Correlation of Horizontal Cephalic Index and Cranial Parameters in Iranian Medical Students

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Abstract- Cranial parameters and cephalic indices are used to evaluate the racial and gender differences. The aim of this study was to assess the cephalic indices, to classify the type of cranium and to determine the relationship between the horizontal cephalic index and cranial parameters among Iranian medical students. This study was done on 200 medical students (100 males and 100 females) with an age range of 18-30-year-old. Head length, head breadth, and auricular height were measured by using a standard spreading caliper. Then cephalic indices were calculated for the classification of cranial type. The linear regression was used for examining the relationship between the horizontal cephalic index and head length, head breadth and auricular height. The results of this study showed that the mean of the horizontal, vertical, and transverse cephalic index in total students were 83.51±6.85, 85.58±5.85 and 102.77±6.35 cm, respectively. According to this result, the predominant head shapes in total students were brachycephalic, hypsicephalic and acrocephalic types. In this study, there was a strongly negative correlation between horizontal cephalic index with head length (r=-0.744, *P*=0.000), moderate positive correlation between horizontal cephalic index with head breadth (r=0.512, *P*=0.000) and weakly negative correlation between horizontal cephalic index with auricular height (r=-0.205, *P*=0.004). The data of the present study can be beneficial in craniofacial reconstruction, clinical diagnosis, and forensic applications.

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Keywords: Head length; Head breadth; Auricular height; Cephalic indices

Introduction

Anthropometric parameters serve as an important indicator of dietary, health conditions, forecasts health, survival, and race identification (1,2). The physical variations among humans can be assessed by measuring various parameters and based on race and sexual dimorphism, we may find some new data (3-6). According to the results from different studies carried out, craniofacial parameters have several applications in clinical medicine including pediatric dentistry and has contributed to better achievement in pituitary and plastic surgeries (7,8). Variations in anthropometric dimensions reflect different ages and genders, diversity of races and ethnicities (9-11). Cephalometric data is also able to determine the normal and abnormal population (12). For example, Otitis media has been observed less in doliocephalic person compared with the brachycephalic person (13). Also Cohen and Kreiborg reported that persons with Apert's syndrome are more hyperbrachycephalic (14).

The head dimensions are influenced by factors such as natural climates, geographical, sex, and ethnic factors (15). One of the important cephalometric indices is the cephalic indices. There are three types of cephalic indices, including horizontal, vertical, and transverse cephalic index (16). The horizontal cephalic index is the ratio of the maximum head breadth to maximum head length. The vertical cephalic index is the ratio of the maximum auricular height to maximum length. The transverse cephalic index is the ratio of the maximum auricular height to maximum head breadth. These indices among different populations are useful tools in estimating race and sex of subjects. Investigation of changes in horizontal, vertical, and transverse cephalic indices between parents and offspring can indicate genetic transmission of inherited characters (17,18). Head shape and cephalic indices could be beneficial for abnormalities of cranial size and shape diagnosis in different populations (19). The aim of this study was to analyze

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cephalometric data, so as to classify the cranial types and to determine the relationship between the cephalic index and head length, head breadth and auricular height among Iranian medical students. Also cephalic indices were compared between men and women. The present study will be beneficial in forensic medicine, plastic, and cosmetic surgery in this region.

Materials and Methods

This study was carried out on two hundred medical students (100 males and 100 females) of the school of Medicine, Tehran University of Medical Science, Tehran, Iran. The age of the subjects ranged between 18-30-year-old. All students participated in this study were healthy and those with craniofacial deformity were not included in this study. The students were sitting on the chair, and their head was in the anatomical position and a spreading caliper was used for taking the measurements.

The head measurements included the following parameters:

1. Maximum head length: It is defined as the straight distance between glabella to the inion

2. Maximum head breadth: It is defined as the maximum distance between the most lateral points of the parietal bones.

3. Auricular height: It is defined as the distance between the external acoustic meatus to the vertex (20).

The above parameters were used for calculating the cephalic indices (17,21). Horizontal cephalic index (HCI)=Maximum head breadth/Maximum head length×100%. Vertical cephalic index (VCI)=Maximum auricular height/Maximum head length×100%. Transverse cephalic index (TCI)=Maximum auricular height/ Maximum head breadth×100%. Head shapes were determined based on the ranges in horizontal, vertical and transverse cephalic indices as follows:

On the basis of the horizontal cephalic index, head shapes were categorized as dolichocephalic (Long head) (HCI<74.90), mesocephalic (Moderate head) (75.0<HCI>79.9), brachycephalic (short head) (80.0<HCI>84.90) and hyperbrachycephalic (very short head) (85.0<HCI); (22).

On the basis of the vertical cephalic index, head shapes were categorized as chamaecephalic (57.9>VCI), orthocephalic (58.0<VCI>62.9) and hypsicephalic (63<VCI); (17,21).

On the basis of the transverse cephalic index, head shapes were categorized as tapeiocephalic (78.9>TCI), metriocephalic (79.0<TCI>84.9) and acrocephalic (85.0<TCI) (17,21).

The data were analyzed by software SPSS 16. Independent-Samples T-Test was used to compare the data. Results were expressed as mean±standard deviation (SD). $P<0.05$ was considered statistically significant.

The relationship between quantitative data was assessed by Pearson's correlation coefficient and the linear regression equations were used to determine the relation between the horizontal cephalic index with head length, head breadth, and auricular height.

Results

The mean head length was 18.16±1.24 cm (Table 1). The mean of head length in male and female students were 18.84±1.12 and 17.48±0.94 cm, respectively. The mean head length was significantly larger in males compared to females (P=0.000, Table 2). The mean of head breadth was 15.11±0.77 cm (Table 1). The mean of head breadth in male and female students were 15.25±0.75 and 14.96±0.77 cm, respectively. The mean of head breadth was significantly larger in males compared to females (P=0.009, Table 2). The mean of auricular height was 15.50±0.80 cm (Table 1). The mean of auricular height in male and female students were 15.91±0.63 and 15.08±0.73 cm, respectively. There was a significant difference between the two sex groups in auricular height (P=0.000, Table 2). The mean of horizontal cephalic index in total students was 83.51±6.85 (Table 1).

Table 1. Comparison of the mean of cranial parameters for total subjects

Parameters	N	Mean±SD
Head length	200	18.16±1.24
Head breadth	200	15.11±0.77
Auricular height	200	15.50±0.80
Horizontal cephalic index	200	83.51±6.85
Vertical cephalic index	200	85.58±5.85
Transverse cephalic index	200	102.77±6.35

N: number of samples, S.D: Standard Deviation

The mean of horizontal cephalic index in male and female students was 81.15±5.41 and 85.87±7.33, respectively. Also, a significant difference between the two sex groups was found in the horizontal cephalic index (*P*=0.000, Table 2).

Table 2. Comparison of the mean of cranial parameters between males and females

Parameters	N		Mean±SD		*P*	Significance
	Male	Female	Male	Female		
Head length	100	100	18.84±1.12	17.48±0.94	0.000	Sig.
Head breadth	100	100	15.25±0.75	14.96±0.77	0.009	Sig.
Auricular height	100	100	15.91±0.63	15.08±0.73	0.000	Sig.
Horizontal cephalic index	100	100	81.15±5.41	85.87±7.33	0.000	Sig.
Vertical cephalic index	100	100	84.69±5.85	86.48±5.74	0.031	Sig.
Transverse cephalic index	100	100	104.52±5.84	101.02±6.39	0.000	Sig.

N: number of samples, S.D: Standard Deviation, Sig.: significant

According to the results, the most common head shape for male students was the brachycephalic type (short head) and for females was the hyperbrachycephalic type (very short head), which was 43% and 50%, respectively.

The next common type of head shape for males was the mesocephalic type (moderate head) that was 30%, but for females it was the brachycephalic type that was 37%.

The least common head shape for males was the dolichocephalic type (long head) which was 7% and dolichocephalic type was absent among female students (Table 3).

Table 3. Distribution of head type in male and female students according to horizontal cephalic index

Head shape	The range of horizontal cephalic index	Male	Female	Total
(1) Dolichocephalic (Long head)	< 74.9	7	0	7
(2) Mesocephalic (Moderate head)	75.0 - 79.9	30	13	43
(3) Brachycephalic (Short head)	80.0 - 84.90	43	37	80
(4) Hyperbrachycephalic (Very short head)	85.0 <	20	50	70

The mean of vertical cephalic index in total students was 85.58±5.85 cm (Table 1) and the mean of vertical cephalic index in male and female students were 84.69±5.85 and 86.48±5.74 cm, respectively. There was a significant difference in vertical cephalic index between males and females (*P*=0.031, Table 2).

According to the vertical cephalic index, type of head in all male and female students was the hypsicephalic type. Chamaecephalic and orthocephalic types were totally absent in the studied subjects (Table 4).

Table 4. Distribution of head type in male and female students according to vertical cephalic index

Head shape	The range of vertical cephalic index	Male	Female	Total
(1) Chamaecephalic	57.9 >	0	0	0
(2) Orthocephalic	58.0 - 62.9	0	0	0
(3) Hypsicephalic	63 <	100	100	200

The result of this study showed that female students have significantly higher horizontal and vertical cephalic index than male students (*P*<0.05, Table 2). The mean of transverse cephalic index in total students was 102.77±6.35 (Table 1) and the mean of transverse cephalic index in male and female subjects was 104.52±5.84 and 101.02±6.39 cm, respectively. Also transverse cephalic index was significantly different between two sex groups (*P*=0.000, Table 2).

Based on this result, the dominant type of head shape for male and female students according to the transverse cephalic index was the acrocephalic type, which was 100% and 98% for male and female students, respectively. Tapeiocephalic and metriocephalic types

each of them were 1% among female students and were totally absent between male students (Table 5).

Based on this results, there was a correlation between the horizontal cephalic index and other parameters that were statistically significant (with positive and negative presentations) (P<0.05, Table 6 and 7). The correlation between horizontal cephalic index with head length and head breadth are shown in Scatter graphs in both genders (Figure 1).

Linear regression analysis showed a relationship between horizontal cephalic index with head length, head breadth, and auricular height (Table 8, 9, and 10).

Table 5. Distribution of head type in male and female students according to transverse cephalic index

Head shape	The range of transverse cephalic index	Male	Female	Total
(1) Tapeiocephalic	78.9 >	0	1	1
(2) Metriocephalic	79.0 - 84.9	0	1	1
(3) Acrocephalic	85.0 <	100	98	198

Table 6. Correlation between the horizontal cephalic index and other parameters in the total sample (N=200)

Variables	Pearson correlation (r)	*P*	Significance
Horizontal cephalic index	1	--	--
Head length	-0.744	0.000	Sig.
Head breadth	0.512	0.000	Sig.
Auricular height	-0.205	0.004	Sig.

Sig.: significant

Table 7. Correlation between the horizontal cephalic index and other parameters between males and females (N=100)

Variables	Male			Female		
	Pearson correlation (r)	*P*	Significance	Pearson correlation (r)	*P*	Significance
Horizontal cephalic index	1	--	--	1	--	--
Head length	-0.698	0.000	Sig.	-0.752	0.000	Sig.
Head breadth	0.483	0.000	Sig.	0.736	0.000	Sig.
Auricular height	0.057	0.571	NS	-0.09	0.374	NS

Sig.: significant, NS: not significant

Table 8. Linear regression analysis for study population with the horizontal cephalic index as the dependent variable and head length as independent variable

Regression equation	± SEE	R^2	*P*
HCI = 158.08 – 4.104 (HL)	0.26	0.55	0.000
HCIM = 144.36 – 3.35 (HL)	0.34	0.48	0.000
HCIF = 187.66 – 5.82 (HL)	0.51	0.56	0.000

HCI: Horizontal Cephalic Index, M: Male, F: Female, HL: Head Length, SEE: Standard Error of the Estimate, R^2: Coefficient of Determination

Table 9. Linear regression analysis for the study population with the horizontal cephalic index as the dependent variable and head breadth as an independent variable

Regression equation	± SEE	R^2	*P*
HCI = 15.18 + 4.52 (HB)	0.53	0.26	0.000
HCIM = 28.18 + 3.47 (HB)	0.63	0.23	0.000
HCIF = -18.34 + 6.96 (HB)	0.64	0.54	0.000

HCI: Horizontal Cephalic Index, M: Male, F: Female, HB: Head Breadth, SEE: Standard Error of the Estimate, R^2: Coefficient of Determination

Table 10. Linear regression analysis for the study population with the horizontal cephalic index as the dependent variable and auricular height as an independent variable

Regression equation	± SEE	R^2	*P*
HCI = 110.65 – 1.75 (AH)	0.59	0.04	0.004
HCIM = 73.34 + 0.49 (AH)	0.86	0.003	0.57 NS
HCIF = 99.33 – 0.89 (AH)	1	0.008	0.37 NS

HCI: Horizontal Cephalic Index, M: Male, F: Female, AH: Auricular Height, SEE: Standard Error of the Estimate, R^2: Coefficient of Determination, NS: Not Significant

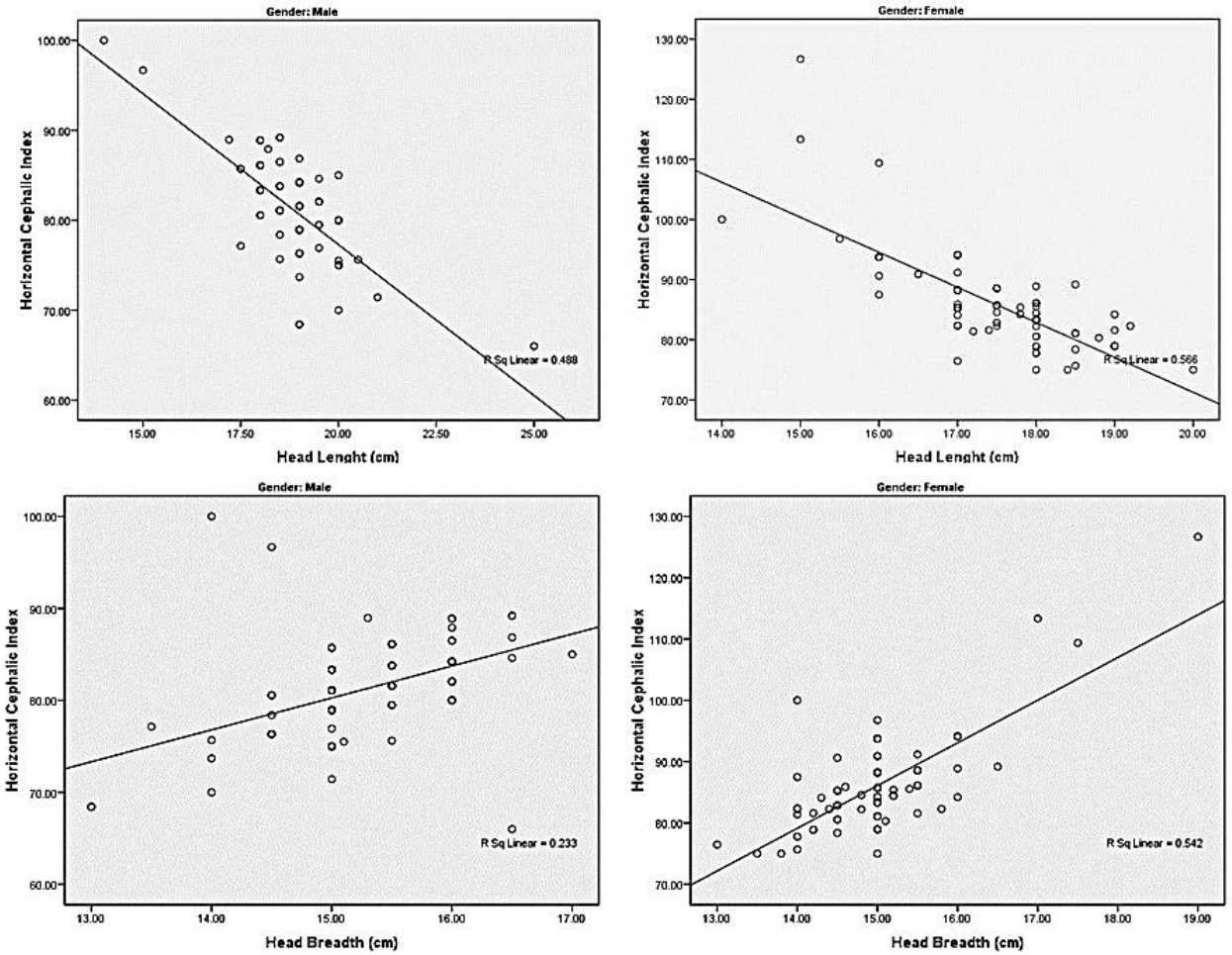

Figure 1. Correlation between horizontal cephalic index with (a) male head length (cm), (b) female head length, (c) male head breadth (cm) and (d) female head breadth (cm)

Discussion

The present study was carried out among students of Tehran University of Medical Sciences between ages of 18-30-year-old. The result of this study shows that the mean horizontal cephalic index in all students was 83.51±6.85 cm. It was also 81.15±5.41 for males and 85.87±7.33 cm for females. The common head shape was brachycephalic and hyperbrachycephalic types in male and female students, respectively. Oladipo *et al*., (2010) reported that the mean horizontal cephalic index among Ibibio population was 79.11±5.24. It was reported that for Ibibio males and females 79.85±4.05 and 78.36±6.12, respectively. The dominant type of head shape was mesocephalic in Ibibio population (23). Ilayperuma (2011) showed that the mean horizontal cephalic index was 78.54±6.35 cm in adult Sri Lankan population, 78.04±6.53 for males and 79.32±6.25 for females (24).

Gupta *et al*., (2013) reported that the mean horizontal cephalic index in male and female of North Indian origin were 74.74±4.31and 76.83±5.58 cm, respectively. The dominant head type in males was dolichocephalic with

55% and in females was mesocephalic with 47.33%, this is completely different from our results. The rare type of head shape was hyperbrachycephalic for both sexes (25). The mean horizontal cephalic index for males and females of the present study was higher than that in Ibibio population, North Indian origin and adult Sri Lankan population (23-25). Golalipour *et al*., (2007); Golalipour *et al*., (2006) reported that the mean horizontal cephalic index in Turkman group was 80.4±4 and in native Fars was 84.8 (26,27). The results of this study was lower than the results of the study conducted by Hassanzadeh *et al*., (2013), that shows the mean horizontal cephalic index for males was 88.19±5.78 and for females was 86.54±3.23 in Qazvin (Iran) residents, while the mean horizontal cephalic index for males and females of DG Khan (Pakistan) were 84.11±3.7 and 85.27±6.09, respectively which was similar to the results of female students in the present study. The most common head shape in both genders of Qazvin and DG Khan was the hyperbrachycephalic type (28).

In the present study, the dominant type of head shape was brachycephalic (80%) and the rare head shape was dolichocephalic (7%) for all students. This finding is similar to the results of the study conducted by Golalipour *et al*., (2007); Golalipour *et al*., (2006) in Turkman group and in native Fars (26,27).

The differences in cranial measurements are affected by genetic, environmental, sex and ethnic factors and cranial shape and cephalic index can indicate the racial variations (15,26). The previous studies showed that the mean cephalic index varies in different regions (3). So, that longer head shape (dolichocephalic) is found in tropical regions, while it is the round head (mesocephalic or brachycephalic) in temperate regions (29). According to previous studies, the brachycephalic type, which is selected as a consequence of evolutionary forces, (30) has been affected by improvement in nutrition (31).

The result of this study shows that the mean vertical cephalic index in total students was 85.58±5.85 cm and it was 84.69±5.85 and 86.48±5.74 cm for male and female students, respectively. According to the vertical cephalic index, type of head was hypsicephalic in all of the students. Ilayperuma (2011) reported that the mean vertical cephalic index in male Sri Lankan students was 78.53±4.91and for female students was 78.91±7.46, and it was 78.68±5.93 for both gender (24). A study carried out by Salve *et al*., (2014) shows that the mean vertical cephalic index was 73.56±4.03 in the study subjects, 74.08±3.24 for male and 73.03±4.64 for female (32). Another study conducted by Rexhepi and Meka (2008) reported that the mean vertical cephalic index were 64.41 and 63.72 for male and female Kosova Albanian people, respectively. The majority of the subjects were the hypsicephalic type (17) which was in agreement with the results of our results. The mean vertical cephalic index of the present study is higher than that in Sri Lankan students, Indian medical students and Kosova Albanian people (17,24,32).

According to the results of the present study, the mean transverse cephalic index in the total number of the students was 102.77±6.35 and it was 104.52±5.84 for male subjects and 101.02±6.39 for female subjects. The dominant type of head shape for male and female students according to the transverse cephalic index was the acrocephalic type. According to a study by Rexhepi and Meka (2008) study, the mean transverse cephalic index was 77.14 and 75.22 in Kosova Albanian male and female, respectively (17). This is in contrast with the results of our study in which the majority of subjects were the tapeiocephalic type. A study conducted by Ilayperuma (2011) shows that the mean transverse cephalic index in male and female Sri Lankan students was 101.12±8.57 and 99.61±7.29, respectively, and it was 100.52±8.01 for both genders; this is lower than the mean transverse cephalic index in the present study. Also the commonest head shape was the acrocephalic type (24), which is similar to the results of our study.

The difference between the mean vertical cephalic index and the transverse cephalic index in the present study compared to studies mentioned above can be the reason for different racial groups. In this study, there was a correlation between the cranial dimensions with horizontal cephalic index. Pearson's correlation between horizontal cephalic index with head length, head breadth and auricular height was -0.744, 0.512 and -0.205, respectively. Also, a linear regression equation reported using any of these parameters. Based on our results, the horizontal cephalic index had a strongly negative correlation with the head length, a moderate positive correlation with the head breadth and a weakly negative correlation with the auricular height. Agarwal *et al*., (2014) found out a correlation between horizontal cephalic index with head length and head breadth and Pearson's coefficient was -0.558 and 0.566, respectively (33), this is in agreement with the result of our study. Raveendranath *et al*., (2010) reported a relationship between horizontal cephalic index and head length (r= -0.62 in males and r= -0.51 in females), head breadth (r= 0.78 in males and r= 0.86 in females) and auricular height (r= 0.2 in males and r= 0.17 in females) (34), this is near to the results of the present study. Generally, a regression equation was obtained for calculating horizontal cephalic

index using head length, head breadth and auricular height; this could be a be beneficial for reconstruction of a person's head shape with craniofacial deformity. The Cranial measurement is a useful tool for diagnosis of abnormality. Therefore, further studies in different races and in larger samples are required to estimate the cephalic indices.

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