Journal of Kerman University of Medical Sciences

JKMU

Journal of Kerman University of Medical Sciences, 2020; 27 (2): 141-149

The Relationship between Brain Volume, Brain Weight and IQ in Children in Primary Schools in the South of Iran

Fatemeh Pouya, M.Sc. [1], Mahdieh Zamani, M.Sc. [1], Seyed Hassan Eftekhar-Vaghefi, Ph.D. [2], , Yunes Jahani, Ph.D. [3], Farzaneh Raaii, Ph.D. [4], Ali Shamsara, Ph.D. [5]

1- M.Sc., Department of Anatomy, Afzalipour School of Medicine, Kerman University of Medical Sciences, Kerman, Iran
2- Professor, Department of Anatomy, Afzalipour School of Medicine, Kerman University of Medical Sciences, Kerman, Iran
3- Associate Professor, Department of Epidemiology and Biostatistics, School of Public Health, Kerman University of Medical Sciences, Kerman, Iran
4- Assistant Professor, Department of Psychiatry, Kerman University of Medical Sciences, Kerman, Iran
5- Assistant Professor, Department of Anatomy, Afzalipour School of Medicine, Kerman University of Medical Sciences, Kerman, Iran (Corresponding author; E-mail: aliadn308@gmail.com)

Received: 12 August, 2019 Accepted: 7 March, 2020

ARTICLE INFO

Article type:
Original Article

Keywords:
Anthropology
Head circumference
Brain volume
Intelligence quotient

Abstract

Background: Anthropometry is a branch of anatomy. One of the important parts of anthropometry is cephalometry, which is characterized by anatomical dimensions of the head area. The aim of this study was to investigate the relationship between brain volume, weight, and IQ in children.

Methods: This descriptive-analytical study was performed on 300 students. Conventional measuring instruments were used for anthropometric measurements. Body weight and skull dimensions were measured. Then, using the appropriate formulas, the volume and weight of the brain and the brain index were measured.

Results: The Pearson correlation coefficient confirmed a weak correlation between the amounts of IQ and anthropometric dimension in female samples. The mean head circumference of males was 2 cm above the mean head circumference of females. Compared to the central index and the dispersion, anthropometric dimensions were significant between boys and girls. According to the analysis of neural network, the anthropometric dimensions of head height, brain weight, head width, and brain index in boys and anthropometric dimensions around the head volume of head width and head height in girls were the most important in relation to IQ.

Conclusion: The results of this study showed that there was a significant statistical difference between the central index and the distribution of anthropometric dimensions in boys and girls. Moreover, there was not a significant relationship between IQ and anthropometric dimensions of the body. In girls, there was a weak correlation between IQ and head width, head height, brain volume, and brain weight.

Citation: Pouya F, Zamani M, Eftekhar-Vaghefi S.H, Jahani Y, Raaii F, Shamsara A. The Relationship between Brain Volume, Brain Weight and IQ in Children in Primary Schools in the South of Iran. *Journal of Kerman University of Medical Sciences*, 2020; 27 (2): 141-149.

Introduction

Anthropometry is the science of measuring the human body and the evaluation of the effects of heredity, weather, geography and the economic and social conditions on the human body (1). In this science, the anatomical and structural differences between individuals are examined (2). In this standard scientific study, the measurements of the human body can be evaluated. The world health organization has declared

anthropometry as the most easily available, the most dominant and the cheapest way of measuring the size, proportion and density of the body and an invaluable instrument to guide the politicizing of public health and medical considerations (3). Today, the data acquired from anthropometry is used in various fields like industrial designing, cloth designs, ergonomics and architecture (4). Cephalometry is a branch of anthropometry that is dedicated to the definition of the head and face of a cadaver, living human or a radiology sample. Cephalometry uses the landmarks of the skull to take special measurements. These can then be used to determine the gender or race of a person (5). Growth of the brain is accompanied by an increase in brain cells. The major part of the growth in human brains happens prenatally, in a way that in three-month-old embryos the head makes up half of the body and in birth, a quarter of the height (6). Studies showed the peak of brain growth to be in 7th and 11th-12th years of life in both genders and in the 15th year in some males (7). Volume of the cranium is an indirect indication of brain volume and is affected by gender, race, ethnicity, geography and biological and ecological factors (8). Numerous studies are done on the effects of ethnicity on the volume of cranium both inside and outside Iran like the study done by Golalipour et al in 2002 on 423 healthy female babies (212 babies from a native Fars group, and 211 babies from a Torkaman group) in educational and medical center of Gorgan University of Medical Sciences and they concluded that ethnicity can affect the volume and mass of newborn girls (9). Moreover, another study done by Gohiya et al on two tribes in Madiaperdash state confirmed ethnicity as a factor effective on brain volume (10). Intelligence is a mental ability and is consisted of various abilities like deduction, planning, problem solving, abstract thinking, lingual skills and learning (11) which can be measured by raven IQ test. The standard raven IQ test, is a kind of deductive reasoning test that asks participants to choose the right answer from a series of multi-dimensional shapes presented in the text of the question. The shape in question is deduced and chosen from investigating the relationship between the shapes presented in the question (12). The goal of this study was to determine the relations between the dimensions of the skull, head circumference, brain volume and Intelligence Quality (IQ) in children in 4th, 5th and 6th grades in the south of Iran.

Materials and Methods

This research was a cross-sectional study on 300 students in 4th, 5th and 6th grades (150 girls and 150 boys) in Zarand, Kerman, southern Iran in the academic year of 2016-2017 regardless of ethnicity and economic situation of subjects. After acquiring the necessary licenses from education department of Kerman, the city was divided into 4 geographic sectors (north, south, east and west). After getting a list of elementary schools from the education department, it was determined what section each school was in and from each section one boy's school and one girl's school was chosen using cluster sampling and the sampling was done proportional to the number of students.

Raven IQ test that can be evaluated for different age groups was used to determine the intelligence quotient. In this study, each student was given an answer sheet and was asked to write down his/her identifications on top of the sheet in the presented place. Afterwards, the question sheet containing 60 questions was given to the student. Time of the exam was 45 minutes. In the next step, each student was weighted by a handler scale with one kilogram accuracy. The scale was recalibrated after each 10 weighting sessions for more accuracy. Skull measurements were taken using a caliper (made in china, mark Alton) with the participants sitting on chair in a relaxed condition with their heads in the anatomical position.

Maximum Head Length (L) (The distance between glabella and inion)

Maximum Head Width (W) (The longest transverse distance of right and left)

Maximum Head Height (H) (The direct distance between tragus to the head vortex)

Each measurement was taken to the nearest millimeter at least three times and the average was considered for calculation. The magnitude of brain volume was calculated using Lee Pearson's formula:

Male: 0.000337(L-11) (W-11) (H-11) +406.01

Female: 0.000400(L-11) (W-11) (H-11) +206.60

Brain weight in grams was determined by the following formulas: brain volume ×1.035

Head circumference was taken with a tape measure from the most prominent point in the back of the head to the most prominent point of the forehead, in a way that the front part of the tape was placed on the eyebrows. The measurement was in centimeters. Cerebral index was resulted from brain weight divided by body weight multiplied by 100 (3, 11).

Statistical Analysis

After collecting anthropometric information, Pearson correlation coefficient, linear regression, and neural network analysis were used to determine the relationship between brain volume, head circumference, cerebral index, and IQ, and the importance of each anthropometric dimension with IQ Sex. SPSS-22 software was used to analyze the data with a significance level of 0.05.

Results

Minimum, maximum, average, standard deviation of anthropometric measurements (body weight (Kg), head circumference (cm), head length (mm), head width (mm), head height (mm), brain volume (cm^2), brain weight (g), brain index), and IQ in children in 4^{th}, 5^{th}, and 6^{th} grades are shown in Table 1 by gender.

Table 1. Minimum, maximum, mean and SD of anthropometric measurements and IQ in children in 4^{th}, 5^{th}, and 6^{th} grades by gender

	Male			Female		
Variable	Min	Max	Mean ±SD	Min	Max	Mean ±SD
Weight	19	59	32.53 ± 7.66	19	65	35.91± 8.89
Head circumference	51	57	53.77 ± 1.42	50	55	52.84±1.33
Head length	160	213	174.05±7.29	152	189	167.56±6.83
Head width	123	158	137.80±5.10	121	147	132.78±4.55
Head height	110	145	130.61±6.67	110	135	119.44±5.59
Brain volume	1034.36	1446.57	1244.15±80.47	830.77	1291.14	1033.24±75.2
Brain weight	1070.67	1497.20	1287.69±83.28	859.85	1336.30	1069.41±77.83
Cerebral index	2.14	6.67	4.13±0.81	1.71	5.34	3.13±0.68
IQ	75	124	100.02± 11.74	71	129	102.34±12.25

The difference between boys and girls concerning anthropometric measurements was significant in the comparison of central index with standard deviation ($p<0.05$). But the average IQ of boys between boys and girls was not significant ($p<0.05$). (Table 2)

Table 2. Comparison of central index with *standard deviation* and anthropometric measurements between boys and girls in 4th, 5th, and 6th grades

Variable	Boy	Girl	p- value
Weight	32.53 ± 7.66	35.91± 8.89	P<0.0001
Head circumference	53.77 ± 1.42	52.84±1.33	P<0.0001
Head length	174.05±7.29	167.56±6.83	P<0.0001
Head width	137.80±5.10	132.78±4.55	P<0.0001
Head height	130.61±6.67	119.44±5.59	P<0.0001
Brain volume	1244.15±80.47	1033.24±75.20	P<0.0001
Brain weight	1287.69±83.28	1069.41±77.83	P<0.0001
Cerebral index	4.13±0.81	3.13±0.68	P<0.0001
IQ	100.02± 11.74	102.34±12.25	0.095

The Pearson correlation coefficient did not show a meaningful relation between IQ and anthropometric measurements (body weight, head circumference, head length, head height, brain volume, brain weight, cerebral index) in boys ($p \leq 0.05$) (Table 3).

Table 3. Relation between IQ and anthropometric measurements in boys in 4th, 5th, and 6th grades

`	Variable	Variable
IQ – Weight	0.022	0.79
IQ- Head circumference	0.073	0.37
IQ- Head length	0.06	0.45
IQ - Head width	0.024	0.76
IQ- Head height	0.024	0.76
IQ- Brain volume	0.016	0.84
IQ - Brain weight	0.016	0.84
IQ - Cerebral index	0.038	0.64

In girls, the Pearson correlation coefficient showed a meaningful relation between IQ, head width, head height and brain volume. However, these relations were not strong (Table 4).

Table 4. Relation between IQ and anthropometric measurements in girls in 4th, 5th, and 6th grades

Variable	Pearson correlation coefficient	P- Value
IQ – Body weight	0.046	0.57
IQ- Head circumference	0.0	0.41
IQ- Head length	0.077	0.35
IQ - Head width	0.18	0.023
IQ- Head height	0.22	0.007
IQ- Brain volume	0.23	0.005
IQ - Brain weight	0.23	0.005
IQ - Cerebral index	0.019	0.82

In order to relate the variables with the IQ, the neural network analysis method was used which included an input layer (body weight, head circumference, head length, head height, brain volume, brain weight and cerebral index), one hidden layer and one output. Using this analysis we predicted the importance of IQ in boys and girls in 4th, 5th, and 6th grades (Figures 1 and 2)

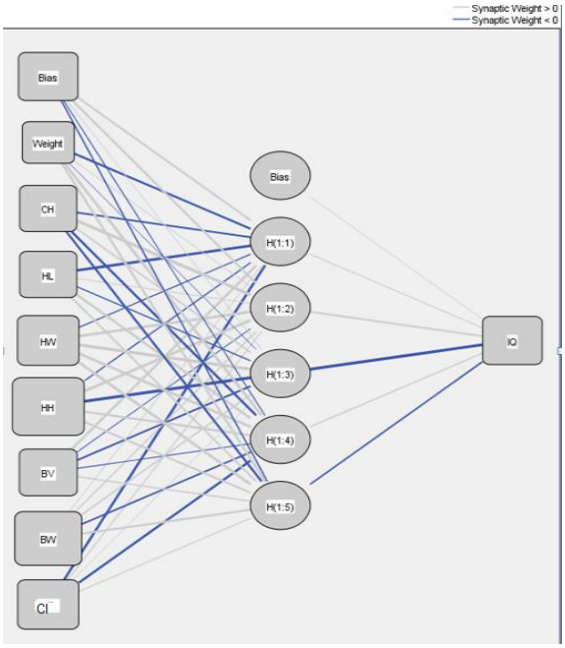

Figure 1. Schamatic from of anthropometric measurements with based artificial neural network in boys in 4th, 5th, and 6th grades

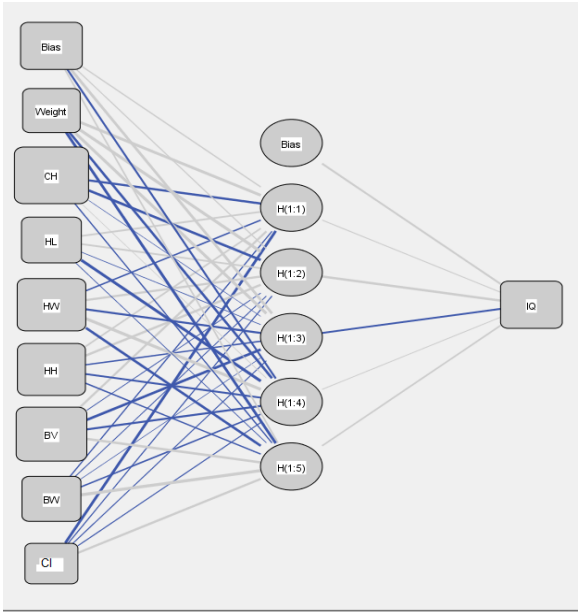

Figure 2. Schamatic from of anthropometric measurements with based artificial neural network in girls in 4th, 5th, and 6th grades

Furthermore, the importance of each of these anthropometric measurements is presented in Table 5 and Table 6. According to Table 5, in boys, the most important anthropometric measurements in relations to IQ were head height, brain weight, head width and cerebral index. . In addition, according to Table 6, in girls, the most important anthropometric measurements in relations to IQ were head circumference, brain volume, head width and head length.

Table 5. Importance of anthropometric measurements in relation to IQ in boys in 4th, 5th, and 6th grades

Variable	importance	Normalized percentage
Head height	0.23	%100
Brain weight	0.18	%79.8
Head width	0.13	%58.5
Cerebral index	0.13	%56.6
Brain volume	0.099	%42.7
Head length	0.092	%39.7
Head circumference	0.091	%39.6
Body weight	0.038	%16.4

Table 6. Importance of anthropometric measurements in relation to IQ in girls in 4th, 5th, and 6th grades

Variable	Variable	Variable
Head circumference	0.21	%100
Brain volume	0.18	%86
head width	0.16	%77.5
head height	0.16	%75.5
Head length	0.90	%42.3
brain weight	0.83	%38.7
Body Weight	0.71	%33.1
brain index	0.31	%14.3

Discussion

This study described a principled attempt to evaluate the relationship between skull dimensions and intelligence in children. The average body weight was 32.53 kg in boys and 35.91 kg in girls showing the average weight of girls to be more than boys. In a study done in Australia, the average body weight of 12-year-old children was 46 kg in girls and 44.8 kg in boys (13). The present study, which was done on a specific race, also confirmed that the average weight was higher in girls. Head circumference is usually presented as the brain index in newborns and those at the beginning of childhood. According to this table, the average head circumference was 53.77 cm in boys and 52.84 cm in girls, showing the average to be higher in boys. In a study done by Safi Khani et al in Ahvaz on children between the ages of 9 to 11, the average head circumference was 52.76 cm in boys and 51 cm in girls which resembled the results of the present study indicating the average head circumference to be higher in boys (14). Moreover, in another study done in Romanis, the average head circumference of 6- to 18-year-olds was 53.4 cm in boys and 52.6 cm in girls (15).

In this study, the average brain volume was 1244.15 cm^2 in boys and 1033.24 cm^2 in girls. The average brain volume was

higher in boys. In a study done by Gohiya et al, the average brain volume of 20- to 25-year-old men was 1380 cm^2 and that of 20- to 25-year-old women was 1188 cm^2, which of course was of a higher range than that of the present study. This group mentioned that head circumference increments decrease with growing age. In girls, adult head circumference is reached at the age of 16 years, whereas head circumference growth continues, in boys, slowly until 18 years (16).

The average brain weight was 1287.69 g in boys and 1069.41 g in girls. The data showed the average brain weight to be higher in boys compared to girls. The brain weight being higher in men compared to women and even the anthropometric measurements of men being bigger than those of women were investigated by researchers in Denmark. They declared the reason was that the weight of the male body was more in relation to its size, and the difference of brain weight in newborn boys and newborn girls was related to their body weight (17, 18).

Several studies also reported a direct relation between head size and intelligence, learning, nutritional status and brain development (19, 20). The average brain index was 4.13 mm in boys and 3.13 mm in girls. The average brain index was higher in boys. In a study that was conducted on students of Ahwaz University of Medical Sciences, the average brain index was 1.33 mm in boys and 1.43 mm in girls (14)

Moreover, in the study done by Golalipour et al on 423 newborn girls of the two Fars and Torkaman groups, the average brain index was 14.36 and 13.43 mm, respectively (9).

These studies showed that the higher the body weight was the higher the brain index. The average IQ was 100.02 in boys and 102.34 in girls revealing the average to be 2 points higher in girls. In a study done by Batterjee et al in Saudi Arabia on 6 to 15-year-olds, there was no meaningful relation between boys and girls (20).

Comparison of anthropometric measurements (body weight, head circumference, head length, head height, brain volume, brain weight, brain index) between boys and girls showed a significant difference ($p<0.05$). Moreover, in Acer's study there was meaningful difference between men and women concerning these anthropometric measurements (head length, head width, head height and brain volume) (21).

Pearson correlation ratio test did not show a meaningful relation between IQ and anthropometric measurements (body weight, head width, head length, head height, brain volume, brain weight, brain index) in boys. Nevertheless, in girls there was a slight relation between IQ, head width, head height, brain volume and brain weight. In a study done by Tramo et al on monozygote tweens, no meaningful relation was seen between head circumference and IQ (22).

A meta-analysis done by McDaniel et al in 2005 showed that age and gender were effective in relation to brain volume and IQ. Furthermore, this study showed that the relation between brain volume and IQ in women was stronger than in men and also this relation was stronger in adults than in women (23).

Conclusion

The results of this study showed that between boys and girls anthropometric measurements (head width, head circumference, head length, head height, brain volume, brain weight, and brain index) were significantly different in the central index and dispersion,. It did not show a meaningful relation between IQ and these anthropometric measurements (head length, head width, head height, brain volume, brain

weight and brain index) in boys but there was a small relation between IQ, head width, head height, brain volume and brain weight in girls.

Acknowledgments

The authors would like to thank school principals in Kerman and the surrounding area. The authors have no conflict of interest with the content of the manuscript.

References

1. Farahani RM, Nooranipour M. Anatomy and anthropometry of human stapes. American journal of otolaryngology. 2008;29(1):42-7.
2. Eftekhar-Vaghefi SH, Shams-Ara A, Jamalizade M. A Study of the Anatomic Variations in Extrahepatic Bile Ducts in 50 Adults Referred to Kerman Forensic Medicine Organization. Anatomical Sciences Journal. 2013;10(1):57-62.
3. Golalipour MJ. The variation of head shapes in 17-20 years old native Fars male in Gorgan-North of Iran. International Journal of Morphology. 2006;24(2):187.٩٠-
4. Pheasant S, Haslegrave CM. Bodyspace: Anthropometry, ergonomics and the design of work: CRC Press; 2016.
5. Umar M, Singh R, Shugaba A. Cephalometric indices among Nigerians. Journal of Applied Sciences. 2006;6(4):939-42.
6. Sadler TW. Langman's medical embryology: Lippincott Williams & Wilkins; 2011.
7. Epstein HT. Stages in human brain development. Developmental Brain Research. 1986;30(1):114-9.
8. Manjunath K. Estimation of cranial volume-an overview of methodologies. J Anat Soc India. 2002;51.٩١-٨٥:(١)
9. Golalipour M, Haidari K, Jahanshahi M, Farahani R. The shapes of head and face in normal male newborns in South-East of Caspian sea (Iran-Gorgan). J Anat Soc India. 2003;52(1):28-31.
10. con la Tribal Korku N-T. Comparative study of cranial capacity of the non-tribal with Korku Tribal population of Madhya Pradesh, India. Int j morphol. 2012;30(1):263-5.
11. Brooks-Gunn J, Klebanov PK, Duncan GJ. Ethnic differences in children's intelligence test scores: Role of economic deprivation, home environment, and maternal characteristics. Child development. 1996;67(2):396-408.
12. Mastery Farahani R, Mohammadi Nasab K, Fadaei Fathabadi F. The Relationship between Neurocranium Anthropometry and Intelligence Quality among Iranian Students in Cold and Tropical Areas. The Neuroscience Journal of Shefaye Khatam. 2015;3(3):64-70.
13. Lazarus R, Wake M, Hesketh K, Waters E. Change in body mass index in Australian primary school children, 1985-1997. International Journal of Obesity. 2000;24(6):679.
14. SAFI KZ, GHAVAMIZADEH B, NEAMAT PR. RELATIONSHIP BETWEEN THE BRAIN VOLUME AND IQ IN CHILDREN 9-11 YEARS OF AGE IN AHWAZ. 2007.
15. Chirita-Emandi A, Doros G, Simina I, Gafencu M, Puiu M. HEAD CIRCUMFERENCE REFERENCES FOR SCHOOL AGE CHILDREN IN WESTERN ROMANIA .Revista medico-chirurgicala a Societatii de Medici si Naturalisti din Iasi. 2015;119(4):1083-91.

16. Gohiya VK. A Comparative study of cranial capacities in BHEEL tribe & non-tribal population in age group 20-25 yesrs old in madhia pradesh. Journal of Punjab Academy of Forensic Medicine & Toxicology. 2010;10(2.(

17. Pakkenberg H, Voigt J. Brain weight of the Danes. Cells Tissues Organs. 1964;56(4):297-307.

18. Voigt J, Pakkenberg H. Brain weight of Danish children. Cells Tissues Organs. 1983;116(4):290-30.١

19. Bartholomeusz H, Courchesne E, Karns C. Relationship between head circumference and brain volume in healthy normal toddlers, children, and adults. Neuropediatrics. 2002;33(05):239-41.

20. Batterjee AA, Khaleefa O, Ashaer K, Lynn R. Normative data for IQ, height and head circumference for children in Saudi Arabia. Journal of biosocial science. 2013;45(4):451-9.

21. Acer N, Usanmaz M, Tugay U, Erteki'n T. Estimation of cranial capacity in 17-26 years old university students/estimacion de la capacidad craneana en estudiantes universitarios entre 17 y 26 anos de edad. International Journal of Morphology. 2007;25(1):65-71.

22. Tramo MJ, Loftus W, Stukel T, Green R, Weaver J, Gazzaniga M. Brain size, head size, and intelligence quotient in monozygotic twins. Neurology. 1998;50(5):1246-52.

23. McDaniel MA. Big-brained people are smarter: A meta-analysis of the relationship between in vivo brain volume and intelligence. Intelligence. 2005;33(4):337-46.