

## **The Craniofacial Indices Correlate with Age, Gender and Environmental Influences-A Study in Malaysian School Children**

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**Abstract:** Cranial indices serve as an indicator of brain size which is a determinant of the intelligence of a population. The aim of this study was to assess the craniofacial indices of children and adolescents in Malaysia. This cross sectional study was conducted on healthy primary and secondary school children. Anthropometric measurements including weight and height of the subject and Cephalometry were measured for each subject. A total of 419 subjects (203 male and 216 female) participated in this study. Mean age of the participants was  $12.51 \pm 2.82$  years. Male subjects were significantly taller ( $p=0.04$ ) and had greater head height ( $p=0.004$ ) and breadth ( $p<0.001$ ) as well as greater face length ( $p<0.001$ ) when compared with female subjects. Only facial length was significantly different between genders in the age groups ( $p=0.001$ ). Lifestyle and ethnicity have an important role in determining the head size of children and adolescents.

**Key words:** Craniofacial Indices • Cephalometry • Childhood • Adolescence • Students • Malaysia

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### **INTRODUCTION**

Intelligence quotient (IQ) encompasses a wide range of brain activities that lead to the ability of brain to learn from past experiences, adapt to the changing conditions and environment [1]. IQ is shown to be under the influence of race, ethnicity and geographical region [2-6]. The effects of genetic characteristics including race and ethnicity on IQ can be assessed by using the brain size estimation [2-6].

Brain size has been shown to be related to IQ [5-7]. Different kinds of techniques to assess the size of the brain have been in practice for long time [8]. Brain size can be estimated directly or indirectly [9-11]. Direct measurement of the brain size is considered as the gold standard since the actual capacity of the brain is measured [12-14]. Brain size can also be indirectly estimated in living using imaging techniques such as

magnetic resonance imaging (MRI) and computer assisted tomography (CAT) [9, 10]. Alternatively, the brain size (cranial capacity) of an individual can also be estimated in living subjects by using his/her craniometrical measurements [11].

Studies have been performed worldwide to assess the craniofacial characteristics of the different races [5, 8, 15]. Comparison of the findings of these studies revealed the fact that there is a significant difference in craniofacial characteristics among races [5, 8, 15]. While the black race was shown to have the smallest cranial capacity and brain size, the East Asians, mostly Japanese and Chinese, were shown to possess the highest cranial capacity among nations [5, 8]. Since the craniofacial characteristics are affected by the race and ethnicity, they vary from country to country and region to region. These findings were in line with the findings of other studies that assessed the IQ of nations. The average IQ score was reported to be

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the highest in East Asian nations such as 108 in Singapore, 106 in South Korea, 105 in China and Japan while the lowest IQ scores were reported in African nations (71 in Ghana and 72 in Kenya) and the IQ scores of countries such as United States of America (98), France (98), Germany (99), Malaysia (92), Indonesia (87) and India (84) were in between [16].

Basing on the findings of the previous studies, craniofacial values cannot be confirmed for certain population by considering the findings of a particular country; hence separate study should be conducted in order to identify the craniofacial characteristics of each race [16]. The aim of this study was to assess the cranial capacity, indirectly the brain size of primary and secondary school students in Kuala Terengganu, Malaysia.

## MATERIALS AND METHODS

This cross sectional study was performed on 419 Malaysian primary and secondary school students (aged between 6 and 16 years) who are studying in rural and urban schools of Kuala Terengganu, Malaysia. Subjects with severe mental or physical disorders that might influence the normal growth and development were excluded from the study. A written informed consent was obtained from each subject as well as from the parent or care taker prior to participation in this research.

This study was approved by 1) University Sultan Zainal Abidin, (UniSZA), 2) Human Research Ethics Committee (UHREC) of UniSZA, 3) The Ministry of Education, Putra Jaya, Malaysia and 4) The State Education Department of Terengganu, Malaysia. The informed consent was confirmed by the University Sultan Zainal Abidin, (UniSZA), 2) Human Research Ethics Committee (UHREC) of UniSZA.

**Measurements:** Body weight and height was measured for each subject in school clothing with emptied pockets and on bare footed. Height and weight were measured twice to the nearest 0.1 cm and 0.1 kg respectively. The mean of the measurements was used for further analyses. The body mass index (BMI) was calculated by dividing body weight in kilograms by the square of the height in meters. The BMI for age percentile was assessed for each subject using the world health organization growth chart [17].

Cephalometry including head length (L), breadth (B) and height (H) were measured using sliding callipers. The boy or girl was asked to be in sitting position and keeping the head in anatomical position. Measurements were taken in 3 trials to the nearest 0.1 cm and the mean of the trials was used for further calculations.

Cephalic index was calculated basing on the following formula [18].

$$\text{Cephalic index} = (\text{maximum head breadth} \times 100) / \text{maximal head length}$$

Facial index was calculated based on the following formula [19].

$$\text{Facial index} = \text{facial height} / \text{bizygomatic breadth}$$

**Statistical Analysis:** Statistical analysis was performed using the statistical package for social sciences (SPSS) version 19.0 software (IBM Inc. Chicago, IL, USA). Data were assessed for normality using the Kolmogorov-Smirnov test. Mean and standard deviation (SD) were used to describe the continuous variables. Independent student t-test was used to compare study values between genders while one sample t-test was used to compare cranial capacity values with previously published values. The multivariate analysis of variance (MANOVA) was used to assess the group difference in terms of gender and age groups. The confidence limit was considered 0.95 and value of p smaller than 0.05 was considered as statistically significant value.

## RESULTS AND DISCUSSION

A total of 419 subjects (203 male and 216 female) gave consent to participate in this study. The mean and SD for age of the subjects were  $12.51 \pm 2.82$  years. Characteristics of the study subjects, along with their gender comparison, were shown in table 1.

Age related craniofacial values of the study subjects were shown in table 2. Although significant improvements were observed in head length ( $p=0.005$ ), head height ( $p=0.002$ ) and head breadth ( $p=0.01$ ) as well as face length ( $p<0.001$ ), no significant difference was observed between age groups in terms of cephalic index ( $p=0.05$ ), facial width (0.06) and facial index ( $p=0.25$ ) (Figure 1, 2). The only significant difference between genders in age groups was found in face length ( $p=0.001$ ).

Table 1: Anthropometric characteristics of the study subjects

		Mean	SD	t	p
Age	Male	12.45	2.92	-0.39	0.70
	Female	12.56	2.72		
Body weight (kg)	Male	43.19	16.54	1.38	0.17
	Female	41.13	13.76		
Height (cm)	Male	148.01	17.45	2.02	0.04*
	Female	144.94	13.15		
BMI (kg/m <sup>2</sup> )	Male	19.41	4.85	0.30	0.77
	Female	19.27	4.85		
Head length (mm)	Male	175.12	10.96	1.71	0.09
	Female	173.27	11.22		
Head breadth (mm)	Male	141.85	12.73	3.96	<0.001**
	Female	137.17	11.41		
Head height (mm)	Male	131.18	10.50	2.89	0.004*
	Female	127.87	12.85		
Face length (cm)	Male	11.88	1.03	4.17	<0.001**
	Female	11.46	0.98		
Face width (cm)	Male	9.28	3.55	1.21	0.23
	Female	8.97	1.30		
Facial index	Male	76.66	12.33	-1.54	0.13
	Female	78.34	10.00		
Cephalic index	Male	81.48	10.55	1.95	0.05
	Female	79.51	10.04		

BMI= body mass index, cm= centimetre, kg= kilogram, ml=millilitre, mm=millimetre, SD= standard deviation

\* significant at  $\alpha=0.05$ \*\* significant at  $\alpha=0.01$ 

Table 2: Comparison of craniofacial measurements between genders and age groups

	Age group	Male	n	Female	n	Total	n
Head length (mm)	7-9 y	171.83±11.11	58	170.86±9.29	53	171.38±10.27*	111
	10-13 y	176.76±9.84	54	172.97±14.82	76	174.56±13.06	130
	14-17 y	176.27±11.16	91	175.02±8.07	87	175.65±9.76*	178
Head breadth (mm)	7-9 y	139.84±15.05	58	134.61±13.44	53	137.39±14.50*	111
	10-13 y	144.85±14.23	54	140.20±13.59	76	142.15±14.00*	130
	14-17 y	141.34±9.59	91	136.25±6.52	87	138.84±8.59	178
Head height (mm)	7-9 y	126.86±10.59	58	126.76±13.27	53	126.82±11.87*	111
	10-13 y	133.13±9.93	54	129.63±11.44	76	131.09±10.93*	130
	14-17 y	132.80±10.05	91	127.07±13.77	87	129.98±12.33	178
Cephalic index (%)	7-9 y	81.70±10.63	58	78.57±7.09	53	80.24±13.23	111
	10-13 y	82.35±11.13	54	82.02±14.63	76	82.16±13.24	130
	14-17 y	80.61±10.05	91	77.99±5.22	87	79.32±8.13	178
Face length (cm)	7-9 y	10.84±0.64	58	10.60±0.60	53	10.73±0.63*	111
	10-13 y	11.67±0.86	54	11.52±0.74	76	11.59±0.79*	130
	14-17 y	12.67±0.60 <sup>a</sup>	91	11.91±1.01 <sup>a</sup>	87	12.30±0.91*	178
Face width (cm)	7-9 y	9.11±6.29	58	8.17±0.95	53	8.67±4.64	111
	10-13 y	9.10±1.42	54	9.13±1.25	76	9.12±1.32	130
	14-17 y	9.50±1.34	91	9.29±1.33	87	9.40±3.55	178
Facial index (%)	7-9 y	76.94±11.90	58	77.29±9.72	53	77.10±10.88	111
	10-13 y	78.41±14.35	54	79.20±9.15	76	78.87±11.57	130
	14-17 y	75.14±11.01	91	78.21±10.89	87	76.65±11.03	178

Multivariate analysis of variance (MANOVA) was used for the analysis. Values are shown as mean ± standard deviation (SD)

\* Significant difference between age groups

<sup>a</sup> Significantly different between genders

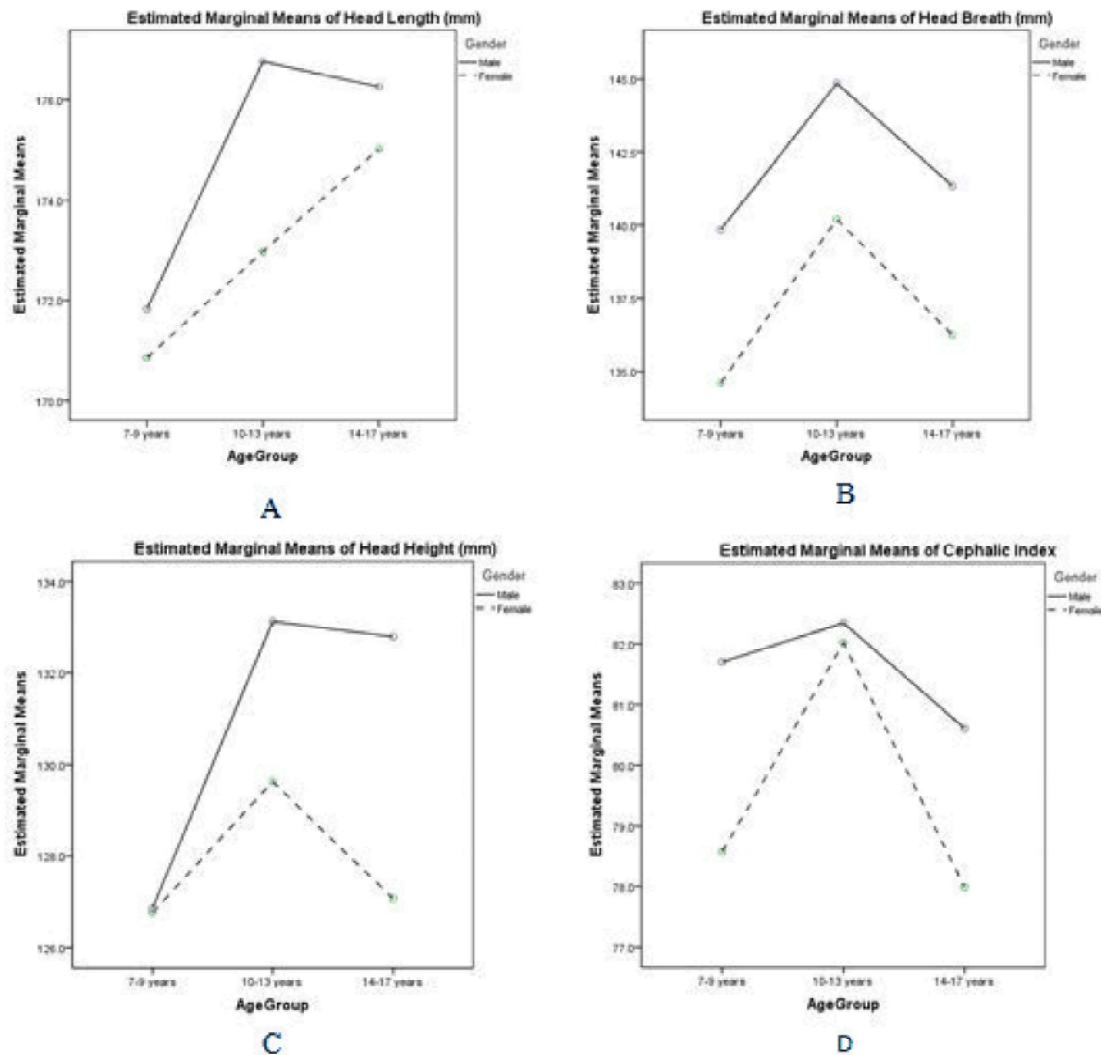


Fig. 1: Cephalometric measurements between genders and age groups

The head length (A), head width (B), head height (C) and cephalic index (D) are shown as per age group and genders.

This study revealed that male subjects have significantly higher values of head length, breadth and height when compared with female. This finding is in line with the findings of the previous studies which reported higher head size in males when compared with females [20-22]. Moreover, this study also revealed that male subjects are significantly taller than female subjects. It was previously shown that the higher values of head measurement in males could be due to the larger stature of males when compared with females [20-22]. While female adolescents have a more rapid growth in early adolescence due to their earlier maturation when compared with adolescent males, male adolescents have a longer span of growth compared with females [20-22].

The head growth in males continues till the maturation age which results in bigger stature and head diameters in males [20-22].

The findings of this study revealed that the craniofacial values of both the gender are lower than that of their Brazilian age matched counterparts [23]. This finding is against the previous one that indicated larger head size in East-Asian populations when compared with Caucasian, European and African ethnicities [5, 8, 15]. The difference between the findings of this study with that of Pereira might be due to the smaller sample size in the study by Pereira *et al.* [23]. The small sample size of the Brazilian study makes it hard to generalize the results into the whole Hispanic population.

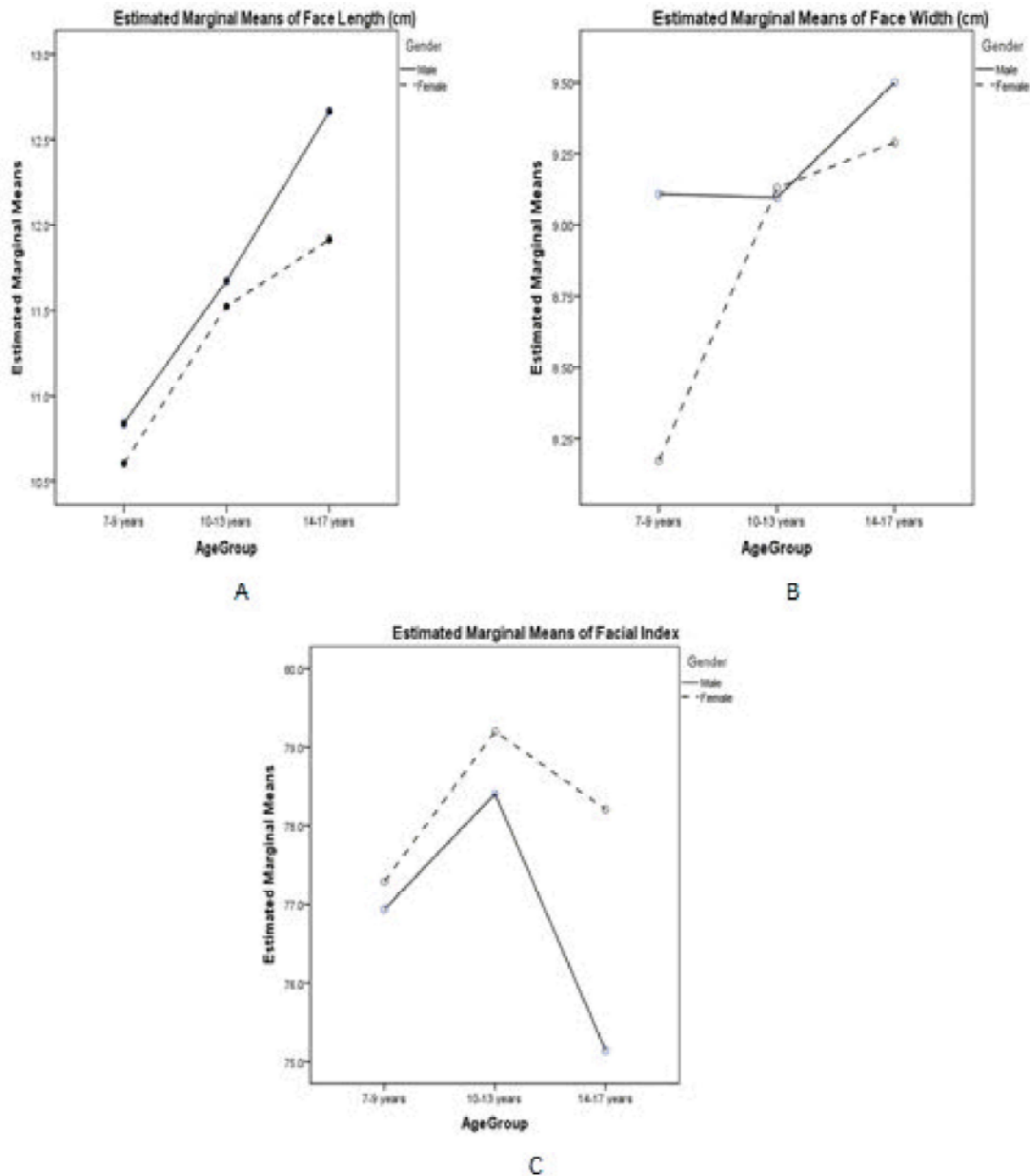


Fig. 2: Facial measurements between genders and age groups

The facial length (A), facial width (B) and facial index (C) are shown as per age group and genders.

The most interesting finding of this study was the lower craniofacial values of the subjects between 14 to 17 years old when compared with the younger subjects. It is believed that head size increases in line with the longitudinal growth [5, 21]. In contrast, this study revealed a decrease in craniofacial measurements by increasing age. Similar finding was also observed in previous studies in rapidly developing societies [21-24]. As it appeared prominently in the study by Karacan *et al.*, (2013) in Turkey, the head size was smaller in 14 to 17 year

old subjects when compared to 9 to 13 year old and both the groups had smaller head size values than subjects who were below 9 years old [24]. This finding might in part be due to the economic and public health improvements [25, 26]. It was previously reported that the consumption of milk and poultry products dramatically raised in 1995 (18 years prior to this study) in Malaysia [27]. This improvement might have resulted in a better longitudinal growth in mothers' and children's body constitution after this critical time and therefore resulted

in a higher head size gain [23, 28]. This pattern seems to exist in both genders regardless of the differences in growth pattern of female and male adolescents as well as social and healthcare equalities between genders in Malaysia.

The most important strength of this study was the large sample size with more female subjects compared with males which enabled the authors to better evaluate the differences between genders in different age groups. Regarding the cross sectional nature of this study, this study could still indicate the effect of longitudinal lifestyle changes on morphology in humans. It is therefore recommended for future researchers to conduct many more longitudinal cohorts to assess the exact effects of different environmental exposures on morphological status of Malaysian children and adolescents. One of the weaknesses of this study was the prevalence of Malay subjects who are in majority that prevented the authors from evaluating the effect of ethnicity on craniofacial values. It is recommended further future researchers to perform assessments on ethnicity matched groups of Malaysians in order to find out the effects of genetics and ethnicity on the Cephalometry values of Malaysians.

#### ACKNOWLEDGEMENTS

This study is funded and financed by the university grant, (Code: UniSZA/12/GU (012), Universiti Sultan Zainal Abidin (UNISZA), Kuala Terengganu, Terengganu, Malaysia. Without the cooperation and timely action of the university management authorities and the staff it would have not been possible to carry out the project.

Sincere acknowledgement ought to be paid to the Ministry of Education, Putrajaya, Malaysia and authorities and staff of Terengganu State Education Department, Terengganu, Malaysia. The great and valuable role played in making the task a big success, by the school principals, heads, teachers responsible and school children participated and helped, is memorable. Last but not least, is the major role, hardship, consistent skilled efforts poured into the project by way of data collection and incorporation by the research assistants made to get the best results and output, is valuable forever.

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