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Assessment of Gender Dimorphism Using Cephalometry in Iranian Population

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Abstract
Objectives: This study aimed to asses Gender Dimorphism Using cephalometry in the Iranian Population.
Methods: Different variables like cranial length (CL), cranial width (CW), and cranial height (CH) were measured and cranial index (CI), cranial capacity (CC), and brain weight of 400 Iranian volunteers were calculated. Data were analyzed by means of SPSS 22.0.
Results: There were significant differences in the mean value of all nasofacial parameters ($P < 0.05$). The highest sensitivity and specificity to predict the gender dimorphism were related to FL and FW (0.990 and 0.97) and (0.970 and 0.94), respectively.
Conclusion: Considering the differences between male and female cranial structures, can be useful in forensic medicine and designing neurosurgical and ergonomic instruments in addition, to distinguish and discover the gender of the humans related to the many years ago.
Keywords: Anthropometry, cranial index, cranial capacity, Iranian population

Introduction

Anthropometry has been defined as the measurement of different aspects of the human body, and it consists of a series of systematic measurement techniques which quantify this aspect.[1-3] These measurements can be performed on a alive human or cadaver or skeleton.[4,5] Different factors like gender and shape are inconsistent with anthropometric features of a person and have a close relationships with each other.[5] Moreover, these factors are manifestations of internal structures (which is influenced by environment) and histological components (which is influenced by genetics).[6] The main objects of forensic anthropometry are defining the age of an individual at the time of his/her death, gender, race, ethnicity, stature, and finally the reason for death according to the evidence.[7,8] Another application of an anthropometric measurement is in the production of artificial organs and also in surgeries specially cosmetic surgeries or in designing ergonomic instruments.[9,10]

Anthropometry is divided into two sub groups: somatometry and osteometry. Somatometry includes cephalometry and osteometry includes craniometry.[3] Somatometry measures alive person or cadaver including face and skull and cephalometry measures a different aspects of head and face in cadaveric, living specimens, or radiological images.[3,11] Cephalometric measurement is influenced by the environment, age, gender, and race.[2,12,13] One of the main parameters in forensic medicine for identification is gender determination.[14,15] For gender determination, different bones can be used but among them pelvic and then skull have the most frequency.[16] Gender determination by means of the skull is not possible until puberty.[17] Different landmarks of the skull can be used in the measurement of indices in cephalometry. These are useful for determining gender and race.[18,19] In fact due to different factors like genetic biochemical and environmental factors these proportions and relationships are changing continuously from childhood to adolescence.[20] The height, weight length, thickness and width are the simplest parameters in the anthropology of different parts of the body and these factors are not the same in the tribe to tribe or race to race and even between the two sexes.[21] Also By means of cranial index, the skull is classified into different types, brachycephalic, mesocephalic, and dolichocephalic.[22]

The aim of this study is to determine gender based on cephalometric criteria including cranial length (CL), cranial width (CW), cranial height (CH), cranial index (CI), cranial capacity (CC), and brain weight (BW) in Iranian population.

Materials and Methods

In a cross-sectional study, 400 Iranian volunteers (201 males and 199 females, age range: 20–25) were included. Only those volunteers without any history of craniofacial abnormalities, trauma, and head and face surgery were evaluated. Informed consent was given from each individual. Required information such as age, gender, and cephalic measurements for each individual were inserted in a form designed for this study. By means of sliding venire calipers different measurements like cranial length (CL), cranial width (CW), and cranial height (CH) were calculated twice. Dahlberg formula was used for calculating the errors of measurement (this formula is written below).

$$F = \sqrt{\sum_{j=1}^{M} \frac{x_j^2}{2M}} \qquad (1)$$

x: The amount of difference between the two measurements, M: sample size.

Definitions in Anthropometry

Inion (I): A projection on the occipital bone.
Nasion (n): Most anterior point on the frontonasal suture.
Vertex (V): The highest point of the skull.
Glabella (G): Most prominent point in the median sagittal plane between the supraorbital ridges.

Opisthocranion (OP): The point, wherever it may lie in the sagittal plane on the occipital bone, which marks the posterior extremity of the longest diameter of the skull, measured from the glabella.
Euryon (Eu): Either of the lateral points marking the ends of the greatest transverse diameter of the skull.
Cranial breadth (CB): The linear distance between parietal eminences.
Cranial length (CL): The linear distance between inion and glabella.
Cranial height (CH): The linear distance between vertex and nasion.
Cephalic index (CI): Calculated using formula no. (2).[23]

$$\text{CI: } [(CB/CL)] \times 100 \quad (2)$$

Depending upon this index the types of head shapes were classified as defined in Table 1.[24]
Cranial capacity (CC): Calculated using the formulas no. (3) (males) & 4 (females):[25]

$$CC_{male}: 0.000337(L-11)\ (w-11)\ (HT-11) + 406.01 \quad (3)$$
$$CC_{female}: 0.000400(L-11)\ (w-11)\ (HT-11) + 206.60 \quad (4)$$

Brain weight (BW): Calculated using formula no. (5):[26]
BW: CC × 1.035 (mass density of brain: 1.035) (5). All measurements were summarized in Figure 1.

Statistical Analysis

SPSS 22.0 software was used for statistical analysis. Statistical analysis was done using an independent *t*-test for showing the differences between the two sex groups. Receiver Operating Characteristic (ROC) curve analysis was done to calculate the cut-off point, sensitivity, and specificity of cranial variables. The *P* values less than 0.05 were considered statistically significant.

Results

In the current study, 400 medical students (201 males and 199 females) with a mean age of 22.15 ± 2.45 were investigated. According to the Dahlberg's double determination method, method errors of measurements was estimated to be <0.9 mm for CL, CB, and CH. The values of cranial measurements including CL, CW, CH, CC, CI, and BW of all subjects were summarized in Table 2. Significant differences were reported in the cranial measurements including CL (P = 0.0001), CB (P = 0.0001), CI (P = 0.0001), CC (P = 0.0001), and BW (P = 0.0001) bases on sex groups (Table 3). Additionally, based on the cephalic index, the head shapes were estimated. The distribution of head shapes was as follows: 24 dolichocephalic (6%), 233 mesocephalic (58.2%), 100 brachycephalic (25%), and 43 hyperbrachycephalic (10.8%) types. The distribution

Table 1. **Head shapes**

Head shape	Cranial index
Ultradolichocephalic	<64.9 1
Hyperdolichocephalic	65–69.9 2
Dolichocephalic	70–74.9 3
Mesocephalic	75–79.9 4
Brachycephalic	80–84.9 5
Hyperbrachycephalic	85–89.9 6
Ultrabrachycephalic	90< 7

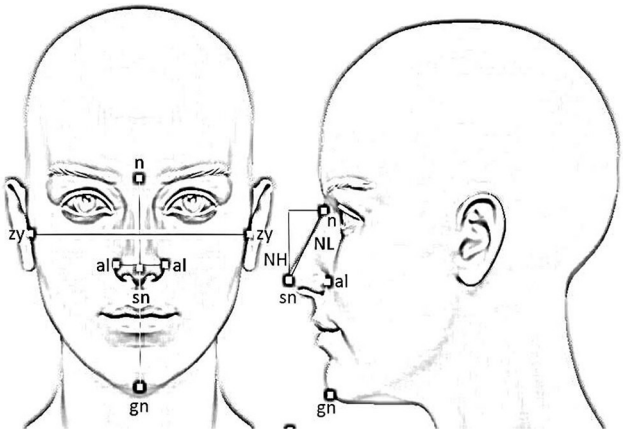

Fig. 1 **Anthropometric measurements of nasofacial parameters. n, Nasion; gn, Gnathion; Zy, Zygions; sn, subnasale; al, ala of nose; NL, nasal length; NH, nasal height; NW, nasal width; FH, facial height; FW, facial width.**

Table 2. **Summery of cephalometric characteristics among Iranian population**

Variables	Mean	SD	Min	Max
Age (year)	22.15	2.45	18.00	41.00
CL (cm)	19.176	0.833	15.900	21.100
CB (cm)	15.223	0.532	13.900	17.000
CH (cm)	13.15	2.18	9.90	17.00
CI	79.51	3.95	70.73	94.44
CC (mm^3)	306.83	99.83	206.59	406.10
BW (gr)	317.57	103.32	213.82	420.31

SD, Standard deviation; Min, Minimum; Max, Maximum; CL, Cranial length; CB, Cranial breadth; CH, Cranial height; CI, Cephalic index; CC, Cranial capacity; BW, Brain weight.

Table 3. **Comparing the cephalometric characteristics of male and female among Iranian population**

	Sex	Mean	*P*-value
Age (Year)	Male	22.40	0.12
	Female	22.90	
CL (cm)	Male	19.616	0.0001
	Female	18.731	
CB (cm)	Male	15.363	0.0001
	Female	15.081	
CH (cm)	Male	13.29	0.197
	Female	13.00	
CI	Male	78.39	0.0001
	Female	80.63	
CC (mm^3)	Male	406.04	0.0001
	Female	206.63	
BW (gr)	Male	420.25	0.0001
	Female	213.86	

SD, Standard deviation; Min, Minimum; Max, Maximum; CL, Cranial length; CB, Cranial breadth; CH, Cranial height; CI, Cephalic index; CC, Cranial capacity; BW, Brain weight.

of head shapes in the sex groups was demonstrated in Table 4. Although the most frequent head shape was related to mesocephalic type in both sex groups, there were significant differences in the head shape distribution of males and females (P = 0.0001). The cutoff point as well as sensitivity and specificity of all variables were calculated to predict the dimorphism among the Iranian population (Tables 5–9, Figure 2) and the highest sensitivity (100%) and specificity (100%) were related to CC and BW (Tables 8 and 9, Figure 2).

Discussion

The structure of the cranium depends on the alterations in the proportion and position of the face components.[27] Different factors such as gender, geography, biology, race, and age can be effective in the growth and developments of human skulls.[28,29]

Table 4. **Distribution of head shape based on sex groups among Iranian population**

		Sex				*P*-value
		Male		Female		
		N	%	*N*	%	
Head shape	Dolichocephalic	13	3.2	11	2.8	0.0001
	Mesocephalic	136	34.0	97	24.2	
	Brachycephalic	46	11.5	54	13.5	
	Hyperbrachycephalic	6	1.5	37	9.2	

Table 5. **Sensitivity and specificity for cut-off point value of CL to predict gender among Iranian population**

CL values	Sensitivity	Specificity
18.05000	0.980	0.231
18.15000	0.980	0.261
18.25000	0.980	0.266
18.35000	0.980	0.276
18.45000	0.980	0.312
18.55000	0.905	0.397
18.65000	0.905	0.417
18.75000	0.900	0.457
18.85000	0.900	0.523
18.95000	0.886	0.603
19.05000	**0.726**	**0.759**
19.15000	0.692	0.819
19.25000	0.687	0.839
19.35000	0.687	0.854
19.45000	0.667	0.859
19.55000	0.572	0.91
19.65000	0.532	0.915
19.75000	0.502	0.92
19.85000	0.438	0.925
19.95000	0.398	0.925
20.05000	0.289	0.97

Table 6. **Sensitivity and specificity for cut-off point value of CB to predict gender among Iranian population**

CB values	Sensitivity	Specificity
14.25000	1.000	0
14.35000	1.000	0
14.45000	0.995	0.005
14.55000	0.930	0.07
14.65000	0.930	0.07
14.75000	0.910	0.09
14.85000	0.900	0.1
14.95000	0.866	0.134
15.05000	0.697	0.303
15.15000	0.632	0.368
15.25000	0.592	0.408
15.35000	**0.532**	**0.468**
15.45000	0.463	0.537
15.55000	0.289	0.711
15.65000	0.254	0.746
15.75000	0.199	0.801
15.85000	0.149	0.851
15.95000	0.144	0.856
16.25000	0.025	0.975
16.75000	0.005	0.995
18.00000	0.000	1

Table 7. **Sensitivity and specificity for cut-off point value of CI to predict gender among Iranian population**

CI values	Sensitivity	Specificity
78.0052	0.478	0.241
78.0296	0.468	0.246
78.055	0.443	0.246
78.068	0.438	0.246
78.0922	0.438	0.251
78.141	0.413	0.251
78.182	0.413	0.256
78.2019	0.413	0.276
78.2151	0.413	0.281
78.2281	0.408	0.281
78.2726	0.408	0.291
78.3426	0.408	0.307
78.3997	0.408	0.322
78.437	0.403	0.322
78.4935	0.403	0.332
78.5527	**0.398**	**0.347**
78.5892	0.398	0.352
78.6264	0.378	0.352
78.6794	0.378	0.362
78.7181	0.373	0.362
78.7472	0.373	0.367

Table 8. **Sensitivity and specificity for cut-off point value of CC to predict gender among Iranian population**

CC values	Sensitivity	Specificity
206.6682	1	0.894472
206.6692	1	0.899497
206.671	1	0.904523
206.6734	1	0.924623
206.6752	1	0.929648
206.6761	1	0.934673
206.6767	1	0.939698
206.6769	1	0.944724
206.6781	1	0.959799
206.6796	1	0.964824
206.6805	1	0.979899
206.6825	1	0.984925
206.6948	1	0.98995
206.7068	1	0.994975
306.3578	**1**	**1**
406.0081	0.995025	1
406.0087	0.99005	1
406.0088	0.985075	1
406.0088	0.9801	1
406.0088	0.975124	1
406.0091	0.970149	1
406.0097	0.965174	1

Table 9. **Sensitivity and specificity for cut-off point value of BW to predict gender among Iranian population**

BW values	Sensitivity	Specificity
213.9045	1	0.904523
213.907	1	0.924623
213.9088	1	0.929648
213.9097	1	0.934673
213.9103	1	0.939698
213.9106	1	0.944724
213.9118	1	0.959799
213.9134	1	0.964824
213.9143	1	0.979899
213.9164	1	0.984925
213.9291	1	0.98995
213.9415	1	0.994975
317.0803	**1**	**1**
420.2184	0.995025	1
420.219	0.99005	1
420.2191	0.985075	1
420.2191	0.9801	1
420.2191	0.975124	1
420.2194	0.970149	1
420.22	0.965174	1
420.2209	0.905473	1
420.2214	0.900498	1

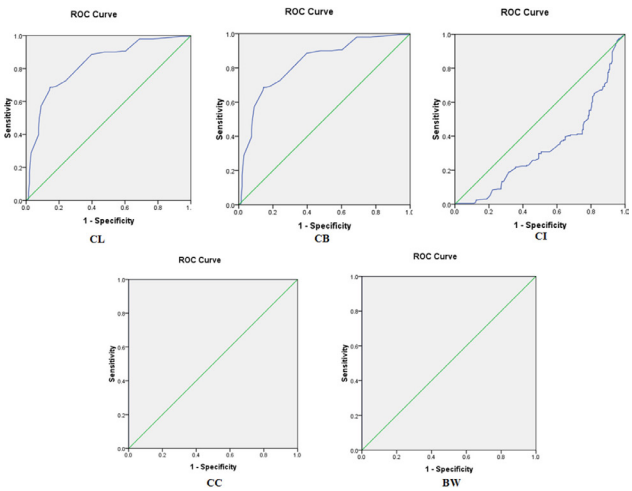

Fig. 2 **ROC curves of nasofacial variables in prediction of gender. CL, Cranial length; CB, Cranial breadth; CI, Cephalic index; CC, Cranial capacity; BW, Brain weight.**

Each ethnicity has its own characteristics. Some studies have shown that by using some anthropometric criteria, we can guess many details about the cranial features, like gender, age, and race.[30, 31] Mesocephaly is one of the classifications for the cranium that is seen more than the others between the Asian population.[32] In our study which was about the determination of cranium classification and cranial capacity and brain weight in the Iranian medical students in Tehran University of Medical Sciences, it was shown that the majority of cranium both in male and female samples is mesocephalic. In this study CI values were higher in the male in comparison to the female. Also, the CC of the male samples was higher than the female. Moreover, our findings demonstrate that the brain weight of the male samples is more than the female. These findings confirmed the existence of sexual dimorphism in the Iranian population. In a similar survey conducted by Dodangheh et al.,[33] it was shown that there was sexual dimorphism in male and female in Iran. In a study carried out by Eboh et al., it was cleared that there was sexual dimorphism in CC among Ukwuani People of South Nigeria and they showed that the CC increased with age. They determined that males had significantly higher values than females for all parameters ($P < 0.05$).[34] In another research carried out by Indian scientist, it was cleared that the adult human skulls capacity were directly in relation to the sexual differences. They showed that the mean cranial capacity of male skulls was found to be 1302.95 + 108.8 c.c. (range 1070–1560 c.c.), while in the female skulls the mean cranial capacity was found 1179.92 + 97.08 c.c. (range 1000–1420 c.c.). Hence a highly significant difference was observed between males and females for intracranial volume.[35] Despite many surveys about the relation between sex and brain size, some studies have shown that there isn't any relation between sex and brain size, directly. However, by reanalyzing the brain mass of many samples for black and white men and women, they show that, after correcting for body height or body surface area, men had about 100 g heavier brain mass in comparison to the women for all groups.[36]

In another study carried out by Sangeetha et al., they showed that the male skull was 5–15% higher than the female skull and the cranial capacity in men was higher than the women.[37] Also, Nooranipour & Farahani measured the brain weight and cranial capacity of 772 Iranian people, aged

Table 10. **Different values of cephalic capacity in various populations**

Author (year)	Population	CC (cc)	CC_m (cc)	CC_f (cc)
Present study	Medical Students (Iran)			
Sangeetha et al.[37]	Karnataka, India		1213cc ± 138.66	1276.26cc ± 68.72
Golalipour et al. (2007)[28]	Turkman people (North of Iran)		1420.60 ± 85	1227.2 ± 120
Eboh et al. (2016)[34]	Ukwuani People of South Nigeria	1408.90 ± 116.44	1460.31 ± 93	1348.61 ± 112.6
Nooranipour & Farahani (2008)[38]	Normal Iranian adults		1343.45 ± 102.37	1163.02 ± 115.76
Lalwani et al. (2012)[35]	Bhopal, India		1302.95 ± 108.8	1179.92 ± 97.08

Table 11. **Different values of cephalic index and head shape in various populations**

Author (year)	Population	CI	CI (m)	CI (f)	Head shape
Present study	Medical Students (Iran)	77.12 ± 4.2	77.01 ± 2.71	78.21 ± 2.35	M: Mesocephalic F: Mesocephalic
Golalipour (2006)[23]	Turkman (Iran)	–	–	82.8 ± 3.6	Brachycephalic
Odokuma et al. (2010)[40]	Nigeria		77.67	78.14	M: Mesocephalic F: Mesocephalic
Ilayperuma (2011)[42]	Srilankan		78.04	79.32	M: Mesocephalic F: Mesocephalic
Patro et al. (2014)[45]	Southern Odishia (India)		77.28	78.38	M: Mesocephalic F: Mesocephalic
Orish and Ibeachu (2016)[44]	Nigeria		76.03	76.12	M: Mesocephalic F: Mesocephalic

between 18–22 and found that the cranial capacity and brain weight in male was higher than female.[38]

Understanding about the head shape of the Iranian population and getting facts about the majority of their head shape can be effective in archeology and ergonomy and forensic medicine aspects, thus some studies were carried out in this field in Iran. For example, Golalipour et al., found that the most head shape of the Turkman population in Iran is brachycephalic by 42.4%. They measured the cephalic index of this population and concluded that the mean cephalic index for them was 80.4 ± 4.[23]

In a survey by Eun and his colleague, they showed that the most common type of skull in the modern Thai people was brachycephaly by a frequency of 42.7% and after that, the majority of the people who had mesocephalic skulls were 27.03%.[39]

In a survey carried out by Odokuma et al., they showed that the majority of the skulls in Nigeria both in males and females were mesocephaly.[40] This finding was correct for some investigations carried out in Nigeria, Srilankan and Southern Odisha in India.[41-43] Some studies carried out about the cranial index and cranial capacity have been shown in Tables 10 and 11.

In the current study carried out on Tehran University of Medical Science students, we understood that there was sexual dimorphism in cranial indices between male and female in the Iranian population. The shape of skulls for all cases including both male and female was mesocephaly. It means that despite dimorphism in cranial index, cranial capacity and brain weight between the male and female, all the skulls shape for all cases is mesocephaly.

Conclusion

Considering these differences between male and female cranial structures can be useful in forensic medicine and designing neurosurgical and ergonomic devices in addition to an understanding about the gender, race, geography, and genetics of humans related to the past times.

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Conflicts of interest

Author declares no conflicts of interest.

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