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Craniofacial Anthropometry and Their Correlation with Personality Traits in Indian Medical Students

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ABSTRACT

Introduction: This study aimed to explore the relationship between craniofacial anthropometric measurements and personality traits among medical students. Understanding these associations could provide novel insights into how physical characteristics relate to psychological dimensions.

Methodology: A cross-sectional study was conducted at Jawahar Lal Nehru Medical College, DMIMS, Wardha, India, involving 295 participants (130 males, 165 females) aged 18–30 years. Craniofacial measurements, including forehead length, bizygomatic width, and cephalic index, were obtained using calibrated instruments. Personality traits were assessed using the Big Five Personality Test. Data analysis included Pearson's correlation and regression models, with $p < 0.05$ considered significant.

Results: Significant gender differences were noted in craniofacial dimensions; males exhibited larger measurements in most parameters, while females had higher cephalic indices. Personality traits also varied, with females scoring higher in Agreeableness and males in Emotional Stability. Correlation analysis revealed significant associations between specific craniofacial features and personality traits, such as Bizigomatic Width with Extraversion and Cranial Length with Intellect/Imagination.

Conclusion: The study demonstrates notable gender differences and significant correlations between craniofacial measurements and personality traits. These findings highlight potential interdisciplinary links between anatomy and psychology, warranting further research in diverse populations.

Keywords: Craniofacial anthropometry, Personality traits, Gender differences, Big Five, Medical students

INTRODUCTION

Craniofacial anthropometry, the scientific measurement of skull and face dimensions, is integral to multiple disciplines, including anthropology, forensic science, and medical research. These dimensions vary based on genetic, environmental, and lifestyle influences, serving as markers of identity, ethnic diversity, and even potential health indicators. The face serves as a central element in human interaction, providing a wealth of observable information. By examining facial features, one can infer basic attributes such as age and gender, as well as form subjective impressions about a person's health, attractiveness, and personality traits.[1,2]

Personality is a relatively enduring and consistent characteristic or pattern unique to an individual.[3] It significantly influences various aspects of life, including inter-

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personal relationships[4], emotional regulation[5], and overall health[6]. Research has demonstrated that personality traits can be reliably inferred from static images of neutral facial expressions.[7]

Increasingly, studies have investigated the connection between biological facial features and personality traits, uncovering intrinsic links between the two in humans and even in other species.[8,9] Notably, facial symmetry has been reported to have a strong association with the Big Five personality traits.[10] Among the most widely examined facial indicators is the facial width-to-height ratio (fWHR). This metric has been linked to a range of personality attributes, including achievement drive[11], unethical behavior[12], perceived dominance[13], aggression[14], and risk-taking tendencies[15].

Facial traits, inherited from parents, have been suggested to play a role in the transmission of personality characteristics. Traits such as aggression and trustworthiness are often associated with specific facial measurements.[16] Research highlights intriguing correlations, such as the relationship between forehead slant, impulsiveness, and cortical brain thickness.[17] Additionally, individuals with a narrower bizygomatic arch have been found to exhibit greater self-sufficiency and a reduced tendency to express emotions compared to those with a broader arch.[18]

The objectives of the study were to evaluate the relationship between craniofacial anthropometric measurements and personality traits among medical students.

MATERIALS AND METHODS

This cross-sectional study was conducted at Jawahar Lal Nehru Medical College, DMIMS, Wardha, Maharashtra, India. Ethical approval was obtained from the Institutional Ethics Committee, and informed written consent was secured from all participants. The study followed the ethical principles outlined in the Declaration of Helsinki.

Study Population and Sampling: The study recruited participants aged 18–30 years from the college's student population. All students were explained about the study and invited to participate in the study at predetermined date, time and place. All consecutive students who appear to participate were included after assessing eligibility criteria. Students who had history of craniofacial deformities, trauma, or surgeries were excluded from the study. Those with systemic illnesses, congenital abnormalities, or other conditions influencing craniofacial structure were also excluded. Total 295 eligible students voluntarily appeared to participate and all were included in the study.

Anthropometric Measurements: Craniofacial anthropometric measurements were obtained using validated techniques and precise instruments, including a digital sliding calliper, digital spreading calliper, outside callipers, and a steel scale. These instruments were calibrated before each session to ensure accuracy. Anthropometry measurements were done by two of the authors themselves. They demonstrated each measurement in front of each other to make measurement methods consistent. Inter-observer and intra-observer reliability assessments were conducted by repeating measurements on a subset of 20 participants, with results showing consistency (intraclass correlation coefficient =0.86).

Key craniofacial dimensions included **Forehead Length (FHL)** (Distance from hairline to hairline at the mid of perpendicular to forehead width), **Forehead Width (FHW) (**Measured from the glabella to the trichion), **Byzygomatic Width (BZW) (**The maximum distance between the right and left zygions, representing the widest part of the face), **Upper Facial Height (UFH) (**Vertical distance from the nasion to the prosthion), **Facial Height (FH) (**Vertical distance from the nasion to the gnathion), **Bigonial Width (BGW) (**Maximum transverse distance between the right and left gonions at the angle of the mandible), **Biparietal Width (BPW) (**Maximum transverse distance between the parietal eminences), **Glabella to Opisthocranion Distance (GTO) (**Maximum cranial length measured from the glabella to the opisthocranion).

Craniofacial indices, such as the **Facial Index (FI), Upper Facial Index (UFI),** and **Cephalic Index (CI),** were calculated using the following formulas:

FI: (Nasion-Gnathion Height/Byzygomatic Breadth)×100
UFI: (Nasion-Prosthion Height/Byzygomatic Breadth)×100
CI: (Maximum Cranial Width/Maximum Cranial Length)×100

The identification of anatomical landmarks, such as the nasion, gnathion, zygion, trichion, gonion, opisthocranion, and glabella, followed established anthropometric definitions. Measurements were taken thrice for each dimension, and the mean value was used for analysis to minimize variability.

Personality Trait Assessment

The Big Five Personality Test (BFPT), sourced from the International Personality Item Pool (IPIP)[19], was used to assess personality traits after necessary permission. This 50-item questionnaire evaluates five dimensions: extraversion, agreeableness, conscientiousness, Emotional Stability, and openness to experience.

Each item was scored on a five-point Likert scale ranging from 1 (disagree) to 5 (agree). Positively keyed items were scored directly, while negatively keyed items were reverse-scored. Examples include:

Extraversion: Measures sociability and enthusiasm, with positively keyed items like "I am outgoing, sociable" and negatively keyed items like "I prefer solitude."
Agreeableness: Assesses cooperation and compassion, with items like "I sympathize with others' feelings" and reverse items like "I insult people."
Conscientiousness: Evaluates organization and diligence, with items such as "I am always prepared."

Neuroticism (Emotional Stability): Reflects emotional resilience or instability, with items like "I get stressed easily" (negatively keyed).

Openness to Experience: Captures creativity and intellectual curiosity, with items like "I have a vivid imagination."

The mean scores for each trait were calculated, and participants' results were categorized as "low," "average," or "high" based on one-half standard deviation from the mean. The BFPT's high reliability was evidenced by Cronbach's alpha values for each trait (e.g., extraversion: 0.87, agreeableness: 0.82).

Data Collection and Statistical Analysis: Data were collected in a controlled environment to ensure consistency and minimize measurement errors. Descriptive statistics, including means and standard deviations, were computed. IBM SPSS Statistics V. 29 was used for statistical analysis. Pearson's correlation coefficient assessed the relationship between craniofacial dimensions and personality traits, while linear regression models adjusted for potential confounders. A p-value <0.05 was considered statistically significant.

Potential sources of bias in this study were carefully addressed to enhance the reliability and validity of the findings. To mitigate bias from self-reported personality traits, the validated Big Five Personality Test (BFPT) was used, and participants completed the questionnaire in a private, non-judgmental environment with clear instructions to minimize social desirability bias and misinterpretation. Measurement errors were minimized by calibrating instruments before each session, providing thorough training to personnel conducting the measurements, and ensuring high inter-observer and intra-observer reliability through assessments, with repeated measurements taken thrice and averaged. Selection bias was reduced by employing a clearly defining inclusion and exclusion criteria and voluntary participation.

Ethical Considerations: The study-maintained confidentiality by anonymizing all data. To achieve anonymization, participants' data were anonymized by coding and separating it from identity data, with a securely stored code sheet for re-linking if needed. Participants were fully informed about the study's purpose, and they retained the right to withdraw at any time without penalty. Ethical guidelines were strictly followed to protect participants' welfare. The methodology was approved by Doctoral research committee and before initiation of this study; ethical approval was obtained from institutional Ethical Committee with the reference number DMIMS (DU)/IEC2022/320 dated 07/10/2022.

RESULTS

The results from the study, which involved 130 males and 165 females, reveal significant differences in craniofacial measurements and personality traits between the two genders. Additionally, several craniofacial features were found to correlate with personality traits. In both males and females, the correlations between craniofacial measurements and personality traits varied by gender.

Table 1: Craniofacial Anthropometric measurements and Cranial Indices according to gender

Anthropometry (in mm)	Male (n=130) (Mean±SD)	Female (n=165) (Mean±SD)	p-value*
Forehead length	116.4±7.8	107.1±9.2	<0.001
Forehead Width	59.1±8.2	56.6±7.1	0.008
Bizygomatic Width	128.2±8.1	119.9±7.2	<0.001
Upper facial height	65.8±6.9	62.3±5.7	<0.001
Facial height	110.0±7.4	101.1±7.4	<0.001
Bigonial width	106.0±7.0	99.4±6.1	<0.001
Biparietal width	148.5±7.5	141.8±7.6	<0.001
Cranial length	185.9±10.6	173.5±11.4	<0.001
Facial index	86.15±8.38	84.67±8.72	0.142
Upper facial index	51.64±6.93	52.29±6.75	0.414
Cephalic index	80.10±5.45	82.20±8.58	0.015

*t-test applied for calculation of p value

Table 2: Personality traits score according to gender

Personality traits	Male (n=130) Mean±SD	Female (n=165) Mean±SD	p-value*
Extraversion	29.42±6.91	29.02±7.89	0.65
Agreeableness	34.58±6.04	37.91±4.93	<0.001
Conscientiousness	32.83±6.87	33.40±6.19	0.45
Emotional Stability	29.09±7.07	25.55±7.32	<0.001
Intellect/Imagination	36.32±5.34	36.99±5.19	0.277

*t-test applied for calculation of p value

Table 1 represents the craniofacial anthropomentric measurements and cranial indices according to gender, Significant gender differences are observed in several craniofacial dimensions. Males show larger measurements for Forehead length (116.4 mm vs. 107.1 mm), Bizygomatic width (128.2 mm vs. 119.9 mm), Upper facial height (65.8 mm vs. 62.3 mm), Facial height (110.0 mm vs. 101.1 mm), Bigonial width (106.0 mm vs. 99.4 mm), Biparietal width (148.5 mm vs. 141.8 mm), and Cranial length (185.9 mm vs. 173.5 mm), with all p-values being less than 0.001. Cephalic index is significantly higher in females (82.20 vs. 80.10, p = 0.015). However, no significant gender differences are found in the Facial index (p = 0.142) and Upper facial index (p = 0.414).

Table 2 presents the personality traits scores according to gender, comparing males (n=130) and females (n=165). For Extraversion, males (29.42 ± 6.91) and females (29.02 ± 7.89) show no significant difference, as indicated by the p-value of 0.65. Agreeableness is significantly higher in females (37.91 ± 4.93) than in males (34.58 ± 6.04), with a p-value of 0.00. There is no significant difference in Conscientiousness, with males scoring 32.83 ± 6.87 and females scoring 33.40 ± 6.19 (p-value = 0.45). Emotional Stability is significantly higher in males (29.09 ± 7.07) compared to females (25.55 ±

7.32), with a p-value of 0.00. Finally, Intellect/Imagination shows no significant difference between the genders, with males scoring 36.32 ± 5.34 and females scoring 36.99 ± 5.19 (p-value = 0.277).

Table 3: Correlation of Personality traits and Craniofacial anthropometric measures in males (n=130)

Craniofacial anthropometric	Personality Traits									
	Extraversion		Agreeableness		Conscientiousness		Emotional Stability		Intellect Imagination	
	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value
Forehead length	0.128	0.148	0.097	0.274	+0.484**	0.001	0.106	0.23	+0.481**	0.001
Forehead width	-0.431**	0.001	0.011	0.902	0.049	0.58	0.021	0.815	0.014	0.873
Bizygomatic width	+0.196*	0.025	-0.165*	0.032	0.054	0.544	-0.048	0.59	-0.057	0.522
Upper facial height	-0.014	0.873	-0.004	0.96	-0.013	0.883	-0.084	0.344	-0.023	0.794
Facial height	0.048	0.587	0.021	0.81	+0.157*	0.038	-0.09	0.309	-0.099	0.262
Bigonial width	-0.062	0.487	-0.082	0.352	0.14	0.112	-0.076	0.387	0.098	0.268
Biparietal width	0.008	0.928	-0.03	0.736	0.04	0.649	0.145	0.099	0.061	0.489
Cranial length	+0.210*	0.017	-0.139	0.116	0.028	0.754	+0.178*	0.029	0.057	0.52
Facial Index	0.103	0.241	0.061	0.488	-0.111	0.209	-0.029	0.741	-0.019	0.83
Upper facial index	-0.341**	0.001	0.033	0.708	-0.022	0.808	-0.04	0.653	0.016	0.853
Cephalic Index	-0.167*	0.032	0.102	0.249	0.015	0.864	-0.002	0.98	0.002	0.983

**Correlation is significant at the 0.01 level (2-tailed).; *. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Correlation of Personality traits and Craniofacial anthropometric measures in females (n=165)

Craniofacial anthropometric	Personality Traits									
	Extraversion		Agreeableness		Conscientiousness		Emotional Stability		Intellect Imagination	
	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value
Forehead length	-0.091	0.246	0.066	0.398	+0.211**	0.007	-0.127	0.103	0.058	0.456
Forehead width	-0.021	0.79	0.029	0.715	-0.099	0.207	-0.11	0.159	-0.118	0.131
Bizygomatic width	-0.022	0.78	-0.165*	0.034	0.002	0.981	0.124	0.112	0.042	0.593
Upper facial height	-0.076	0.335	-0.1	0.2	0.001	0.994	-0.023	0.767	-0.038	0.631
Facial height	-0.135	0.083	-0.045	0.566	+0.169*	0.03	0.052	0.506	0.072	0.358
Bigonial width	+0.162*	0.037	0.02	0.795	-0.067	0.393	0.029	0.707	-0.079	0.311
Biparietal width	-0.02	0.8	-0.005	0.95	-0.09	0.252	0.106	0.176	0.055	0.486
Cranial length	0.012	0.877	0.014	0.861	0.012	0.879	-0.018	0.818	+0.196*	0.012
Facial Index	-0.083	0.287	-0.011	0.892	+0.174*	0.025	-0.032	0.687	0.02	0.796
Upper facial index	-0.041	0.599	-0.059	0.455	0.002	0.98	-0.073	0.351	-0.051	0.518
Cephalic Index	0.003	0.964	-0.011	0.892	-0.058	0.462	0.075	0.336	0.016	0.839

**Correlation is significant at the 0.01 level (2-tailed).; *. Correlation is significant at the 0.05 level (2-tailed).

Several significant relationships were observed. Forehead Length showed a positive correlation with Intellect/Imagination (r = 0.484, p = 0.001) and Extraversion (r = 0.481, p = 0.001). Bizygomatic Width was positively correlated with Extraversion (r = 0.196, p = 0.025) but negatively correlated with Agreeableness (r = -0.165, p = 0.032). Cranial Length demonstrated a positive correlation with Extraversion (r = 0.210, p = 0.017) and Emotional Stability (r = 0.178, p = 0.029). Additionally, Upper Facial Index was negatively correlated with Extraversion (r = -0.341, p = 0.001), and Cephalic Index showed a significant negative correlation with Extraversion (r = -0.167, p = 0.032). These results suggest that certain craniofacial features, such as forehead length, cranial length, and bizygomatic width, may be linked to specific personality traits in males, offering insights into the potential associations between physical characteristics and psychological traits, although many other measures did not exhibit significant correlations. [Table 3]

The correlations between craniofacial measurements and five personality traits-Extraversion, Agreeableness, Conscientiousness, Emotional Stability, and Intellect/ Imagination-were examined. Forehead length was positively correlated with Conscientiousness (r = 0.211, p = 0.007). Bizygomatic width had a negative correlation with Agreeableness (r = -0.165, p = 0.034) and a positive correlation with Bigonial width and Extraversion (r = +0.162, p = 0.037). Additionally, Facial height showed a positive correlation with Conscientiousness (r = +0.169, p = 0.03), Cranial length was positively correlated with Intellect/Imagination (r = +0.196, p = 0.012), and Facial Index was positively correlated with Conscientiousness (r = +0.174, p = 0.025). [Table 4]

DISCUSSION

The study results highlight distinct gender differences in craniofacial dimensions and certain significant correlations between anthropometric measures and personality traits.

Gender Differences in Craniofacial Measurements: The craniofacial measurements, including forehead length, forehead width, bizygomatic width, upper facial height, facial height, bigonial width, biparietal width, and cranial length, were significantly greater in males compared to females. These dimensions are biologically and anthropologically significant as they reflect underlying skeletal growth patterns influenced by hormonal variations and genetic factors, which play a key role in physical development and forensic applications. These findings are consistent with prior studies, such as those by Krishan et al., which demonstrated gender-based craniofacial differences likely attributed to variations in skeletal growth patterns influenced by hormonal differences.[20,21] The cephalic index, however, was higher in females, indicating relatively broader head shapes in females, as corroborated by Patil et al.[22] Beyond its forensic relevance for gender determination, a higher cephalic index in females may also reflect evolutionary adaptations, aesthetic norms, or underlying developmental patterns that shape gender-specific cranial morphology. Such differences have implications in forensic and anthropological applications where gender determination is crucial.

Gender Differences in Personality Traits: The personality traits agreeableness and emotional stability displayed significant gender differences, with females scoring higher on agreeableness and males scoring higher on emotional stability. These findings align with previous psychological research suggesting inherent gender-based variations in personality constructs, often shaped by sociocultural and biological factors.[23,24] Higher agreeableness in females has been linked to evolutionary roles emphasizing nurturing and cooperative behaviors.[25]

Correlations Between Craniofacial Measurements and Personality Traits: Significant correlations between craniofacial anthropometry and personality traits were observed, with traits like conscientiousness and emotional stability showing the strongest associations. In males, forehead length showed a positive correlation with conscientiousness (p=0.001), suggesting that craniofacial development might reflect underlying biological processes influencing personality. Similarly, bizygomatic width negatively correlated with agreeableness (p=0.032), which could be explained by the association between broader facial structures and dominance-related traits as proposed by Stirrat and Perrett.[26] Facial height positively correlated with conscientiousness (p=0.038), a finding supported by theories linking facial symmetry and structure to behavioral tendencies.[27]

In females, forehead length was significantly associated with conscientiousness (p 0.007), while cranial length showed a positive correlation with Intellect imagination (p=0.012). These associations suggest gender-specific pathways linking craniofacial morphology to psychological traits, potentially mediated by neurodevelopmental and genetic factors.[28] Studies by Zebrowitz et al. and Little et al. have highlighted associations between facial features and perceived personality traits, reinforcing the notion that craniofacial morphology can subtly influence personality expression or perception.[29,30] While our study aligns with these findings, the observed gender-specific correlations emphasize the need for considering sex as a moderating factor in such analyses.

A noteworthy observation is the lack of significant correlations for certain measurements like biparietal width and cephalic index with most personality traits. This absence of correlations could be hypothesized as these specific dimensions may not have a strong neurodevelopmental link to personality traits or may lack variability sufficient to influence psychological characteristics in meaningful ways. Further research could explore whether these measurements are associated with other non-personality-related biological or functional attributes. These findings resonate with literature suggesting that not all craniofacial dimensions are equally predictive of personality, indicating the specificity of trait-morphology relationships.[31]

Biological Basis of Observed Relationships: The biological basis of the observed correlations may be rooted in shared genetic and hormonal influences on craniofacial development and personality traits. For instance, androgens, which play a significant role in shaping male craniofacial features, are also implicated in traits like dominance and emotional stability.[32,33] Similarly, estrogen, which influences female craniofacial growth, has been linked to agreeableness and other affiliative traits.[34]

The neural crest hypothesis offers another explanation, positing that neural crest cells contribute to both craniofacial structure and brain development, potentially linking facial morphology with behavioral tendencies.[35] However, the precise mechanisms remain speculative and warrant further research.

LIMITATIONS AND FUTURE DIRECTIONS

While this study provides valuable insights, it is limited by its cross-sectional design, which precludes causal inferences. Additionally, the sample size, though adequate, may not capture the full variability in craniofacial and personality traits. Future research could adopt longitudinal designs to elucidate causal pathways and include more diverse populations to enhance generalizability. Exploring specific methodologies, such as multi-level modelling or genome-wide association studies, could provide deeper insights into the observed relationships. Additionally, focusing on underrepresented population groups, such as those from non-Western settings or indigenous communities, may help address current limitations and uncover novel associations.

CONCLUSION

This study highlights significant gender differences in craniofacial measurements and their associations with personality traits, providing valuable insights into the in-

terplay between physical and psychological characteristics. Traits such as conscientiousness and emotional stability showed strong correlations with specific craniofacial dimensions, emphasizing the biological and anthropological relevance of these findings. While some measurements lacked significant correlations, this underscores the complexity and specificity of trait-morphology relationships. The findings hold implications for forensic science, psychology, and anthropology. Future studies with longitudinal designs and diverse populations are essential to validate these associations, explore causal pathways, and deepen understanding of craniofacial morphology's role in personality traits.

Approval of Institutional Ethical Review Board: Approval of institutional ethical committee of the Jawahar Lal Nehru Medical College, DMIMS, Wardha, Maharashtra, India was obtained before the start of the recruitment.

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Individual Authors' Contributions: AS: Conception, design, data collection, analysis, manuscript; **VC:** Design, data analysis; **KVA:** Data analysis, manuscript; **AB:** Design, data collection, analysis, manuscript.

Availability of Data: All the data are available on request from the corresponding author. Send a request mail to the corresponding author to obtain data.

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