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A COMPARISON BETWEEN THE CEREBRAL INDEX, CRANIAL CAPACITY AND BRAIN WEIGHT OF MALE AND FEMALE 7-12 YEARS OLD CHILDREN IN ARAK (CENTRAL IRAN)

ABSTRACT: The comparison between human skulls of different races is achieved by computing anthropometric indices. The present study was concerned with an ethnic subgroup for which no anthropometric information was yet available. This cross-sectional research was carried out in 2003 on 1,695 native children 7-12 years old (890 males and 805 females) in Arak, which is located in Central Iran. Anthropometric data were obtained according to Hrdlička's method. All anthropometric data were drafted in checklists collected by two medical students who had been trained for obtaining inter-observer validity, and they were blind to the contents of the research. Differences in anthropometric data were tested by means of the χ2-test and T-test. Using a linear regression analysis, we investigated the relation between CI (cephalic index) in males and females, and the brain weight and cranial capacity.

The results showed a significant difference in cranial capacity, brain weight and cranial index between two male and female groups of 7-12 years old children in Arak (p<0.001). They also showed the relationship between age and cranial capacity, brain weight and cerebral index in both sexes. In conclusion, an increase of CC resulted in an increase of the body height, body weight and BMI. There are satisfactory correlations between age, BMI, and CC.

KEY WORDS: Anthropometry – Brain Weight – Cephalic index – Cranial Capacity – Iran

INTRODUCTION

The evaluation and measurement of human body dimensions and diameters may be achieved by physical anthropometry (Chamella 1997, Williams 1995). Anthropometric studies are conducted on the age, sex and racial/ethnic groups in certain geographical zones (Heidari *et al*. 2006). Anthropometric measurements are important for the assessment of health status.

An important part of anthropometry is represented by craniofacial measurements for the determination of head and face shapes (Golalipour *et al.* 2003). The comparison between human skulls of different races is greatly facilitated by the computation of different indices, of which the cephalic index reflects the ratio of length to breadth. Cranial capacity, which is in close correlation with brain volume, is especially influenced by race and is thus one of the most common measurements made in physical anthropological studies (Jordaan 1962).

The most important cephalometric dimensions are length and width of the head, which determine the cephalic index. These measurements are used routinely in pediatric, plastic surgery, orthodensy and oral surgery, as well as in diagnostic comprehension between patients and normal healthy population (Argyropoulos, Sassouni 1989, McIntyre, Mossey 2003).

The present study was concerned with an ethnic subgroup for which no anthropometric information was yet available. The purpose of this was to characterize the head and cephalic capacity of the Arak population represented by the subgroup Fars, which belongs to the so-called Caucasoid racial group.

MATERIAL AND METHODS

This cross-sectional research was carried out in 2003 on 1,695 native children 7-12 years old (890 males and 805 females) in Arak, which is located in Central Iran. These children were selected by a staged clustering method from schools of Arak City, which has 45,000 inhabitants. The children came from families, which lived in this region for at least three generations. All children were normal. Those showing any abnormality in cranio-facial and body characteristics were excluded from the study. All measurements were taken from the subject sitting on a chair in relaxed condition, except for length that was measured in standing position. Anthropometric data were obtained according to Hrdlička's method as described above (Ghanbari, Bayat 2009).

The data for each individual were recorded in a special form and processed using the software of SPSS for Windows (Version 11.5). Differences were tested by means of the $\chi 2$-test and T-test; significance was set up at $p<0.05$.

Using a linear regression analysis, we investigated the relation between CI (cephalic index) in males and females, and the brain weight (g) and recumbent cranial capacity (cm^3) at different child age.

RESULTS AND DISCUSSION

In *Table 1*, the means and standard errors (SE) of the head height, head breadth, auricular length and body weight measurements are presented. There was a significant difference in cranial capacity, brain weight and cranial index between two male and female groups of 7-12 years old children of Arak ($p<0.001$). The distribution of cranial capacity, brain weight and cranial index of children is shown in *Figures 1-3* with scatter plots and regression lines showing the relationship between age and cranial capacity, brain weight and cerebral index in both sexes.

The results of this study indicated significant differences between males and females in head height and head breadth with the exception of nine-year-old children. All measured values in males were higher than in females but in the nine-

TABLE 1. Means (mm), SE and p-values of various head parameters measured among 7-12 years old children in Arak.

	Head breadth		Head length		Auricular length	
Age	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
7-7.9	141±5.4	140±5.6	178±6.8	176±6.8*	112±4.9	104±4.9*
8-8.9	142±5.6	141±5.5	180±6.8	177±6.7*	112±4.8	106±5.4*
9-9.9	144±6.9	142±5.4*	180±6.8	178±6.4	114±5.1	109±4.2*
10-10.9	143±6.0	143±5.7	180±7.8	179±7.7*	114±4.4	111±4.6*
11-11.9	144±6.4	144±6.3	182±7.1	180±7.5*	114±4.6	112±4.5
12-12.9	145±7.0	145±5.8	182±6.4	181±7.4	114±4.2	113±4.4

*P≤0.05 significance

TABLE 2. Means, SE and p-values of cerebral index, cranial capacity and brain weight measurements among 7-12 years old children in Arak.

	Brain weight (g)		Cranial capacity		Cerebral index	
Age	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
7-7.9	1,194±73.6	1,039±67.5*	1,153±71.1	1,004±65.2*	5.3±0.7	5.0±0.9*
8-8.9	1,212±74.5	1,075±83.1*	1,171±72.0	1,038±80.3*	5.0±0.7	4.7±0.7*
9-9.9	1,234±81.9	1,136±76.4*	1,192±79.2	1,098±73.2*	4.6±0.8	4.4±0.9*
10-10.9	1,243±80.8	1,140±81.9*	1,201±78.1	1,101±79.1*	4.1±0.7	3.9±0.6*
11-11.9	1,249±75.4	1,166±95.5*	1,206±82.6	1,126±92.3*	3.8±0.6	3.6±0.7*
12-12.9	1,250±76.1	1,188±94.3*	1,208±73.5	1,148±91.1*	3.7±0.6	3.4±0.7*

*P≤0.001 significance

year-old children, the measures were equal. In auricular height there were significant differences between males and females in 7-10 years of age but no significant differences in 11-12 years old children. These results are somewhat similar to those from the study carried out in India which indicated significant differences between males and females in head height, head breadth, and auricular height values (Shah, Jadhav 2004), and in Nepal where significant differences were indicated in head height, head breadth and cephalic index of males and females (Lobo *et al.* 2005).

The present study showed that significant differences were observed between males and females in cranial capacity, brain weight and cerebral index in children of every age (*Table 2*). These results proved that with increasing age, body weight increased but cerebral index decreased because in this period (7-12 years of age), body weight increased by about 22 kg but brain weight only by 100 g. The result of this phenomenon is a decrease in cerebral index.

The overall trend in cranium throughout this period of development (7-12 years of age) is illustrated by local regression surfaces plotted for males and females. The plots indicate that cranial index was highest for 7-year-old boys and lowest for 12-year-old girls. The regression surfaces plotted indicate brain weight and cranial capacity for males and females. They were similar whereby the highest values for both cranial capacity and brain weight were detected in 12-year-old boys and the lowest in 7-year-old girls.

Many studies show that the cranial capacity (CC) in association with increasing age is mostly achieved in the first 5 years of age (Piatt, Arguelles 1991, Sgouros *et al.* 1999). From the age of 16-20 on, the CC does not change its size during the rest of the life (Knutson *et al.* 2001, Wolf *et al.* 2003). At a young subject, the correlation between the following pairs of characters was recorded: brain weight and stature, brain weight and age, brain weight and skull length, brain weight and skull width.

An initial linear regression analysis examined the effect of age and BMI on normalized brain volume to determine whether the effect observed in elderly females could be observed in younger males and females as well (Gustafson *et al.* 2004). Ward *et al.* (2005) presented that to determine whether additional variables may also predict normalized brain volume, a stepwise linear regression analysis was used to examine the effects of age, BMI and gender on normalized brain volume. Ward's results showed that age and BMI together were the best predictors of normalized brain volume (Gustafson *et al*. 2004, Ward *et al*. 2005). Acer *et al*. (2007) also found support for the increase in cranial volume in correlation with age, and all effects of sustained control over height and weight (Acer *et al.* 2007). In conclusion, an increase of CC resulted in an increase of body height, body weight and BMI. There are satisfactory correlations between age, BMI, and CC.

Two factors can affect brain weight and cranial capacity: 1 – genetic and ethnic characteristics, and 2 – environmental factors. Regarding the first factor, anthropometric parameters such as brain weight and cranial capacity turned

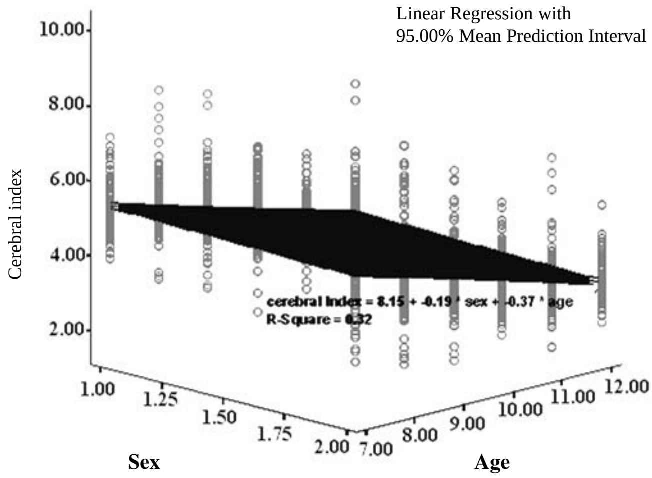

FIGURE 1. Scatter plot and regression lines showing the relationship between age and brain weight in both sexes for 7-12 years old children in Arak. 1=males and 2=females (Sex axis).

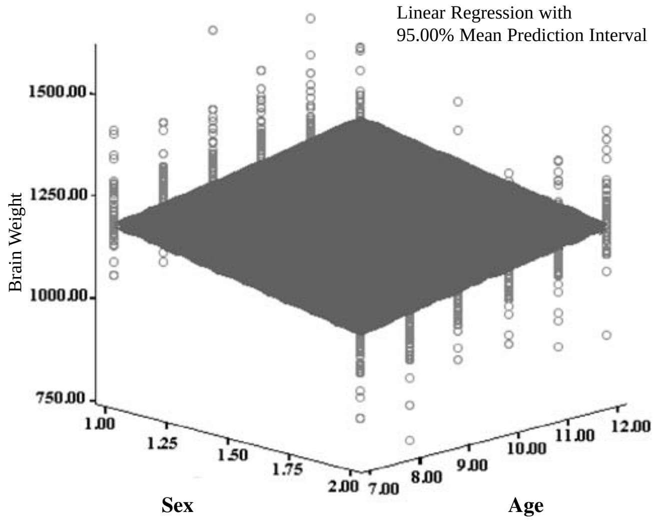

FIGURE 2. Scatter plot and regression lines showing the relationship between age and brain weight in both sexes for 7-12 years old children in Arak. 1=males and 2=females (Sex axis).

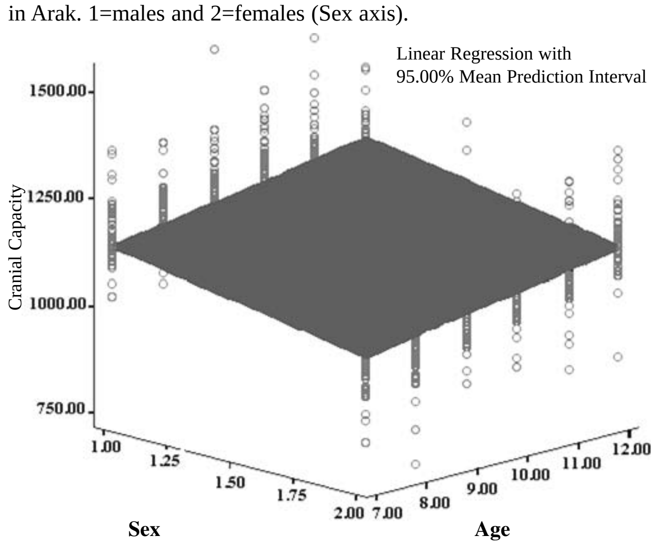

FIGURE 3. Scatter plot and regression lines showing the relationship between age and cranial capacity in both sexes for 7-12 years old children in Arak. 1=males and 2=females (Sex axis).

out to depend on gene expression 11. In addition, different ethnic groups may exhibit different patterns of gene expression. Therefore, gene expression may be used as a determining factor (Golalipour *et al*. 2004). However, while the genetics of head shape are not simply resolvable, it must be conceded that within a homogeneous group and under stable conditions the cephalic index remains constant for a long time, and this must arise mainly from hereditary transmission. Environmental factors and varying ecological conditions and food habits may cause changes in head shape. The fact that environmental pressures reduce noticeable differences between people with respect to the cranial capacity is an important factor in enabling man to adapt to life in diverse environmental conditions (Irmak *et al.* 2004).

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