

Nasal Anthropometry as Predictor of Stature in Garhwal Uttarakhand: A Community Based Observational Study

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Abstract

Background: Human identification at the times of calamities becomes a challenging task for the forensic experts, especially when recovered bodies are in a state of mutilation. Stature plays an important role in identification of these unknown individuals. When other body parts are partially recoverable, estimation of stature from nasal parameters becomes important. So, it becomes necessary to find relation between nasal dimensions and stature, if it exists. Garhwal, Himalayas experiences disasters very often and owing to paucity of available research in this region, the present study was undertaken. **Material and Methods:** Multistage sampling was employed to measure males and females for their different nasal parameters and stature in all 15 blocks of Garhwal. Pearson's correlation coefficient was calculated using Statistical Package for Social Sciences {SPSS} with p-value taken significant at <0.05. Further, regression equation was designed for estimation of stature. **Results:** Statistically significant positive linear correlation was found between physiognomic nasal length and height in males. Regression equation for the same was formulated as $\text{Stature} = 153.11 + 0.303 \times \text{Physiognomic Nasal Length}$. To the contrary, no significant correlation was found between stature and other parameters in males and for all dimensions in females. **Conclusion:** The findings of this study suggests that in Garhwal Uttarakhand, stature has positive correlation with Physiognomic Nasal Length in males. However, it can be concluded that nasal parameters have low predictive value for stature estimation when used alone. The accuracy increases significantly when other body dimensions are used alongside. Hence, forensic experts should remain informed about this fact during personnel identification.

Keywords: Forensics, Correlation, Identification, Disaster, Regression.

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INTRODUCTION

Disasters all over the world are a major threat to the infrastructure and poses heavy toll on human and animal lives thus hindering the development gained after years of sustained efforts. Disaster can be in the form of cloud bursts, flash floods, landslides, earthquakes and forest fires along with conflicts between nations resulting in massive damage to the property and ecology of the area.^[1-3] This is when the mortality rate witnesses a steep rise and when National Disaster Management Authority comes into action. Besides rescue and stabilization processes, most efforts becomes directed towards disaster victim identification.^[4] Personnel identification becomes challenging when the full body is not recoverable and only altered and fragmentary remains are available.^[5-11]

Krogman in 1986 coined the term "Big Four" to establish identification of an individual, which includes sex, age, stature and race.^[11] Modern times have witnessed newer technological advances in the field of victim verification, like imaging techniques, DNA profiling, dactylography and anthropometry of different body parts including stature. This helps in narrowing down of investigations.^[12] Although, DNA profiling is the gold standard technique, but the

accessibility, availability and feasibility become a major limiting factor. This is when, identification by stature estimation finds its importance.^[7,13] A number of techniques are employed by the forensic anthropologists for stature estimation viz. bones. Femur is established to be best associated with height, as documented by Reddy NKS and Murty OP in their book titled "The Essentials of Forensic Medicine and Toxicology".^[12] However, finding intact bones is not always an easy task in such catastrophic situations. During these times, facial features including nose, ear, palate, cephalic and facial dimensions play an important role for calculating height and thus identity of an individual.^[8,14-20] The stature is believed to be thirty times the length of nose. A relationship is also found between length of thumb with that of

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nose and length of hand with face.^[21]

There exists a constant debate in the research world regarding the reliability of nasal anthropometry for height estimation. Sugavanam S and Chandran M in 2021 found nasal parameters to be reliable predictors for height.^[22] On the other hand, Elrewny NM et al. in 2023 has found insignificant association of nasal parameters with stature in Egyptian population. They formulated multiple regression equations for stature estimation with greater reliability from a mix of nasal and ear dimensions.^[23] Acharya S et al. has also validated that strength of association increases more when measurements of other body parts are also included.^[7] Stature estimation using nasal parameters shows gender and region-specific variations across different populations.^[4,10,19,24]

Other than forensic science, the use of nasal dimensions also finds significance in the field of Archaeology and Anthropometry.^[4,17,19,24] One of the most famous examples is of the Mummy project of Dr. Rosalie David at University of Manchester in 1972.^[25] They estimated the stature of the deceased using measurements of nasal aperture.

Garhwal Uttarakhand remains to be a culturally rich and racially distinct region which is very well represented by their physical appearance.^[26] It is located in Himalayan range, known for frequent natural disasters. History reveals repeated earthquakes and flash floods in this region with landslides becoming a part of daily life.^[27] Human activities to some extent can be held responsible for the devastating episodes witnessed. Kedarnath tragedy was one of the most recent catastrophic events faced by the mankind which emphasize the significance of individual level profiling. In this regard, there is a need to document the anthropometric database specific to the natives of this region.^[4,8,28] Limited studies are documented for stature estimation using facial measurements.^[29] So, the present study was intended to find an association between stature and different nasal parameters.

MATERIALS AND METHODS

A cross-sectional observational study was conducted in the Garhwal Uttarakhand, using a community-based approach. Approval from Institutional Ethics Committee was obtained prior to the commencement of the study {MC/IEC/2024/41 dated- 01/07/2024}. Sample size of 246 was calculated using the standard deviation of 0.2 from a reference study of Mukherjee AA et al.^[30] Multistage sampling technique was employed for the selection of the participants of age 18-40 years for the study. Sample size was distributed among 15 blocks of Garhwal region of Uttarakhand and were further divided into 6 age-groups with representation from both the

sexes.

Individuals having suffered any injury, undergone surgery of head and neck region, nasal deformities, congenital problem,^[6,15] or having multiple piercings of nose,^[31,32] were not included in the research.^[17,18,24,33,34] All the volunteers were made aware about the study and their written, witnessed consent obtained. Stature was measured using a metallic measuring tape,^[22] {least count of 0.1cm} with participant in anatomical position. Nasal parameters were measured with subject's face relaxed,^[11,35] and positioned along Frankfurt horizontal plane.^[10,14,18,36-38] Physiognomic nasal height and length, nasal breadth and depth were assessed using digital Vernier callipers,^[10,17,18,26,30,39] {least count 0.1mm} as shown in Fig 1 {1: Glabella as mid-point between two eyebrows; 2: Sub-nasale point of intersection of columella and philtrum; 3: Pro-nasale anterior most point on tip of nose; 4,5: lateral most point of two alae. A: Physiognomic Nasal height {PNH} distance between glabella and sub-nasale,^[40,41] B: Physiognomic Nasal length {PNL} distance between glabella and pro-nasale,^[42] C: Nasal breadth {NB} distance between lateral most point of two alae,^[4,16,17] D: Nasal depth {ND} distance between pro-nasale and sub-nasale,^[13,24] and E: Stature {S} distance from Vertex to Heel.^[6,7,10]

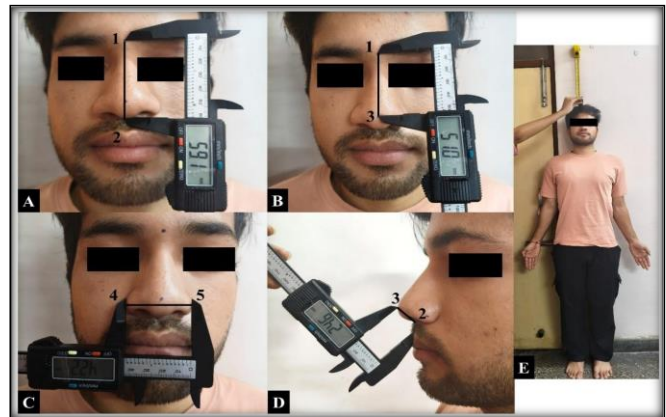


Figure 1: 1: Glabella; 2: Sub-nasale; 3: Pro-nasale; 4,5: lateral most point of two alae. A: Physiognomic Nasal height; B: Physiognomic Nasal length; C: Nasal breadth; D: Nasal depth; E: Stature.

The collected data was then analysed using Statistical Package for Social Sciences. Pearson's correlation coefficient was assessed between stature and physiognomic nasal height and length, nasal breadth and depth.

RESULTS

Correlation coefficient between stature and various nasal variables are illustrated in [Table 1] and shown in [Chart 1].

Table 1: Correlation coefficient between stature and nasal variables.

Variables	Total		Male		Female	
	r	p-value	r	p-value	r	p-value
Physiognomic Nasal Height	0.280	<0.05	0.152	>0.05	0.118	>0.05
Physiognomic Nasal Length	0.239	<0.05	0.198	<0.05	0.163	>0.05
Nasal Breadth	0.512	<0.05	0.148	>0.05	0.043	>0.05
Nasal Depth	0.341	<0.05	0.068	>0.05	-0.042	>0.05

r: Correlation coefficient; p-value<0.05: Significant.

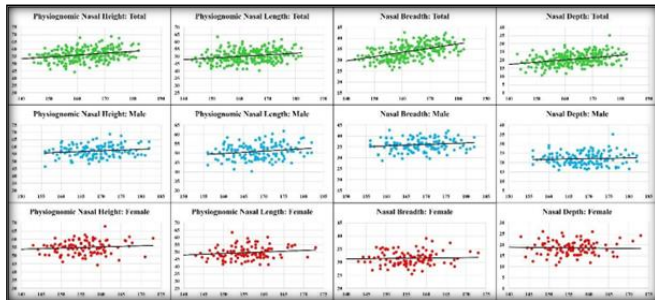


Chart 1: Correlation between stature and nasal variables.

All nasal variables revealed significant correlation with stature in total sample population. However, no statistically significant correlation was found when assessed for the two genders separately.

Physiognomic nasal length exceptionally showed significant positive linear correlation with height in males. Thus, simple linear regression model was developed to estimate stature from physiognomic nasal length in males {PNLM}. $S=153.11+0.303 \times \text{PNLM}$, Standard error of estimate {SEE}=6.02, Coefficient of determination $\{R^2\}=0.039$, $p\text{-value}<0.05$.

DISCUSSION

The results of the present study concludes that estimation of stature from PNL is a feature of sexual dimorphism. This could be explained by the fact, that males exhibit relatively higher values for almost all body dimensions than females owing to the effect of androgens. This may have forecasted the relation that never truly existed in nature. These findings are in accordance with the observations of Elrewieny NM et al.^[23] Similarly, Lukpata PU et al. in 2016 studied association of stature with different nasal parameters in Ogoja, Nigeria and did not find any significant correlation. Hence, they opined that nasal dimensions when used alone have limited predictive value in estimating the stature of an individual.^[43] In contrast, Kamdar RS and Babu YK in 2016 researched South-Indian population with 25 males and 75 females. They formulated regression equations $\{Y=3.004 \times \text{NB} + 151.448\}$ {in cm}; $R^2=0.010$ from nasal breadth and $\{Y=5.325 \times \text{ND} + 155.582\}$ {in cm}; $R^2=0.049$ from nasal depth. They concluded that these formulae could reliably be used to estimate height from nasal parameters of an individual.^[13] Similarly, Malviya SK et al. in 2024 investigated 100 males and 100 females in Karnataka and authenticated the association of nasal breadth with stature $\{r=0.207$ in males, $S=153.758+3.875 \times \text{NB}$, $\text{SEE}=6.76$ and $r=0.122$ in females, $S=144.099+2.261 \times \text{NB}$, $\text{SEE}=6.27$. Simultaneously, they also suggested that correlation becomes strong when other parameters are combined.^[8] Safak NK et al. in 2023 studied Turkish population and also concluded significant moderate positive correlation of stature with nasal width and depth.^[24] On the same lines, Sugavanam S and Chandran M derived multiple regression equations for various nasal parameters for calculating stature $S=150.157+6.020 \times \text{NW} \pm 7.026$ $\{r=0.404\}$ in males and $S=142.356+3.684 \times \text{NW} \pm 4.624$ $\{r=0.356\}$ in females.^[22]

Vijay RR and Modi V in 2023 also found positive correlation with nasal width $r=0.084$, $Y=161.03+1.8 \times \text{NW}$, $\text{SEE}=6.78$ in males and $r=0.142$, $Y=144.12+2.6 \times \text{NW}$, $\text{SEE}=6.63$ in females with significant p value in females only.^[9] Similarly, Adefisan IE et al. in 2021 conducted a study on 217 males and 151 females and revealed highly significant correlation only in females. Hence, they necessitated population specific models for stature estimation using nasal variables.^[20]

Dhirubhai VR and Jayantilal MP in 2018 conducted a study in Gujarat with nasal parameters and validated nasal breadth to be significantly correlated with stature $\{r=0.188$ for males and $r=0.124$ for females}. They also formulated regression equations $S=154.305+3.544 \times \text{NB}$ {males} and $S=143.265+2.351 \times \text{NB}$ {females} for the same. They also concluded that stature estimation from nasal parameters follows region and gender specificity.^[15] Shreshtha RN et al. in 2016 found positive correlation of stature with nasal height in both males $\{r=0.18\}$ and females $\{r=0.19\}$. Regression equation in males was found to be $S=148.22+3.02 \times \text{NH}$ and in females $S=133.01+3.12 \times \text{NH}$. With this they opined that nasal height can be used for estimating stature in Nepalese population.^[44]

Agnihotri AK et al. in 2011 studied 75 males and 75 females belonging to Indo-Mauritian ethnicity. They found weak to moderate positive correlation between different cephalo-facial measurements and height, indicating its limited predictive value. Their key predictor came out to be nasal breadth and thus concluded that cephalo-facial dimensions are unreliable for stature estimation when taken alone.^[45] This is in agreement with the findings of the present study for Garhwali population.

CONCLUSION

This study demonstrated linear nasal parameters to be unreliable predictors of stature in Garhwali population. However, it appears that when used in conjunction with other anthropometric variables, their reliability could increase for stature estimation and thus, establishment of identity of victims during mass destruction and crime scenes. Hence, they have limited utility in forensic identification when used alone.

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Conflicts of interest

There are no conflicts of interest.

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