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Inheritance of Craniofacial Indices: A Study on Bengalee Hindu Population of West Bengal, India

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Abstract

Bone morphology and facial features are multi factorial i.e. combination of gene and environment with a complex inheritance pattern. Previous studies mostly from abroad participants suggested significant genetic contribution in linear and proportional measures on the basis of twin and family studies. In this background, the present study is the maiden attempt to understand the familial correlation and heritability pattern of different craniofacial indices from Indian context. To achieve the purpose, cross-sectional study was undertaken on Bengalee Hindu caste among 100 families. Ten (10) craniofacial measurements and six (6) indices were derived using standard techniques and formulae respectively. Significant *($p<0.05$)* sexual dimorphisms were found in majority of the indices. Father-child combination demonstrated significant *($p<0.05$)* positive correlation compared to those of their mother-child counterparts. In addition to that, coefficient of determination (R^2) and heritability (h^2) estimation indicated a strong trend of unilateral patterns of inheritance in Bengalee Hindu Caste population.

Keywords: Craniofacial Indices; Heritability (h^2); Family study

Abbreviations: MHL: Measurements includes maximum head length; MHB: Maximum Head Breadth; NB: Nasal Breadth; NL: Nasal Length; PEB: Physiognomic Ear Breadth; PEL: Physiognomic Ear Length; MFH: Morphological Facial Height; BZB: Bizygomatic Breadth; MFB: Minimum Frontal Breadth; BGB: Bigonial Breadth; TEM: Technical Error of Measurements.

Introduction

Facial indices are generally used to understand the shape or proportion of face [1]. Bone morphology and structure of craniofacial region, however, follows specific developmental process and eventually being special and complex part of human body [2].

Twin and family studies have established that heredity played a significant role in growth and development of craniofacial measurements [3-9]. Previous twin study revealed the contribution of gene was significantly higher for vertical measurements than horizontal and as well as evinced moderate to high heritability of length and breadth of central mid facial structures [8-11]. Apart from twin studies, family study demonstrated significant genetic effect on the basis of several angular measurements, like soft tissue facial angles and hold away [12]. Furthermore, family study also revealed the evidence of significant genetic contribution of craniofacial linear and proportional measures, and eventually, indicated sons demonstrated strong relationship with mothers than fathers while daughters showed strong relation with both parents for linear and proportional measurements.

Study on facial indices imperatively significant in various fields including genetics, anatomy, anthropology and most importantly in forensic studies [2,13]. Moreover, several studies envisaged that assessment of facial type by using facial measurements played a crucial role for the planning and prognosis of orthodontic treatment as well as in evolutionary biology pertaining to human origin [1,2,9,14,15]. In view of the above, to best of the knowledge the present study is the first attempt to study the inheritance of craniofacial indices using correlation and heritability estimation from Indian context.

Material and Methods

The present cross sectional study was conducted among Bengalee Hindu caste population from 24 Parganas (North), West Bengal, India. A total of 300 adult individuals were measured, which included 200 parents (100 mothers and 100 fathers) and 100 adult offspring (Son=56, Daughter=44). Ten (10) craniofacial measurements were taken using standard techniques [16]. Measurements includes maximum head length (MHL), maximum head breadth (MHB), nasal breadth (NB), nasal length (NL), physiognomic ear breadth (PEB), physiognomic ear length (PEL), morphological facial height (MFH), bizygomatic breadth (BZB), minimum frontal breadth (MFB), bigonial breadth (BGB). All measurements were taken from the respondent's eye-ear plane on sitting position using the appropriate landmarks [17] (Figures 1-3).

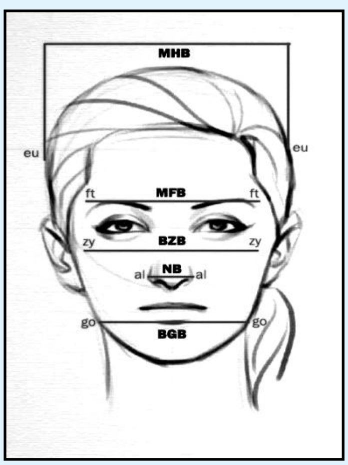

Figure 1

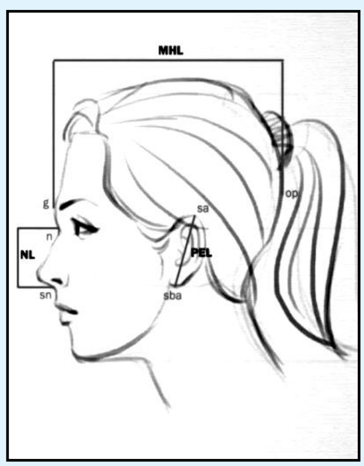

Figure 2

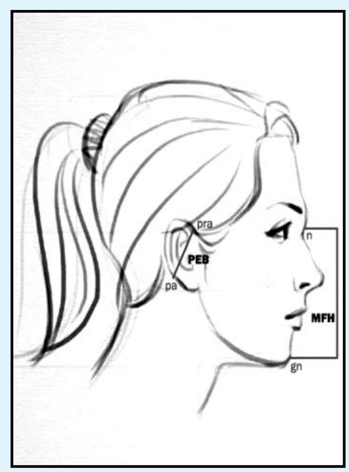

Figure 3

Figures 1,2,3: Respondent's eye-ear plane on sitting position.

Six (6) craniofacial indices were computed on the basis of obtained ten (10) craniofacial measurements [18]. Inclusion criteria for selecting the families were: no history of craniofacial injury and healthy parents (without adopted or step child). Verbal informed consent was obtained from each participant. All the measurements were double checked to avoid typological errors. Obtained measurements was found to be within permissible Technical Error of Measurements (TEM) Statistical analysis includes Pearson correlation of coefficient, linear regression and heritability estimation [19]. The equation of heritability between parents and offspring was twice the regression coefficient, *b*, of the offspring on the parent, thus $h^2 = 2 \times b$. For any trait, a heritability estimate of 1 indicated theoretically with no environmental influence; on the other hand, an estimate of 0 defined the trait with no heritable influence. A midway value of 0.5 would have its variability influenced by both environment and gene [9,20,21]. Heritability value more than 1 was considered as meaningless value [20]. Cut off value was set as $p=0.05$.

Results

The distribution of craniofacial indices among the studied population (Table 1) revealed significant $(p<0.05)$ sex differences for most of the indices among the parents and the offspring. No bilateral asymmetry was noticed for physiognomic ear index (PEI) for left and right ear for all groups (father, mother, son, and daughter).

Variable	Father (n=100)	Mother (n=100)	Son (n=56)	Daughter (n=44)
	Mean ± SD	Mean ±S D	Mean ± SD	Mean ± SD
Age (years)	54.93±8.65	46.99±8.15	25.78±8.99	20.87±3.92
Cephalic Index (CI)	78.40±3.82	78.07±3.76	78.66±4.47	79.58±3.88
Breadth-height Index (BHI)	110.70±8.40*	109.00±7.65	109.68±8.41*	106.78±6.23
Jugo-frontal Index (JFI)	105.59±6.15	107.93±6.88*	108.14±6.34	109.55±4.51*
Jugo-mandibular Index (JMI)	98.57±7.35*	96.11±7.15	98.18±8.40*	92.95±9.18
Nasal Index (NI)	76.10±8.22	74.83±6.62	75.77±9.86*	72.72±6.13
Physionomic ear Index (PEI)	51.20±4.43	52.63±4.22*	52.27±3.70	53.50±4.26

Table 1: Distribution of Craniofacial indices among the studied population.
* p<0.05

Correlation coefficients of craniofacial indices as presented in Table 2 demonstrated significant $(p<0.05)$ positive correlations in all six indices (CI, BHI, JFI, JMI, NI, PEI) in between father and son, while, father and daughter demonstrated significant positive $(p<0.05)$ correlation in five (CI, BHI, JFI, JMI, NI) indices. On the other hand, CI, BHI, JFI, JMI and NI revealed significant $(p<0.05)$ positive correlation between mother and daughter, and CI, JFI, and NI revealed significant $(p<0.05)$ positive correlation between mother and son. In addition to that, examination on Parent-daughter relationships revealed significant $(p<0.05)$ positive correlation for CI, BHI, JFI, JMI and NI, while, Parent-son relationship demonstrated significant $(p<0.05)$ positive correlation for CI, JFI, and NI. Nevertheless, CI, JFI and NI was found to have significant $(p<0.05)$ positive correlation between both father-offspring and mother-offspring.

variable	Father-son (n=56)	Father-daughter (n=44)	Mother-son (n=56)	Mother-daughter (n=44)
	h^2	h^2	h^2	h^2
Cephalic Index (CI)	0.96	0.56	0.57	0.63
Breadth-height Index (BHI)	1.08 [b]	0.42	0.47	0.6
Jugo-frontal Index (JFI)	0.77	0.45	0.79	0.67
Jugo-mandibular Index (JMI)	0.99	0.88	0.37	1.24 [b]
Nasal Index (NI)	0.6	0.39	0.66	0.99
Physionomic ear Index (PEI)	0.72	0.34	0.42	0.43

Table 2: Parent offspring relationship of different craniofacial indices.
*r = coefficient of correlation, R^2 = coefficient of determination, *p<0.05, **p<0.01*

Analysis of heritability estimation of parents and offspring as presented in Table 3 demonstrated that heritability (h^2) values for father-son (CI, h^2= 0.96; BHI, h^2= 1.08 [b]; JFI, h^2= 0.77; JMI, h^2= 0.99; NI, h^2=0.60; PEI, h^2=0.72) were higher for all six indices. Though for all the indices heritability (h^2) values are strong for father-son group, while, JMI value for father-daughter heritability (h^2) value showed rather relatively strong value (JMI, h^2= 0.88) which was almost having closer value with father-son group (JMI, h^2= 0.99). Whereas, heritability estimation of mother offspring revealed that, values are higher for mother-daughter (CI, h^2 = 0.63; BHI, h^2= 0.60; JMI, h^2= 1.24 [b]; NI, h^2= 0.99; PEI, h^2= 0.43) than mother-son (JFI, h^2= 0.79).

variable	Father-son (n=56)		Father-daughter (n=44)		Mother-son (n=56)		Mother-daughter (n=44)	
	r	R^2	r	R^2	r	R^2	r	R^2
Cephalic Index (CI)	0.394**	0.155	0.287*	0.082	0.264*	0.07	0.255*	0.065
Breadth-height Index (BHI)	0.518**	0.268	0.289*	0.084	0.217	0.047	0.362**	0.131
Jugo-frontal Index (JFI)	0.378**	0.143	0.307*	0.094	0.440**	0.194	0.483**	0.233
Jugo-mandibular Index (JMI)	0.396**	0.157	0.391**	0.153	0.151	0.023	0.516**	0.266
Nasal Index (N I)	0.244*	0.059	0.276*	0.076	0.241*	0.058	0.463**	0.214
Physionomic ear Index (PEI)	0.445**	0.198	0.169	0.029	0.235	0.055	0.219	0.048

Table 3: Heritability (h^2) Estimation craniofacial Indices in the studied population.
[b] = *Meaningless value*

Discussion

Craniofacial structures are the result of complex interaction of gene, environment and its additive effect, and inheritance patterns of those multi factorial trait fellows some specific fashion. However, study on inheritance of linear measurements among the Bengalee Hindu caste population also demonstrated overall strong heritability with the parents [21]. Present study is the first attempt to understand the likelihood of relationship and heritability of facial index using diverse facial measurements among Indian (Bengalee Hindu Caste) population using family studies. Result revealed, significant *($p<0.05$)* sex difference was observed in most of the indices, and the result corroborated with the study on the European, (Belgian) families ,Asian (Korean) family and somewhat among the Midlle East (Saudi) families [2,16,20]. A general overview of result of correlation revealed a promising number of significant ($p<0.05$) correlations between parents and offspring of Bengalee population, which also indicated that might have more genetic effects than other epigenetic factors. Among father-son group 16% for CI, 27% for BHI, 14% for JFI, 16% for JMI, and 20% for PEI were explained the variation However, for father daughter group only in JMI, 15% was explained the variation (Table 3). It was also found that between father-offspring group, good numbers of measurements have significant ($p<0.05$) positive correlation in father-son group (CI, BHI, JFI, JMI, NI, PEI) than in father-daughter group (CI, BHI, JFI, JMI, NI) (Table 2). On the other hand, for mother-son group only in JFI, 19% found to be explained the variation between them. But, in case of mother-daughter ratios explained variation viz. 13% for BHI, 23% for JFI, 27% for JMI, 21% for NI (Table 3). However, revealed mother-offspring group, had significant *($p<0.05$)* positive correlation in mother-daughter group (CI, BHI, JFI JMI, NI) rather than mother-son group (CI, JMI, NI) (Table 2). General observations from the present study demonstrated father-offspring and mother offspring, the pattern of inheritance indicated that, the transmission of facial traits might have unilateral type and the present study also in corroboration as the highest/strong correlation between father-son and mother-daughter, while lowest correlation was found in opposite sex pairs done on photographic family study on facial characters. On the basis of the result of the present attempt, the correlation of coefficient (r) and coefficient of determination (R^2) it is envisaged that, among parent offspring groups' father-offspring relationship was much stronger than mother-offspring relationship, which was also corroborated with the family study on linear measurements [21].

A moderate to high heritability (h^2) was evident in majority of the indices which also indicated that, there might be moderate to high aggregation of gene(s) for those indices/traits in the family. Similar to the correlation, heritability (h^2) estimation also confirmed almost similar result. Among parent offspring groups heritability (h^2) values were higher for father-son groups compared to father-daughter group and mother-daughter group than mother-son group i.e. between opposite sex pair group. It is being important to mention that, in some of the cases (BHI for father-son, JMI for mother-daughter) heritability (h^2) values come out with the value which, exceed the range (0 to 1). Conventionally, heritability (h^2) value fall within value of 0 to 1. If the value exceeds the range, which is consider as "meaningless values", which may be either due to sampling fluctuation or due to "cohabitational effect" which is due to shared environment between family members [22].

Findings of the present study indicated a trend of strong genetic influence in transmission of facial indices (facial measurement) and somewhat indicated a trend of unilateral patterns of inheritance in Bengalee Hindu Caste population.

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References

1. Kumari KL, Babu V, Kumari PK, Nagamani MA (2015) Study of cephalic index and facial index in Visakhapatnam, Andhra Pradesh, India. IJRMS 3(3): 656-658.
2. Kim H, Im S, Jargal G, Lee S, Yi J, et al. (2013) Heritabilities of facial measurements and their latent factors in korean families. Genomic Inform 11(2): 83-92.
3. Šidlauskas M, Šalomskienė L, Andriuškevičiūtė I, Šidlauskienė M, Labanauskas Ž, et al. (2014) Mandibular morphology in monozygotic twins: acephalometric study. Stomatologija 16(4): 137-143.
4. Amini F, Borzabadi-Farahani A (2009) Heritability of dental and skeletal cephalometric variables in monozygous and dizygous Iranian twins. Orthod Waves 68(2): 72-79.
5. Ermakov S, Kobyliansky E, Livshits G (2005) Quantitative genetic study of head size related phenotypes in ethnically homogeneous Chuvasha pedigrees. Ann Hum Biol 32: 585-598.
6. Martínez-Abadías N, Esparza M, Sjøvold T, González-José R, Santos M, et al. (2009) Heritability of human cranial dimensions: comparing the evolvability of different cranial regions. J Anat 214(1): 19-35.
7. Clark PJ (1956) The Heritability of Certain Anthropometric Characters as Ascertained from Measurements of Twins. Am J Hum Genet 8(1): 49-54.
8. Aksakalli S, Demir A (2013) The comparison of facial estethics between orthodontically treated patients and their parents. Sc World J Article ID 903507: 1-7.
9. Carels C, Van Cauwenberghe N, Savoye I, Willems G, Loos R, et al. (2001) A quantitative genetic study of cephalometric variables in twins. J Clin Orthod 4(3): 130-140.
10. Weinberg, S M, Parsons TE, Marazita ML, Maher BS (2013) Heritability of face shape in twins: a preliminary study using 3D sterophotogrammerty and geometric morphometrics. Den 1(1): 1-5.
11. Baydaş B, Erdem A, Yavuz I, Ceylan I (2007) Heritability of facial proportions and soft-tissue profile characteristics in Turkis Anatolian siblings. AJODO 131(4): 504-509.
12. Franco FC, Araujo TM, Vogel CJ, Quintão CC (2013) Brachycephalic, dolichocephalic and mesocephalic: Is it appropriate to describe the face using skull patterns? Dental Press J Orthod 18(3): 159-163.
13. Ding YC, Wooding S, Harpending HC, Chi HC, Li HP, et al. (2000) Population structure and history in East Asia, PNAS 97(25): 14003-14006.
14. Gad A, Laurino M, Maravilla KR, Matsushita M, Raskind WH (2008) Sensorineural deafness, distinctive facial features, and abnormal cranial bones: a new variant of Waardenburg syndrome? Am J Med Genet 146A(14): 1880-1885.

15. Jelenkovic A, Povenda A, Susanne C, Rebato E (2010) Common genetic and environmental factors among craniofacial traits in Belgian nuclear families: Comparing skeletal and soft-tissue related phenotypes. HOMO 61(3): 191-203.

16. Juan Comas (1960) Manual of Physical Anthropology. Thomas, Springfield, Ill.

17. Dubey S, Sharma T (2011) A face recognition system through somatology. IJCSES 3(1): 155-160.

18. Ulijaszek SJ, Kerr DA (1999) Anthropometric measurement error and the assessment of nutritional status. Brit J Nut 82(3): 165-177.

19. Alkhudhairi TD, Alkofide EA (2010) Cephalometric craniofacial features in Saudi parents and their offspring. Angle Orthod 80(6): 1010-1017.

20. Das P, Bandyopadhyay AR, Ghosh JR (2014) Family study on some head and face measurements. Nrtattv 3-6: 114-119.

21. Hunter WS, Balbach DR, Lamphiear DE (1970) The heritability of attained growth in the human face. Am J Orthodont 58(2): 128-134.

22. Johannsdottir B, Thorarinsson F, Thoradarson A, Magnusson TE (2005) Heritability of craniofacial characteristics between parents and offspring esimated from lateral cephalograms. AJODO 127(2): 200-207.