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Correlation of Skull Size and Brain Volume, with Age, Weight, Height and Body Mass Index of Arak Medical Sciences Students

Correlación del Tamaño Craneal y Volumen del Cerebro, con Edad, Peso, Talla e Índice de Masa Corporal de los Estudiantes de Ciencias Médicas de Arak

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SUMMARY: Anthropometric indices that are indicators of nutrition status in children and adults can be affected by racial and geographic factors. The aim of present study was to investigate the relation of skull size and brain volume of Arak University of Medical Sciences students with their age, weight, height and body mass index. The present study was a cross-sectional study on 18-26 years old students of Arak University of Medical Sciences (150 female and 136 male) in 2009-2010 educational year. Sampling methods were probability and multi-stage methods which were performed using students' educational file and interviewing the subjects. Questions regarding anthropometric data (height, weight, age, body mass index and skull index) were included in the personal questionnaires. Data was analyzed and evaluated statistically using SPSS statistical software. Mean height was 177.27±6.41 cm in males and was 166.61±5.35 cm in females. Mean weight of males was 73.33±9.11 kg and mean weight of females was 55.55±7.28. Mean BMI was 23.20±2.43 and 21.27±2.69 in males and females, respectively. Mean skull index was 1.99±0.26 in males and 2.20±0.3 in females. Mentioned data were significantly different between males and females. Also mean age of females was less than males. Positive relations were found between skull volume and height, weight, age and BMI in both sexes and this relation is stronger regarding BMI. The present study, supporting the other studies in this field, confirms the relation between skull index and body mass index and indicates the effect of race. Considering the studied population which are students of Arak University of Medical Sciences and are from different regions of the country, similarities between results of this study and studies from Iran and studies conducted in a special region reveals that factor of race is affected by geographical factors.

KEY WORDS: Anthropometry; Body Mass Index (BMI); Skull Index; Iran.

INTRODUCTION

Anthropometry is the study of human measurements such as height, weight, head and face morphology (Chamella, 1997). Anthropometric indices display the status of nutrition in children and adults. Anthropometric data in children comprises of status of health, nutrition and growth considering the time. Adult body measurements are used to evaluate the status of health, nutrition, risk of diseases and changes in body during the life of every individual (Grau *et al*., 2001; Williams *et al.,* 1995).

Physical differences in various human races convinced the anthropologists to study factors affecting body measurements in different races considering their gender. Among them are skull size and brain volume, and possible effects of them on body measurements and proportions. Brain volume has a close relation with skull volume and is related to racial characteristics. Data regarding skull volume and brain size, and their relation with other measurements are used in phylogenic studies (EL-Feghi *et al.*, 2004; Relethford, 1994).

Furthermore, study of skull volume and brain size is very important in anthropometry and the significant amount of studies is allocated to this field. These studies have entered a new area utilizing modern technologies such as magnetic resonance imaging and brain scans; however, up to now brain volume measurement is performed by measurement of skull through the head surface. Skull length, width and height are used for calculation of brain volume. Today there are several measurement methods approved by anthropologists

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(Manjunath, 2002a; Relethford). But in terms of medicine, analysis of data regarding skull volume reveals the status of growth and development, and the prognosis of development disorders such as disorders in size of skull and related deformities and abnormalities. Anthropologists are searching to find out what factors are affecting skull size (Haack, & Meihoff, 1971; Manjunath, 2002a) however, there is still no definite answer (Hwang *et al*., 1995).

Studies in Iran have revealed the effects of different regions on anthropometric indices such as height, weight and BMI in children and youth (Akram & Agboatwala, 2000; Nemati *et al.*, 2008; Razzaghi *et al*., 2006). Although anthropometric indices are affected by factors such as race and geographical region, previous studies in had two limitations. First, previous Iranian studies cannot be an indicator for general Iranian population because they are performed in a single region. Second, these studies have not pointed to skull size and brain volume which are essential anthropometric indices and are determinants of race. Therefore the current study was performed to investigate the relation of brain weight and volume with age, gender, height, BMI in students of Arak University of Medical Sciences as a sample of general youth population of Iran.

MATERIAL AND METHOD

The present study was a cross-sectional study on investigation of anthropometric indices in 18-26 year old students. This study was performed in Arak University of Medical Sciences during 2009-2010 educational years. Sampling was performed using probability and multistage sampling methods. Briefly, first the list of all students was obtained from educational deputy of Arak University of Medical Sciences. Then population proportion of each age and sex section was calculated in faculties and from each faculty a number of students of each entrance year were selected as a cluster. The sample size of study was calculated to investigate mean height, weight and/or BMI in each age section using parameters in the report. One hundred and fifty female students and 136 male students enrolled the study. Criteria being healthy subjects without musculoskeletal, neurologic, and metabolic disorders considering the clinical examination at registration. Two groups had the responsibility of gathering data. Each group was lead by a general practitioner who was well trained before the initialization of the study. The exact age of subjects was determined using their educational files and interview with them. Their weight was measured using a balance scale (100 grams precision) with minimal clothing. For further precision scale was calibrated after each weighing. Height was determined using a wall measure (0.01 meter precision), in maximal stretching of body and in anatomic position, without shoes. Skull measurement was performed using German caliper. BMI was calculated for each subject. Precise age of subjects was determined using a computer (by subtraction of birth date from the data gathering date, at the scale of days, months and years). Then one-year age groups were formed and age of subjects was converted to these age groups. For example, 18 year age group was comprised of subjects from 17 years and one month, to 18 years old. Hrdlicka's method was used to measure cephalic indices (Hrdlicˇka, 1939).

In this method head length, width and height are measured.
Head length= Glabella to inion diameter.
Head width= the maximum transverse diameter between left and right.
Head height= Tragus to vertex diameter.

Statistical analysis. Quantitative variables were described as mean±standard deviation and qualitative variables were described as relative frequency. Comparison of mean height, weight and BMI was performed using Students T Test. P values of <0.05 was considered statistically significant. Linear regression and Pearson's correlation coefficient were used to analyze the relation between brain volume and other variables.

RESULTS

Mean±standard deviation, minimum and maximum of height, weight, brain volume, brain weight, in males and females are shown in Table I. Mean of anthropometric data was significantly different between females and males ($p<0.001$). A positive correlation was found between brain volume and anthropometric indices such as height, weight, age and BMI in both genders which are displayed. Highest correlation was found between brain volume and BMI. Correlation model of BMI and brain volume in both sexes are shown in Fig. 1.

DISCUSSION

Brain volume grows from birth to childhood with the most rapid growth before the fifth year (Sgouros *et al*., 1999). Between the ages 16-20, brain volume reaches its maximal amount and will not grow after that through life (Knutson *et al.*, 2001). A large number of studies were

Table I. Comparison of anthropometric indices in female and male students of Arak University of Medical Sciences in 2009-2010 educational year.

		Age	Height (cm)	Weight (kg)	BMI	Brain volume (mm^3)	Brain weight (g)
Males	136	20.96	177.27	73.33	23.20	1393.31	14445.19
Females	150	20.35	161.66	55.55	21.27	1168.71	1209.61
Total	286	20.52±2.44	169.3±19	64.01±12	22.19±4.8	1276.94±310	1321.61±32.2
P- Value	0.06	0.002	0.001	0.001	0.004	0.001	0.001

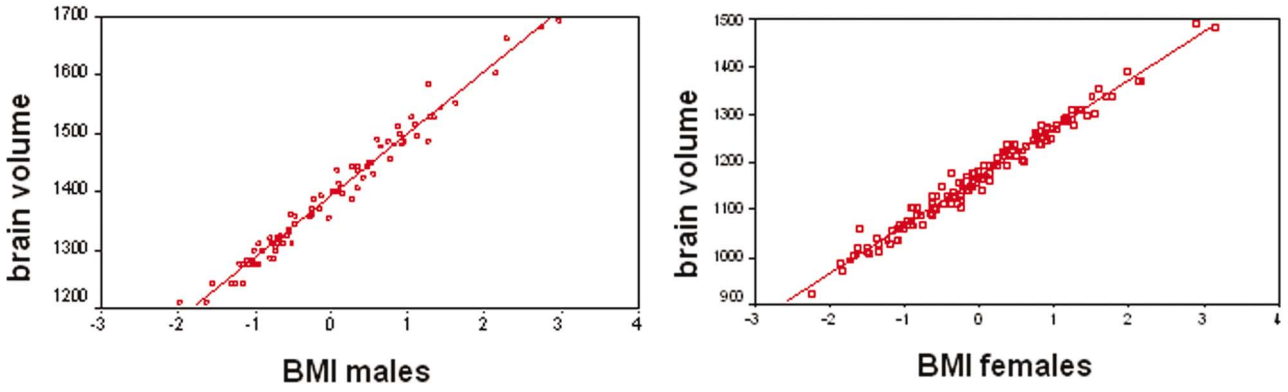

Fig. 1. Correlation between brain volume and BMI in female and male students of Arak University of Medical Sciences in 2009-2010 educational year.

conducted to determine the relation between skull volume and brain weight. The majority of these studies were on dry bone or radiologic images. In the present study we investigated skull volume from the skin surface (Gault *et al.*, 1988; MacKinnon, 1955). Results revealed that mean skull volume was significantly higher in males (1393.31±111 cm^3) compared to females (1168.71±102 cm^3). Manjunath, (2002b) reported skull volume in males and female to be 1152.813±279.16 cm^3 and 1117.82±99.09 cm^3 respectively, which is lower than our study. However, Golalipoor *et al.* (2005) have reported skull volume to be 1420.60± 85 cm^3 in males and 1227.2±120 cm^3 in Turkmen race of Gorgan, which is closer to our study compared to the mentioned Indian study.

Acer *et al*. (2006) calculated the internal skull volume to be 1311±133 cm^3 which is close to amount achieved in the present study (1276.94±310 cm^3). In regression analysis of our study, we found that age and BMI in young males and females is positively correlated with brain volume which supports the results of Gustafson's study (Gustafson *et al.*, 2004). Another study revealed that age and BMI are the best factors for determination of actual brain volume (Ward *et al.*, 2005). There is a positive relation between brain index and brain volume; however, this relation is significantly stronger in females. In short, increase in skull volume is associated with increase in height, weight and BMI and there is statistical correlation between both age and BMI, and skull volume. Consequently a formula can be formed for calculation of skull volume and ability to determine the correlation between skull volume and age, height, weight, and BMI can assist us in diagnosis of dementia, atrophy and neurodegenerative diseases in living subjects (Ward *et al.*).

Body measurements are used for calculation if BMI and also head measurements such as length, width and height can be used to calculate the skull volume. Rushton calculated the skull and brain size and displayed that height, weight and body surface have effects on skull size. He also stated that difference in races results in different in skull size and described the skull size differences between different races on this basis (Rushton, 1991, 1992; Rushton & Osborne, 1995).

In conclusion, the present study, supporting the other studies in this field, confirms the relation between skull index and body mass index and indicates the effect of race. Considering the studied population which are students of Arak University of Medical Sciences and are from different regions of the country, similarities between results of this study and studies from Iran or a studies from a special region reveals that factor of race is affected by geographical factors.

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RESUMEN: Los índices antropométricos que son indicadores del estado nutricional en niños y adultos pueden ser afectados por factores raciales y geográficos. El objetivo del presente estudio fue investigar la relación entre el tamaño del cráneo y el volumen del cerebro con la edad, peso, talla e índice de masa corporal en los estudiantes de la Universidad de Ciencias Médicas de Arak. Se realizó un estudio transversal en estudiantes de 18-26 años de edad en la Universidad de Ciencias Médicas de Arak (150 mujeres y 136 hombres) en el año educativo 2009-2010. Los métodos de muestreo fueron probabilidad y métodos de etapas múltiples que se llevaron a cabo utilizando el archivo escolar de los estudiantes y entrevista a los sujetos. Preguntas sobre los datos antropométricos (talla, peso, edad, índice de masa corporal y el índice del cráneo) se incluyeron en los cuestionarios personales. Los datos fueron analizados y evaluados estadísticamente mediante paquete estadístico SPSS. La altura promedio fue 177,27 ± 6,41 cm en hombres y 166,61 ± 5,35 cm en las mujeres. La media de peso de los hombres fue 73,33 ± 9,11 kg y 55,55 ± 7,28 de las mujeres. El IMC promedio fue 23,20 ± 2,43 y 21,27 ± 2,69 en hombres y mujeres, respectivamente. La media del índice craneal fue de 1,99 ± 0,26 en hombres y 2,20 ± 0,3 en las mujeres. Los datos mencionados fueron significativamente diferentes entre hombres y mujeres. Además la media de edad de las mujeres fue menor que en los hombres. Las relaciones positivas se encontraron entre el volumen craneal y la altura, peso, edad y el IMC en ambos sexos y esta relación es más fuerte en relación con el IMC. El presente estudio, da apoyo a los otros estudios en este campo, confirma la relación entre el índice craneal y el IMC, y se indica el efecto de la raza. Teniendo en cuenta la población estudiada que son los estudiantes de la Universidad de Ciencias Médicas de Arak en diferentes regiones del país, las similitudes entre los resultados de este estudio y estudios de Irán y otros realizados en una región especial revela que el factor de la raza se ve afectada por factores geográficos.

PALABRAS CLAVE: Antropometría; Índice de Masa Corporal (IMC); Índice de cráneo; Irán.

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