.78	18.38 ± 0.81	18.28 ± 0.91	18.31 ± 0.79	18.45 ± 0.70	18.38 ± 0.78	18.50 ± 0.81
HB	14.88 ± 0.76	14.54 ± 1.00	14.49 ± 0.79	14.29 ± 0.63	14.24 ± 0.83	14.02 ± 0.62	14.11 ± 0.70	13.89 ± 0.55
HH				13.80 ± 0.52	13.89 ± 0.63	14.01 ± 0.78	13.93 ± 0.54	13.99 ± 0.69
HC				55.24 ± 1.41	55.35 ± 1.49	55.96 ± 1.49	56.14 ± 1.57	56.94 ± 1.81
MFH				10.76 ± 0.54	10.71 ± 0.68	10.85 ± 0.72	10.98 ± 0.53	11.15 ± 0.74
FB				10.46 ± 0.68	10.41 ± 0.58	10.46 ± 0.55	10.31 ± 0.66	10.37 ± 0.54

[1]BH, body height; HL, head length; HB, head breadth; HH, head height; HC, head circumference; MFH, morphological face height; FB, face breadth.

dents are 182.4 ± 6.28 cm (ranging from 181–184 cm), and of female students, 168.8 ± 5.92 cm (ranging from 168–170 cm). For comparison, in the Dutch population, which is the tallest in Europe, the mean height and standard deviation of men aged 19–21 are 183–184 ± 7.1 cm, while the tallness of their young women is 170.2–170.6 ± 6.5 cm (Frederiks et al., 2000). The same authors stated that the trend toward body-height increase has not yet ceased.

Head breadth and morphological face height are craniofacial measures that significantly changed in both sexes during the 13-year period (from year of birth 1974–1986) in our population (Figs. 1, 2). A head breadth decrease is noted as the key factor during dolichocephalization. Concurrently, the trend of longitudinal and vertical head increase is poorly marked, and the change pattern is equal in both sexes (Table 1). It is noteworthy that the observed significant change in head breadth did not reflect the same change of facial breadth (bizygomatic breadth) in men or women. However, during the same time, the face grew vertically, resulting in the appearance of an elongated face. These results should be viewed with caution, mainly because the geographic composition of the birth year cohorts in this study was not homogenous. In the birth-year 1974–1976 cohort, students from the northwestern and southern parts of the country prevailed. More students from the central and eastern parts were included in the birth-year 1983–1986 cohort. According to our unpublished results, significant geographic variation refers to head length in both sexes and head and face breadth in females, but not to morphological face height measures. A separate regression analysis (data not shown) confirmed a significant head breadth decrease in 3 out of 4 geographic regions in Croatia, and a significant increase of morphological face height in all regions. A significant head-breadth decrease has not been found only in the eastern part of the country, and this part of the country was least represented in our sample. Taking into consideration that head-breadth values in both sexes increase from the southern through northwestern and central to eastern parts of Croatia (unpublished data), the authors believe that the secular change evaluated in this study is not an expression of the geographical heterogeneity of the sample.

The correlation coefficient values (Table 3) suggest a low relationship between craniofacial dimensions and body growth, with the exception of horizontal craniofacial measures,

TABLE 2. Multivariate regression analysis of body height and craniofacial traits[1]

	Males			Females		
	N		Comment	N		Comment
BH	336	NS		556	NS	
HB	336	$\beta = -0.22^*$	Narrower head	556	$\beta = -0.26^*$	Narrower head
HL	336	NS		556	NS	
HC	194	NS		325	$\beta = 0.27^*$	Increase
HH	194	NS		325	NS	
MFH	195	$\beta = 0.26^*$	Longer face	325	$\beta = 0.18^*$	Longer face
FB	194	NS		325	NS	

[1]BH, body height; HB, head breadth; HL, head length; HC, head circumference; HH, head height; MFH, morphological face height; FB, face breadth; NS, nonsignificant.
$^*P < 0.001$.

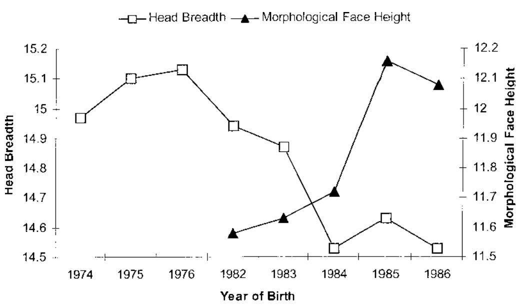

Fig. 1. Secular change in head breadth and morphological face height in males.

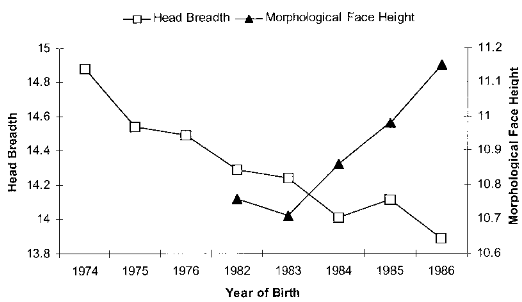

Fig. 2. Secular change in head breadth and morphological face height in females.

the correlation of which is weak or insignificant in both sexes. Vertical and longitudinal measures correlate well with body height, meaning that taller individuals tend to have a longer and higher skull (dolichocephaly and dolichofacial morphology) and a more elongated face (leptoprosopic morphology) than shorter individuals. Dolichofacial morphology, determined by a long anterior face and short posterior facial height, was often found to be associated with a dolichocephalic skull (Bastir and Rosas, 2004). Brachycephalics, in contrast, show a greater population tendency toward a broad facial pattern (euryprosopic) (Bhat and Enlow, 1985) and an equal anterior and posterior facial height (Bastir and Rosas, 2004). Head and face width probably follow other causes of change not associated with vertical head, face, and body growth. This is not the case in the Japanese, in whom the head-breadth pattern of change is very similar to that of body height (Kouchi, 2004). Lieberman et al. (2000) showed that cranial base dimensions (cranial base breadth and height) are key components that constrain maximal head breadth, and together with endocranial volume, influence overall cranial shape and, to some extent, facial characteristics (facial width and depth). During the last century, endocranial capacity significantly increased among Americans (especially white males) and Europeans (Jantz and Meadows Jantz, 2000; Miller and Corsellis, 1977). Dolichocephaly rises on account of large brains on a narrow cranial base. As the cranial-base breadth narrows and the brain enlarges, the vault size increases vertically and posteriorly. Vertical vault growth results from the movement of the basion to an inferior and slightly posterior position (Wescott and Jantz, 2005), while longitudinal vault growth correlates with endocranial volume not being restricted by cranial-base dimensions (Lieberman et al., 2000). In this context, significant head-breadth decrease, followed by a slight increase in head length and height measures in our study, may reflect potential long-term changes in basicranial measures or changes in the growth rate of the brain, thus affecting vault shape changes.

The exact relationship between the face, basicranium, and neurocranium is still not completely clear. Although the face, cranial base, and vault grow in a morphologically integrated manner, a certain developmental inde-

TABLE 3. Correlation coefficients between craniofacial measures, body height, and year of birth[1]

	Males				Females			
	Body height		Birth year		Body height		Birth year	
Variable	$df^{HL,HB} = 362$; $df^{HH,HC,MFH,FB} = 194$				$df^{HL,HB} = 551$; $df^{HH,HC,MFH,FB} = 320$			
HL	0.28	$p = 0.0000$	0.13	$p = 0.014$	0.28	$p = 0.0000$	0.02	NS
HB	0.10	NS	−0.22	$p = 0.0000$	0.10	$p = 0.017$	−0.26	$p = 0.0000$
HH	0.30	$p = 0.0000$	0.09	NS	0.27	$p = 0.0000$	0.08	NS
HC	0.37	$p = 0.0000$	0.12	NS	0.26	$p = 0.0000$	0.27	$p = 0.0000$
MFH	0.29	$p = 0.0000$	0.28	$p = 0.0000$	0.28	$p = 0.0000$	0.18	$p = 0.001$
FB	0.11	NS	−0.03	NS	0.10	NS	−0.06	NS

[1]HL, head length; HB, head breadth; HH, head height; HC, head circumference; MFH, morphological face height; FB, face breadth; NS, nonsignificant.

pendence between these components was suggested (Liebermann et al., 2000; Zollikofer and Ponce de Leon, 2002). A significant degree of independence was also determined between the three axes of facial (Smith et al., 1986) and basicranial (Lieberman et al., 2000) growth direction. The results of the partial correlation analysis of this study (Table 4) are consistent with the hypothesis of integration between the neurocranium and face, but also with the finding that most aspects of facial shape are independent of neurobasicranial dimensions. The correlation between different craniofacial measures is generally highly significant, but weak. Horizontal craniofacial measures (head breadth and face breadth) showed a moderate, highly significant correlation. Vertical measures (head height and morphological face height) also correlate significantly, although the correlation is stronger in males than in females. The correlation between longitudinal (head length) and vertical (head height) cranial measures is low and significant. The longitudinal measure (head length) does not correlate significantly with any horizontal measure. Head circumference correlates moderately-to-low but significantly with all cranial and facial measures in the study. In conclusion, the pattern of dependency is similar in both sexes for all cranial measures. When cranial and facial measures are compared, different patterns of interdependence appear between sexes (Table 4) that may be interpreted as an indication of more homogenous growth of the skull in females (Rude and Mertzlufft, 1987). Two variables showing secular change in our study, head breadth and morphological face height, do not correlate in either sex. It follows that the neurocranial variation influence on facial characteristics is low, and that face height changes, as observed in this study, may not be directly connected to head-breadth decrease. An apparent lack of correlation between morphological face height and head-breadth values may be explained by the fact that the face and neurobasicranium follow different growth trajectories. The neurobasicranium follows a neural growth pattern. The basicranium is the first region of the skull to reach adult size, probably early in life, constraining head and facial breadth. The face follows the general pattern of growth seen for body dimensions, and vertical facial variation was found to correlate with a broad spectrum of skull morphology, from a long-faced (dolichofacial) to short-faced (brachyfacial) morphology. Therefore, the influences of factors unrelated to neurobasicranium dimensions or size changes of the particular parts of the face may be related to the increase in morphological face height in our study.

TABLE 4. Partial coefficients of correlation between cranial and facial measures[1]

	Males		Females	
Cranial measures				
HL-HB	0.02	(NS)	0.03	(NS)
HL-HH	0.22	($p = 0.002$)	0.19	($p = 0.001$)
HB-HH	0.16	($p = 0.032$)	0.16	($p = 0.004$)
HH-HC	0.24	($p = 0.001$)	0.24	($p = 0.000$)
HL-HC	0.44	($p = 0.000$)	0.55	($p = 0.000$)
HC-HB	0.37	($(p) = 0.000$)	0.20	($p = 0.000$)
Facial measures				
MFH-FB	0.17	($p = 0.023$)	0.03	(NS)
Cranial and facial measures				
HB-FB	0.37	($p = 0.000$)	0.30	($p = 0.000$)
HH-MFH	0.31	($p = 0.000$)	0.15	($p = 0.008$)
HB-MFH	0.12	(NS)	0.04	(NS)
HH-FB	0.07	(NS)	0.13	($p = 0.019$)
HL-MFH	0.13	(NS)	0.18	($p = 0.001$)
HL-FB	−0.10	(NS)	−0.01	(NS)
HC-FB	0.17	($p = 0.027$)	0.23	($p = 0.000$)
HC-MFH	0.18	($p = 0.014$)	0.23	($p = 0.000$)

[1]HL, head length; HB, head breadth; HH, head height; HC, head circumference; MFH, morphological face height; FB, face breadth; NS, nonsignificant.

Since the face is divided into a series of morphogenetically independent but interacting components (integrated morphometric units of the face that show a higher degree of intercorrelation), some of which were already determined (Bastir and Rosas, 2005; McCarthy and Lieberman, 2001), it would be of interest to determine on account which part(s) of the face (upper, middle, or lower part) is facial height changing in our population, to evaluate other facial characteristics (e.g., posterior facial height and facial depth), and to correlate those findings with overall skull morphology. A decrease of the head-breadth measure resulted in a further decrease of cephalic index (data not shown). Mean values of cephalic indices in the studied 13-year period border on mesocephalic toward dolichocephalic values in our population, and our results corroborate that the decrease in head breadth is a major factor in the process of dolichocephalization.

An increase in body height and a craniofacial morphology shift in the European population is evident since the Neolithic (Jeager et al., 1998a,b; Sardi et al., 2004). Their consistency at a global level suggests the effect of environmental factors, although the exact mechanisms driving these processes are still the subject of debate. A strong relationship between improved nutrition and healthcare and changes in growth and craniofacial morphology was suggested (Cole, 2000; Silventoinen et al., 2003, Sardi et al., 2004; Wescott and Jantz, 2005). However, body height, and head and face shape, are also greatly influenced by genetic factors. Notwithstanding similar secular changes in body height and head shape in many populations and races, variations between ethnic groups remain significant, suggesting, along with a high heritability of cranial measures within families, a strong genetic component (Sparks and Jantz, 2002; Silventoinen et al., 2003; Livshits et al., 2002). In their female twin study, Peng et al. (2005) reported significant genetic effects on the vertical plane, and a significant environmental effect on the antero-posterior plane, of facial growth. Good socioeconomic conditions and adequate nutrition have probably enabled the expression of genetic cranial-base and brain growth potential in the human population, thus substantially affecting cranial and, to some degree, facial measures. Facial growth during ontogeny is additionally affected by epigenetic stimuli: masticatory (Varella, 1992; Rangel et al., 1985) or respiratory (Yang et al., 2002; Mattar et al., 2004).

An almost identical trend in craniofacial dimension change was registered in the Hungarian student population (Gyenis, 1994), as in ours, with the distinction that we have not determined the facial narrowing trend. It is possible that the amplitude of change in face breadth was relatively small, so we were not able to observe it in the very short 5-year follow-up period. The trend of face-breadth and face-height changes was also observed in American whites of both sexes during the past 150 years (Jantz and Meadows Jantz, 2000). The face-narrowing process is explained by changes in nutritional habits and an increased consumption of highly processed food that reduces masticatory stress. This changes the necessity for a wide masticatory muscle anchor base on the cranial bones, which could contribute to the facial narrowing process. There is a long-term interaction between craniofacial growth and biting muscle force. It was shown that a "long-face" type of craniofacial morphology was associated with a lower bite force (Sonnesen et al., 2001), although different findings were reported (Farella et al., 2005).

Although the study covers a relatively short period and the results are, for that reason, very limited, they allow an assumption of the trend of cranial vault and face shape remodeling in our younger adult population. The trend toward a narrower cranial vault and more elongated face is consistent with dolichocephalization. Monitoring the tendency of change in particular craniofacial measures and its contributing factors in our population will be our interest in the future.

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