Innovations

Exploring the Human Facial features: A Nasofacial Analysis with Elevation using Rhinobase software

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Abstract: *The human face is a canvas of cultural and geographical expression. It is a representation of nature, culture, history, and beliefs. From the shape and size of our eyes to the contours of our noses and lips, each human face has a unique combination of traits that may indicate a person's personality, culture, and origin. Asians have a wide range of anatomical features. The creation of the human body is shaped by the environment which comprises climate, geography, and resource availability. Over several centuries, people may adapt to the circumstances where they live. Various geographical factors influencing the human face are elevation, temperature, climate, and precipitation. This study determines the correlation of nasofacial features of female students from different parts of India. By taking the zoom-in photograph of a female student, the photographic analysis of the frontal profile of the student is analysed using the Rhinobase software. Further, the data wasanalysed using IBM SPSS Statistics 20 software. The correlation between the nasofacial parameters and elevation is examined using Pearson's Correlation. Principal Component Analysis (PCA) is calculated using R Software. The result shows a positive significant relationship between the nasofacial parameters (LFH, ULL, SM) (MFH, AL-AL, EN-EN, and X-X) (WD-WD and UFH).*

Keywords*: Nasofacial, Environmental Determinism, Altitude, Rhinobase, Correlation*

Abbreviations- Lower facial height (LFH), Upper lip length (ULL), Chin vertical (SM),Middle facial height (MFH), Interalar width (AL-AL),Intercanthal width (EN-EN),Base bony width (X-X),Dorsum width (WD-WD), Upper facial height (UFH).

Introduction

Humans are a byproduct of Mother Earth where she has a biological laboratory of nature to raise her child wisely. She provides habitat to each of her child according to the climatical conditions in with they live. In her book *Influences of Geographic Environment* (1911), *Ellen Churchill Semple* explains Mother Earth provides the iron-rich leg muscles needed to climb the mountain slopes from her biological environment laboratory. She gave vigorous arms and chest to hold a paddle for a person who lives across the river valley (Semple, 1911).*Al-Masudi* correlated humans with nature and concludes the earth's power influences man differently with the three factors i.e., water, native plants, and landscape (Hussain, 2015) The creation of the human body is influenced by the environment, which includes climate, geography, and resource availability. Over several centuries, people may adapt physiologically to many circumstances in the environment where they live. The diversity in the topography, climate, and environment changes the structure of the human body focusing on the human face (Majumder, 1998; Rajlakshmi, 2012)

Given their deep interest in environmental factors and spatial patterns, geographers have long studied how physical environments shape the traits of humans. Among the many ideas that make up geographic philosophy, geographical determinism is one of the most well-known lenses through which to examine the connection between human qualities and location. According to this viewpoint, the physical environment is crucial in determining a population's look along with its behavioural and cultural characteristics. Geographers have examined the geographical factors that influence human physical variety, ranging from the effects of temperature on skin pigmentation to the adaption of nasal characteristics to varying elevations. In *environment determinism*, human growth, and cultural patterns are predetermined by the natural world. For example, an isolated island nation from the continent would give rise to distinctive cultural characteristics. The natural world is sacred and has a powerful energy that should be respected. By obeying nature, humans can conquer it. When people first arrived on Earth, the ecosystem began to change and adapt to accommodate them (Hussain & Kumawat, 2017)

Geographers accept cultural ecology, a viewpoint that emphasizes the mutual interdependence between human cultures and their environment, in addition to geographical determinism. Understanding cultural behaviours connected to body alteration, decoration, and aesthetic preferences is crucial when analyzing the geographical variety of face characteristics in the context of nasofacial analysis. The human face is a cultural canvas that is etched with the values, customs, and conventions of society. Through the integration of cultural ecology into the study of nasofacial traits, geographers advance a comprehensive knowledge that goes beyond physical adaptations.

The understanding of human variation and the processes that determine human facial characteristics are enhanced by nature. Historically, the main areas of study for a geographer have been the geographical distribution of human populations and the environmental variables affecting physical attributes. Within the field of geographical theory, the human face is transformed into a geographical terrain that is influenced by both cultural and natural factors. Geographical determinism is the theory that the physical environment influences human traits. Geographical researchers have examined the complex relationships between physical characteristics and location, ranging from the effects of height on respiratory adaptations to the influence of temperature on skin colour.

Human beings are influenced by the surroundings in which they live in terms of their biological, cognitive, and ethical habits. Earth is composed of two elements: nature and all of its creatures. Humans live on the Earth's surface, which is also a part of the natural world. The natural environment can often be recognized as the face of the globe, the eye of a hurricane, the mouth of a river, the nose of an iceberg, the neck of a gulf, and the soil profile. A naturalized human pays attention to the natural world, respects it, and is terrified of its vengeance (Hussain & Kumawat, 2017)

The human face is a canvas of cultural and geographical expression. It is a representation of nature, culture, history, and beliefs. Faces from many parts of the world have different characteristics. The environment, including factors like climate, altitude, precipitation, and exposure to the sun, shapes the physical features of the face, such as the curve of the nose, the size of the eyes, or the curvature of the lips. Numerous characteristics, such as age, gender, body type, and personality, affect facial analysis (Ridley et al., 2016).

Strabo, Plato, and *Aristotle* explained the reason Greeks were so much more advanced than cultures in colder or hotter climates at such an early age. Aristotle also provided his climatic categorization, which clarified why so few people choose to live in some parts of the world. Different skin colors have their origins in environmental conditions, according to East African writer *Al-Jahiz*. He thought that the black basalt rocks that are so common on the Arabian Peninsula are the reason why many Africans, as well as many different birds, animals, and insects, had darker skin tones.

In his *Muqaddimah* (1377), *Ibn Khaldun* clarified that the darker skin tones of humans are not a result of their ancestry but due to the environment of Sub-Saharan Africa. He refuted the myth of the Hamitic hypothesis, which holds that the son of Ham was cursed because he was black. He described the distinctions between various peoples in terms of their physical surroundings, climate, land, food, and means of subsistence, as well as their cultures and beliefs (Hussain & Kumawat, 2017)

Every part of the world has unique physical traits that set its features apart. The diversity in the topography, climate, and environment changes the structure of the human body focusing on the human face (Majumder, 1998) From the high cheekbones of East Asia to the prominent brow ridges of Africa, every individual has distinct physical characteristics that make their faces stand out. There is an incredible way nature shapes a variety of organisms and the human face on a geographical basis.

Karl Mackey describes the intimate relationship between soil, plants, and an animal's or human's structure and health. He cites the Shetland pony case- The world's tiniest horses, barely three feet tall, are found on the Shetland Islands. Before a businessman started to raise these ponies in the United States to serve the American market, they were thought to be a distinct race of horses. Much to their dismay, ponies raised in the new American circumstances grew bigger and bigger until they reached the same stature as other racehorses (Hussain, 2018)

Natural selection has played a significant role in the evolution of the human body, allowing the necessary traits that increase survival through the generations. The natural environment including resources, climates, and landscapes has a significant role in influencing these adaptations. For example, in response to the challenges of their environment, they needed to manage across the rough terrain and adjust to shifting ecological conditions, and early humans acquired a variety of physical features, including bipedalism, opposable thumbs, and a massive brain.

Ratzel, in his book *Anthropogeography*, described Human geography as the comprehensive study of the interaction between human societies and the surface of the globe. According to *Ellen Churchill Semple*, human geography studies the evolving interaction between the restless man and the unstable earth. According to *Vidal de la blache*, a more comprehensive understanding of the relationships between the living things that inhabit our planet and the physical laws that control it is gained by studying human geography. The study of the nature and distribution of the relationships between the physical environment, particularly the climate, and the traits and behaviours of people is what *Elsworth Huntington* refers to. The study of geography examines the affinity between a people's fate and the characteristics of their nature(Hussain, 2018)

Anthropometry is the study of the assessment of the physiological features and characteristics of the human body using scientific methods and techniques which help in the observation and measurements of a living human body and a non-living skeleton (Choudhary & Choudhary, 2012; Poswillo, 1975). It is a technique that aids in studying the various physical characteristics of the human body and is of enormous interest to scientists who've been fascinated by the variation in the human body as it helps in studying the ancestors over the years (Eickstedt, 1927) Indonesia has diverse cultures, tribes, and races. Ecological, geographical, racial, age, and gender factors can influence the physical dimensions of the human body measured by physical anthropometry (Marini et al., 2020)

Anatomically and morphologically, different sexes, cultural backgrounds, and ethnic origins have different noses, and they all relate to the face differently (Moss et al., 1987; Uzun & Ozdemir, 2014) The nose, a prominent feature in the nasofacial area, is exposed to natural influences and transforms into a geographical terrain. The idea of environmental adaptation is especially pertinent when studying the morphology of the nose. For example, individuals living in diverse regions could have varied nasal characteristics as a result of adaptations to the local humidity and temperature. Nasal passage dimensions, length, and formall important components of respiratory healthmay exhibit regional differences that are a reflection of the selective forces exerted by various settings. The nose is the face's supporting structure due to its central location; any abnormality is likely to be recognized, making it a significant visual aspect. In addition to serving the purpose of breathing, it also aids in defining a person's racial features and endows the face with an appealing trait (Chatrath et al., 2007)

Asian people differ in their physical characteristics. Numerous studies use these variations in physical traits as a guide to determine the relative worth of each face profile from various geographic areas (Jang, 2016) The study by Gao et al. has compared aesthetic measures of four facial features (overall facial form and proportions, eyes, nose, lip, and chin) between Caucasian and East Asian women. Even though Western culture has influenced aesthetic standards over time, Asian women still choose to maintain their ethnic identities by enhancing their Asian traits rather than westernising their looks (Djosan et al., 2022)

There are two methods for evaluating the nasal morphometry, direct and indirect. The direct method includes physical efforts for taking the measurements. The instruments used are the vernier calliper, ruler, and sliding calliper. This method has several benefits, including simplicity, precision, and low equipment costs, but it also has some drawbacks, including time consumption and the need for suitable training and expertise (Farkas et al., 1993; Liou et al., 2004)The indirect method includes photogrammetry, cephalometry, stereo photography, laser scanning, and computerized tomography for measurement (Baumrind & Frantz, 1971) The inability to recognize soft tissue landmarks is this method's fundamental flaw. The most common technique used in medical centres for anthropometric measurements is photogrammetry, which depends on the interpretation of the images (Meruane et gal., 2016)

The area around the nose and its auxiliary characteristics is the nasofacial region. Geographically, the nose acts as a portal for respiratory adjustments to different climates, affecting the dimensions and form of nasal passageways. Culturally, the nose has served as a medium for cultural expression, with many tribes imbuing nasal features with symbolic significance. To further exploration of the nasofacial part of the face, our research uses Rhinobase, a facial analysis software. This nasofacial analysis's use of regional lenses has the potential to reveal fresh perspectives on the intricacies of the human variety.

In this study, indirect anthropometric analysis was performed using the Rhinobase software. It is a photogrammetric software used for facial analysis to gather comprehensive data on the nasofacial anthropometric parameters. Rhinobase is an innovative, all-inclusive software for rhinoplasty that makes it easier to store and retrieve patient data, acts as a self-assessment and educational tool to guide surgeons of all experience levels through the art and science of the procedure, makes facial analysis simpler for surgeons, and archive patient images within the database (Apaydin et al., 2009)

Database and Methodology

The primary source of the data serves as the sole foundation for this study. A total of 100 female samples collected aged 18-22 using a random sampling technique. The photographs of the subjects' frontal profiles were taken from a distance of 2 meters using a standard camera and were adjusted accordingly to the subject's height. The subjects were instructed to maintain a normal and natural look to avoid rotations while their eyes were completely open and level, their lips were closed with no smile, and their ears were in a symmetrical pattern. The study includes only those without face surgery or facial fractures. Samples that satisfied the requirements were marked with photographic analysis.

Rhinobase Software

Rhinobase software is a database for facial analysis using the photographs of the frontal and lateral profiles of the subjects. The Rhino base software was then used to examine all of the metrics. It is a tool used in comparing and analyzing digital photographs for study. Users may compare, visualize and analyse the data from the photo, and spot patterns and trends. It also creates reports and visualizations for understanding the outcomes of the study. The landmarks are marked on the images when calibration using the ruler in the photograph, which enables automatic compute necessary measurements.

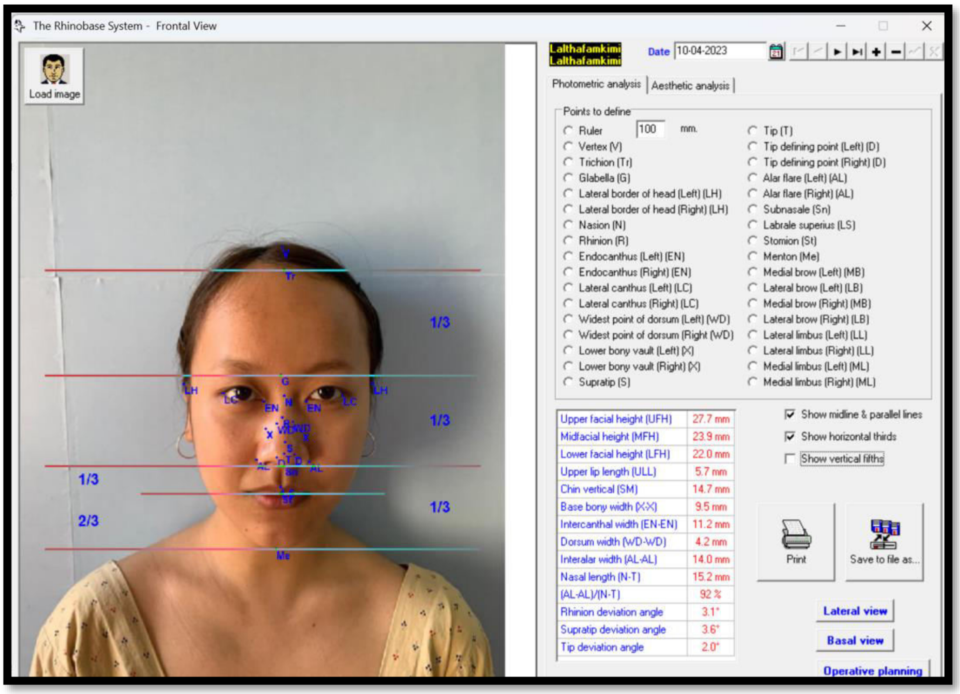


Figure1- Photographic analysis of a subject in Rhinobase Software

Nasofacial Analysis

The nasofacial parameters used for the analysis were: Trichion (Tr), Glabella (G), Nasion (N), Endo canthus (EN), Lateral Canthus (LC), Nasal Tip (T), Alar Flare (AL), Subnasale (Sn), Labrale superius (LS), Stomion (St) and Menton (Me). A detailed description of these nasofacial parameters is given in Table-1. The nasofacial measurements that the Rhinobase software calculated are: Upper facial height (UFH), Middle facial height (MFH), Lower facial height (LFH), Upper lip length (ULL), Chin vertical (SM), Intercanthal width (EN-EN), Interalar width (AL-AL) and Nasal length (N-T). The nasofacial anthropometric parameters used in the software is described in table-1. The nasofacial measurements obtained while calculating is shown in table-2.

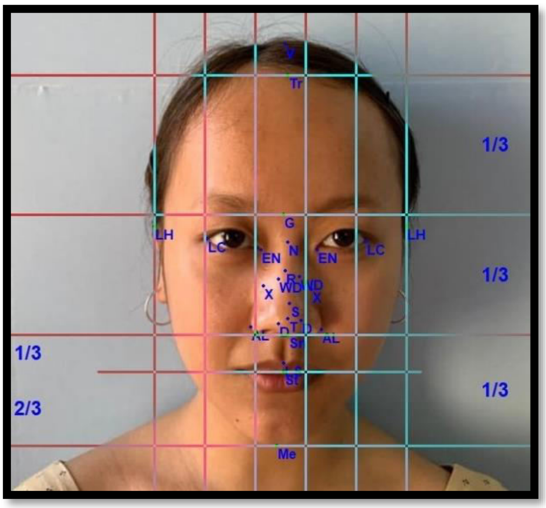


Figure2- Photometric analysis of a subject

Parameter	Descriptions
Trichion (Tr)	Anterior hairline in the midline
Glabella (G)	Most protruded point of the forehead in the mid-sagittal plane
Nasion (N)	The midline bony depression between the eyes where the frontal and two nasal bones meet
Endo canthus (EN)	The point at which the inner ends of the upper and lower eyelid meet.
Lateral Canthus (LC)	The lateral confluence of upper and lower eyelid margins.
Nasal Tip (T)	Point of maximum anterior projection of the nose on the lateral view
Alar Flare (AL)	A common feature that contributes to the width of the lower third of the nose
Subnasale (Sn)	Point where the columella merges with the upper lip in the sagittal plane
Labrale superius (LS)	The midpoint of the vermilion line of the upper lip
Stomion (St)	Point at which the upper and lower lip make contact
Menton (Me)	Most inferior midline point on the inferior border of the chin

Table 1 - Nasofacial anthropometric parameters

Measurements	Descriptions
Upper facial height (UFH)	Distance between trichion and glabella
Middle facial height (MFH)	Distance between glabella and subnasale
Lower facial height (LFH)	Distance between subnasale and menton
Upper lip length (ULL)	Distance measured from subnasale to the inferior border of the upper lip
Chin vertical (SM)	Distance between stomion and menton
Intercanthal width (EN-EN)	Distance between right and left medial cantus
Interalar width (AL-AL)	Widest distance between the alar bases
Nasal length (N-T)	Distance between nasion and nasal tip

Table 2- Nasofacial measurements

Further, the values were analysed using *IBM SPSS Statistics 20 software*.Initially, mean and standard deviation is calculated and then all values were correlated using Karl Pearson's correlation method. And scatter plot graph is also created of the values which are significant to elevation.Principal Component Analysis (PCA) of all the nasofacial parameters is calculated in R software. It plots the graph of individuals, creates Biplot and scree plot that helps determine the data.

Data analysis and Data Interpretation

The calculated mean and standard deviation of each variable is shown in table-3. The maximum mean of 20.07 is of mid facial height while the minimum mean is of dorsum width that is 4.035. The nasal length has the maximum standard deviation of 12.68 and minimum standard deviation is 0.77 of dorsum width.

Parameters	Maximum	Minimum	Mean	Standard Deviation
Upper facial height	28.5	11.4	18.714	2.91
Mid facial height	28	10.8	20.07	2.64
Lower facial height	29.1	8.7	18.76	3.51
Chin vertical	7.4	1.9	4.151	1.08
Upper lip length	19	3.5	12.506	2.56
Base bony width	9.7	4.6	6.9132	0.98
Inter canthal width	14.9	6.3	10.218	1.21
Dorsum width	6.1	2.3	4.035	0.77
Interalar width	18.4	8.9	13.2552	1.68
Nasal length	17.6	5.8	13.773	12.68

Table 3- Nasofacial anthropometric measurements (in mm) of the females

The value of Karl Pearson's correlation coefficient and its significance at 0.05 confidence level is shown in table-4. The correlation of all nasofacial anthropometric measurements is calculated with respect to elevation. The base bony width has correlation of 0.199 with elevation and has 0.048 of the significance value with 2 tailed tests.

	Karl Pearson's Correlation
Elevation	1
Upper facial height	0.08
Mid facial height	0.022
Lower facial height	-0.135
Upper lip length	-0.146
Chin vertical	-0.08
Base bony width	0.199*

Inter canthal width	0.068
Dorsum width	-0.034
Interalar width	0.031
Nasal length	-0.081

Table 4- Karl Pearson's correlation and significance values with respect to elevation

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

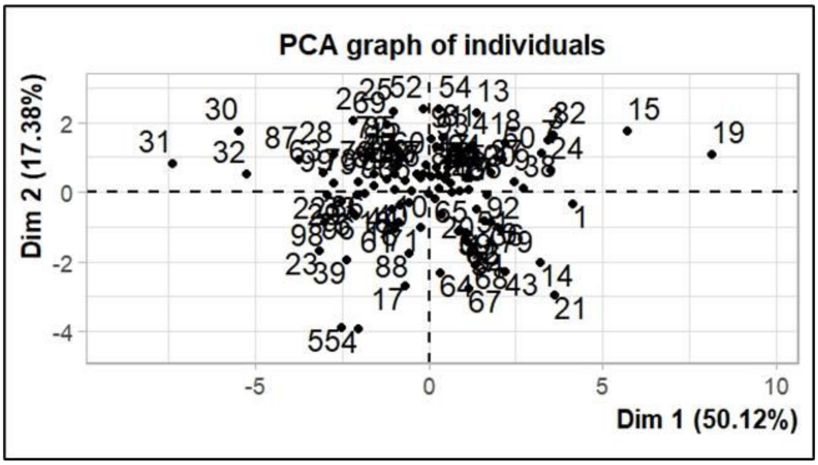
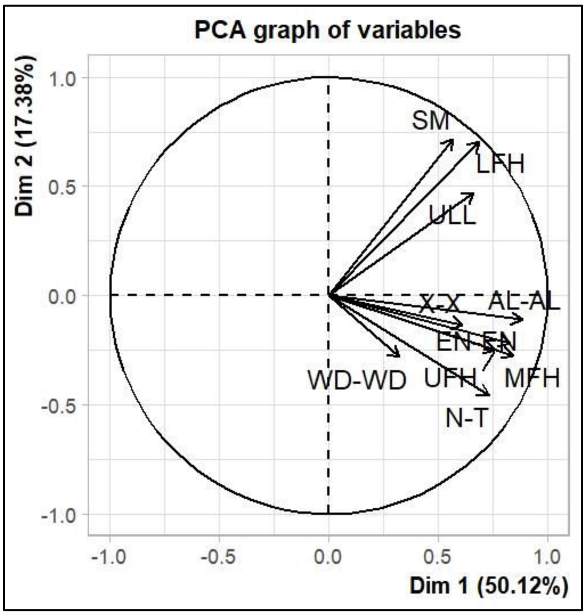


Figure 3- Principal Component Analysis (PCA) graph of individuals

The PCA graph of individuals on 2D space defined by Dim 1 and Dim 2 is described in figure-3. Most of the points are clustered near the coordinate (0,0) which do not significantly differ in characteristics and are average individuals with similar profiles. Those observations which are far (**15, 19, 55, 4, 30, and 31**) from origin indicates the significant deviation from the majority in terms of the characteristics



Legend

Upper facial height (UFH)

Middle facial height (MFH)

Lower facial height (LFH)

Upper lip length (ULL)

Chin vertical (SM)

Intercanthal width (EN-EN)

Interalar width (AL-AL)

Nasal length (N-T)

Figure 4- Principal Component Analysis (PCA) Biplot

Principal Component Analysis (PCA) biplot that shows the correlation between multiple variables shown as a vector in above figure-4. Longer the vector, higher is their importance in explaining the variability. SM, LFH and ULL are the important variables of PCA.

Correlation	gle between vectors	Variables
Positive Correlation	Acute Angle (<90°)	• LFH, ULL, SM MFH, AL-AL, EN-EN, and X-X • WD-WD and UFH
Negative Correlation	Opposite direction (180°)	• UFH and N-T WD-WD and LFH, SM, ULL
Weak or No Correlation	Right Angle (90°)	• WD-WD and LFH or SM • UFH and LFH or SM

Table 5- Principal Component Analysis (PCA) Correlation between Nasofacial Parameters

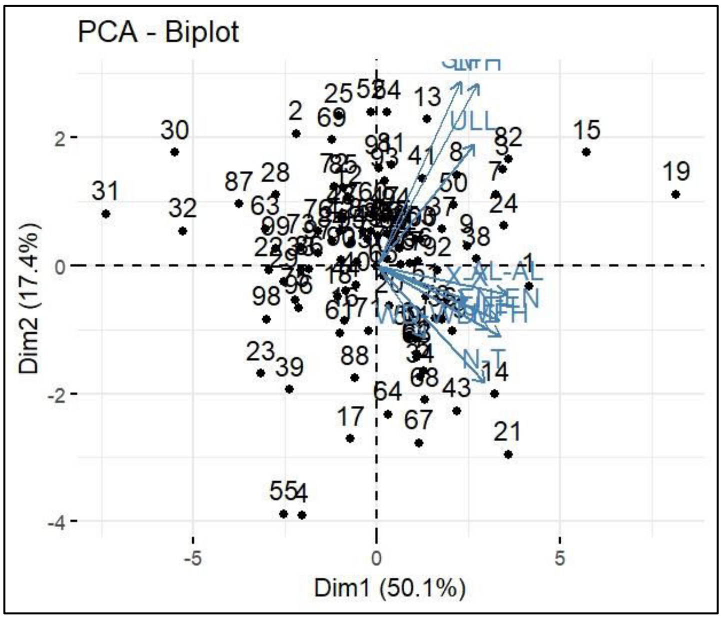


Figure 5- Principal Component Analysis (PCA) Loading plot

1. **Small angle between vectors**

a. LFH, ULL, SM share a common trend and closely aligned variables indicating the positive correlation.

b. MFH, AL-AL, EN-EN, and X-X are grouped together and are aligned closely indicating strong correlation.

c. WD-WD and UFH are positively correlated but dur to shorter vector length the correlation between them is weak.

2. **Vectors in opposite direction**

a. UFH and N-T shows negative correlation as if the one increases, other is likely to decrease.

b. WD-WD is in opposite direction to LFH, SM, ULL that shows a negative correlation as their vector are in opposite direction.

3. Vectors at right angle

a. The angle between WD-WD and LFH or SM is 90° indicating a little to no correlation between them.

b. UFH and LFH or SM has no significant relationship among them.

Dim 1 is the dominant factor with the variability of 50.12%. Variables such as MFH, AL-AL, X-X, EN-EN, and N-T are aligned with Dim 1 showing their variance is strongly explained by this principal component. Dim 2 has variability of 17.38% where LFH, SM, and ULL contribute more to second component. This shows that their variable differs from variables of Dim 1.

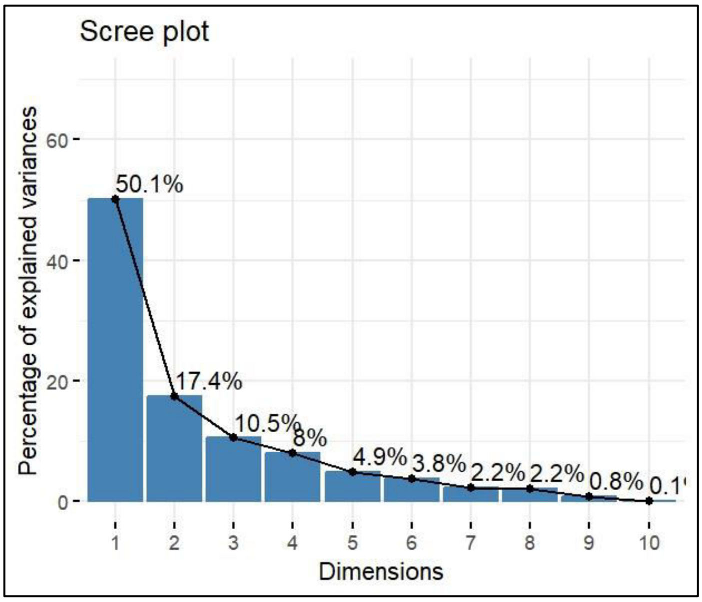


Figure 6- Principal Component Analysis (PCA) Scree Plot

The Scree Plot is a visual representation of proportion of variance explained by Principal component (PC). The X- axis represents the principal components (PC) from 1 to 10 where each component an independent linear combination of the original variables. Y-axis represents the total variance in percentage of the data by each principal component and the bars represents the variance explained by each principal component. The line plot is a connecting point that shows how the variance accumulates as more components are included.

The first principal component (PC1) is the largest contributor that shows 50.1% of the total variance, the second principal component (PC2) is 17.4% of the variance and together sums as **67.5%** which is a substantial proportion. The elbow point is the point where variance starts dropping at PC3 where variance is 10.5% which shows the first, second and third PCs are most important for apprehending the structure in the data. After PC3 the variance decreases abruptly and contribute less than 8% that represents the least importance of the data.

PC1 +PC2 +PC3 = 78.0% (includes maximum variance)

And on including PC4 and PC5 the total is 90.9%. Thus, PC1 and PC2 explains majority of the variance of the data.

The heat map or correlational matrix depicts the correlation coefficient between the parameters, represents how they are related to one another. The relationship between the variables is indicated using colour ranging from -1 (red) to +1 (blue). Red shows a strong negative correlation while blue shows a strong positive correlation between the parameters. UFH, MFH, LFH and ULL have strong positive correlation. NT shows a strong correlation with UFH. EN-EN has moderate positive correlation with UFH, MFH, and LHF while SM and XX has weak or no correlation showing them as an independent factor.

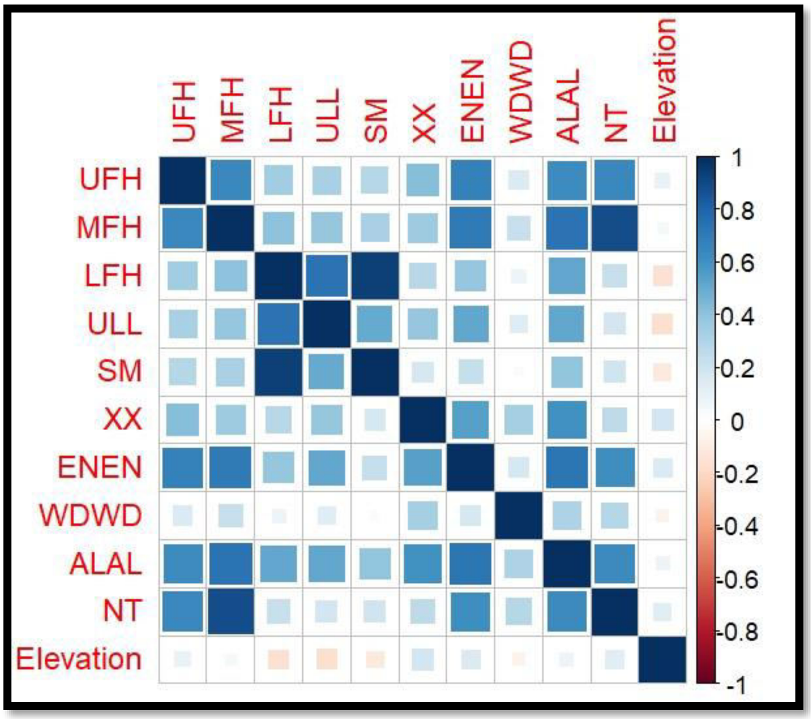


Figure 7- Correlational matrix of Nasofacial parameters and Elevation

The study examines the nasofacial characteristics, and their relationship with elevation indicates a striking relationship. The upper face length is represented on the y-axis, while elevation is shown on the x-axis. The scatter plot shows how the upper facial length varies at different heights. Notably, the Madhya Pradesh area has the highest upper face length measured in the research, which was 28.5mm. On the other hand, Uttar Pradesh has the lowest upper face length, at 11.4 mm. These opposing extremes highlight how elevation influences the nasofacial characteristics. The scatter diagram highlights the importance of considering geographic variations in facial morphometry into account with the wider context of nasofacial research by graphically illustrating the complex nature of the relationship.

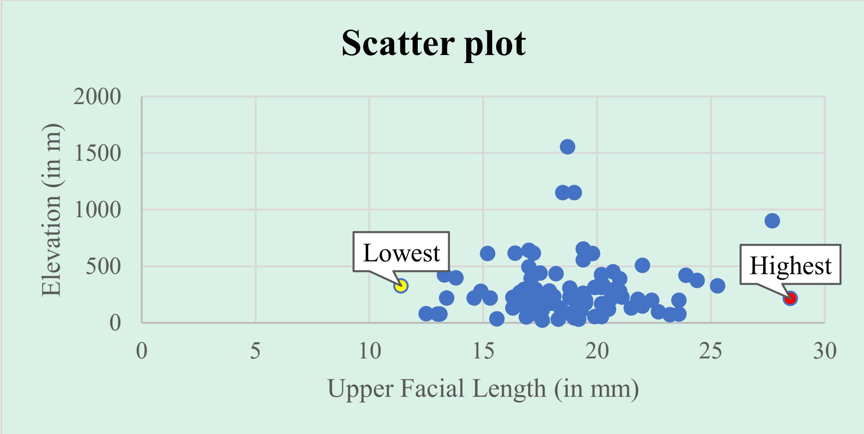


Figure 8- Scatter plot of elevation and upper facial length

A comprehensive scatter diagram, with elevation on the x-axis and mid-facial length on the y-axis, illustrates the correlation between elevation and nasofacial characteristics and the research findings. The impact of regional parameters on mid-facial height is the distinctive characteristic depicted in Figure 2. Gujarat had the highest mid-facial length, which is 28 mm. On the other hand, Uttar Pradesh has the lowest mid-facial length, measuring 10.8 mm. These striking differences highlight how location affects nasofacial features, and the scatter diagram provides an invaluable visual representation of the complex interaction between elevation and mid-facial characteristics.

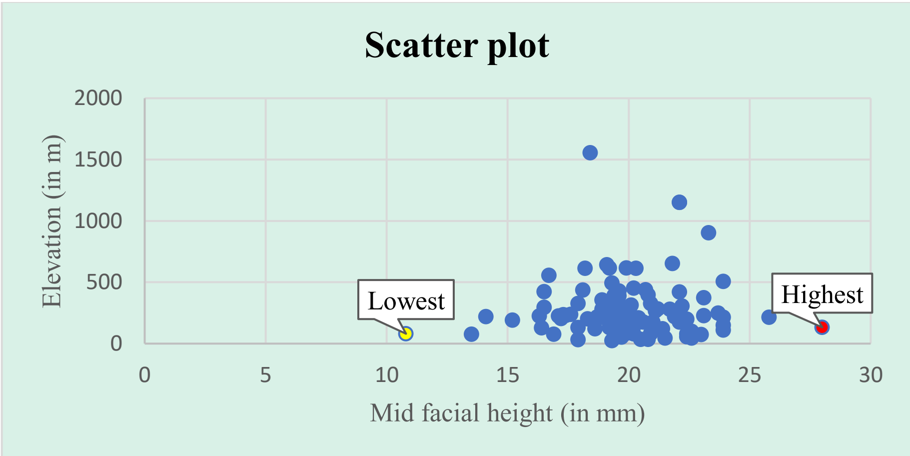


Figure 9- Scatter plot of elevation and mid facial length

The scatter diagram provides an easy-to-understand visual representation of the research data in understanding the intricate connection between elevation and nasofacial characteristics. The diagram's x-axis indicates elevation, while its y-axis clarifies lower face length. The scatter plot shows clear patterns in the lower face lengths at various heights. The data reveals that Arunachal Pradesh has the highest face length measured in the survey, measuring an astounding 28mm. Rajasthan, on the other hand, has the shortest lower face length, measuring in at a very small 10.8mm. These significant differences highlight how much geographic location influences nasofacial traits and the scatter map illustrates how variation in elevation affects facial measurements.

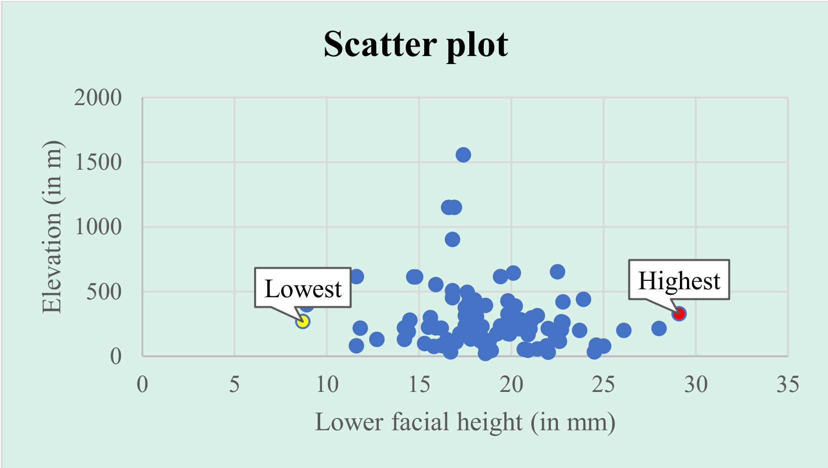


Figure 10- Scatter plot of elevation and lower facial length

The findings of this research provide an overview of the complex interactions between elevation and nasofacial factors in the form of a scatter diagram. The diagram's x-axis shows the elevation, and the y-axis shows the upper lip length. The scatter plot reveals patterns in the size of the upper lip at different elevations with significant differences that highlight the influence of geography on nasofacial features. With an astonishing 7.4mm, Arunachal Pradesh has the highest upper lip length for the research. Jaipur has the shortest upper lip length, at a relatively low 1.9 mm. These sharp differences highlight the complex correlation between elevation and certain nasofacial features.

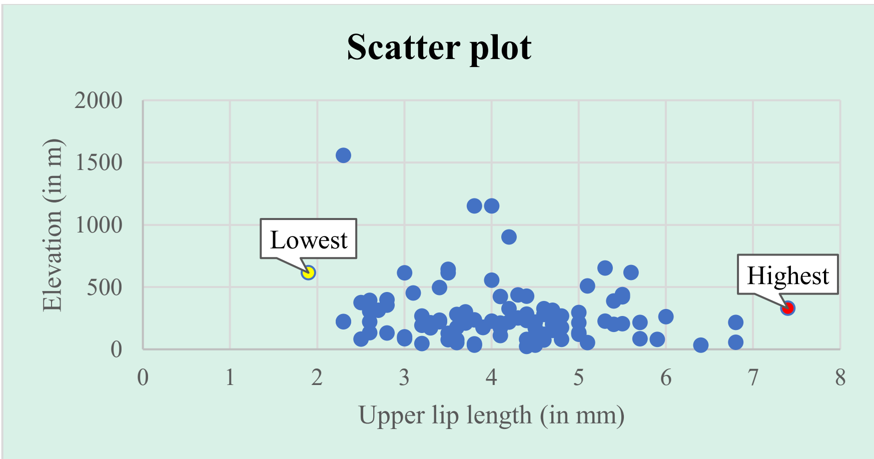


Figure 11- Scatter plot of elevation and upper lip length

The results of this research are illustrated in a scatter diagram, as shown in Figure 1, where the elevation is plotted on the x-axis and the chin vertical values are depicted on the y-axis. This figure illustrates variations in the vertical dimensions of the chin at different altitudes, providing insight into the complex effects of location on nasofacial traits. The data indicates that Arunachal Pradesh has the highest chin vertical measurement, at an astounding 19mm. Delhi, on the other hand, has the smallest vertical chin measurement, at only 3.5mm. These significant differences highlight the impact of elevation on particular nasofacial characteristics.

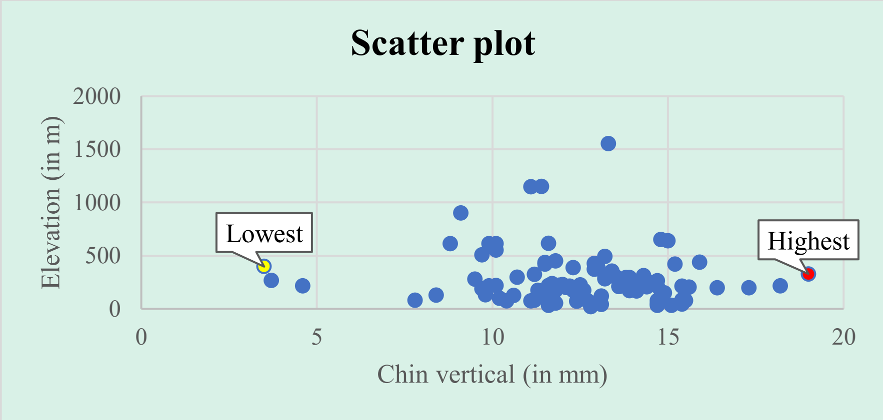


Figure 12- Scatter plot of elevation and chin vertical

This study uses an in-depth scatter diagram to examine nasofacial features. The elevation is represented on the x-axis, while the base bony width is plotted on the y-axis. This scatter diagram reveals patterns in base bone width at different elevations, offering information on the complex influence of geographic variables on nasofacial specifications. According to the research study, Uttar Pradesh has the highest and lowest documented base bony width, with maximum measures of 9.7 mm and minimum measurements of 4.6 mm. These findings highlight how intricate the connection is between elevation and nasofacial characteristics within a single geographic area. The scatter diagram is a visual aid that illustrates the variation in base bone width caused by elevation and adds important details to our knowledge of facial morphology.

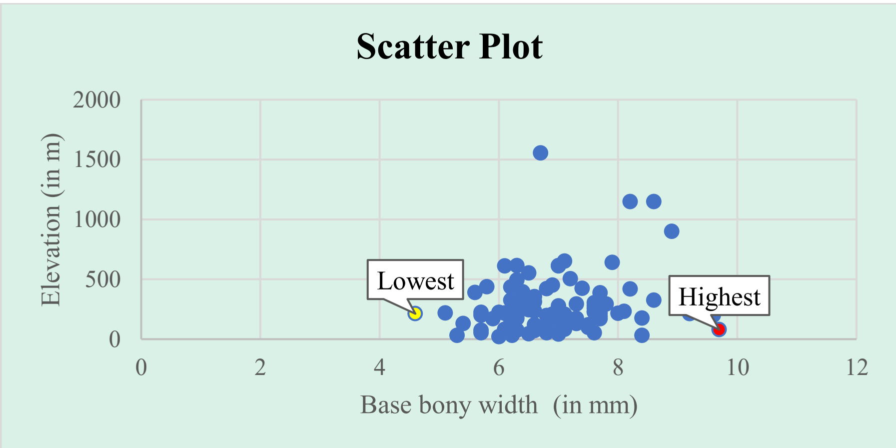


Figure 13- Scatter plot of elevation and base bony width

In the study, the scatter diagram represents a complex link between elevation and intercanthal width, which is one of the research findings. The diagram's y-axis shows the elevation, while its x-axis shows intercanthal width which offers crucial information on the complex influence of geographic variables on nasofacial features. Arunachal Pradesh has the highest intercanthal width of 14.9 mm measured in the study. On the other hand, Uttar Pradesh has the lowest intercanthal width, at only 6.3 mm. These differences highlight the significant impact of elevation on particular nasofacial characteristics, and the scatter diagram provides a visual representation of the variety of facial morphologies influenced by geographic variables.

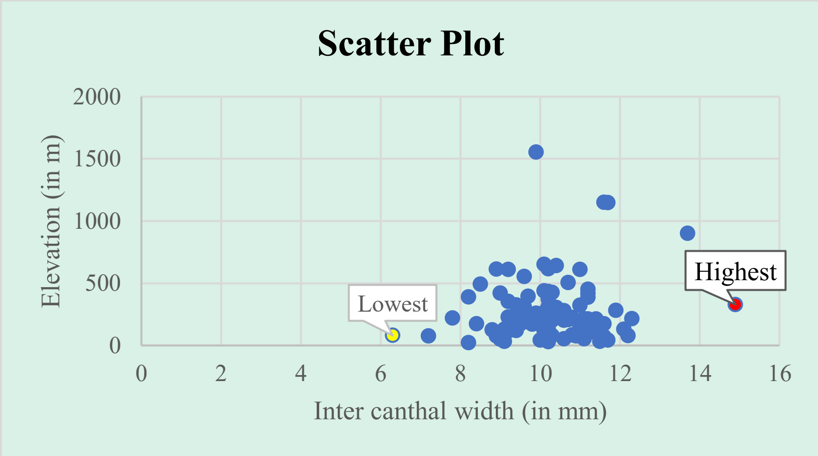


Figure 14- Scatter plot of elevation and inter canthal width

The intricate relationship between elevation and nasofacial parameters in the research findings is displayed in a scatter diagram. Figure 1 depicts the dorsum width on the x-axis and the elevation on the y-axis. The illustration, which shows patterns in dorsum breadth at various heights, offers crucial insights into the intricate interactions between geographic factors and nasofacial characteristics. The research finds that Andaman and Nicobar have the highest dorsum width ever measured, at an incredible 14.9 mm. In contrast, the state of Rajasthan has the lowest dorsum, with a measurement of only 6.3mm.

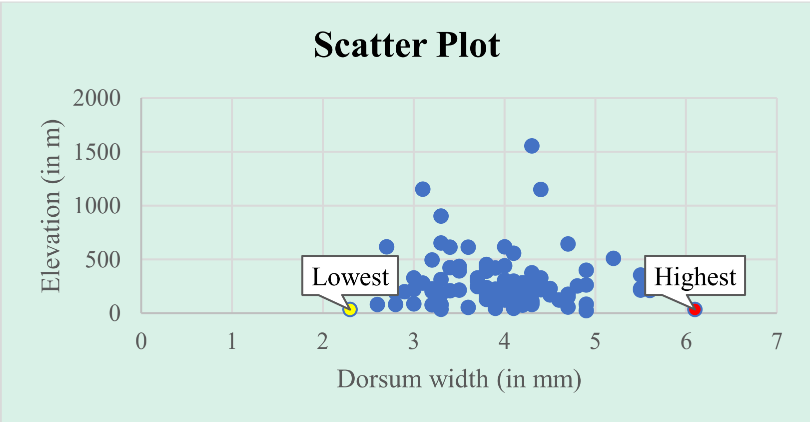


Figure 15- Scatter plot of elevation and dorsum width

The relationship between elevation and nasofacial traits is represented in a detailed scatter plot included in the research findings. The x-axis in the diagram denotes interalar width, whereas the y-axis shows elevation. This graphical representation provides crucial information on the intricate relationship between geographic factors and nasofacial characteristics. Arunachal Pradesh is the area with the highest interalar width in the research, with an interalar width of 18.9 mm. However, with an interalar width of only 8.9 mm, Uttar Pradesh has the smallest interalar width. These statistically significant variations demonstrate the substantial influence of elevation on specific nasofacial traits, and the scatter map illustrates the range of facial morphologies that are influenced by geographical factors.

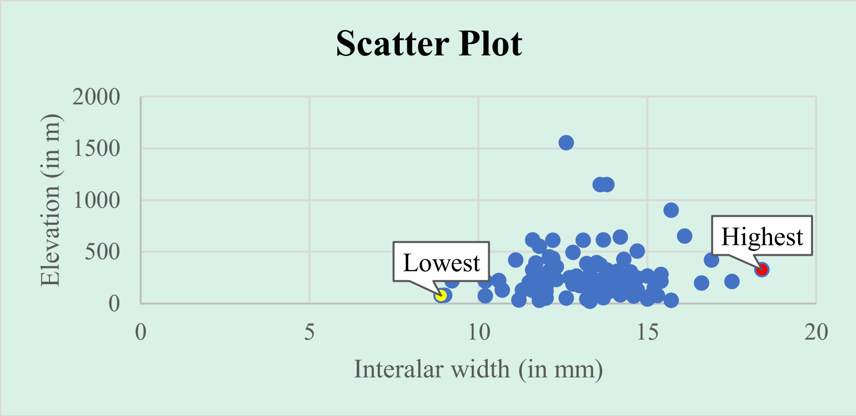


Figure 16- Scatter plot of elevation and interalar width

The study findings regarding the complex relation between elevation and nasofacial characteristics are plotted using a scatter diagram. In Figure 1, there are clear patterns in nasal length at different altitudes on the y-axis, which represents elevation, and on the x-axis, which shows nasal length. Uttar Pradesh is the location with the highest and lowest values on record in the study with the maximum measuring an astounding 17.6 mm, while the minimum is 5.8 mm. These findings demonstrate the intricate connection between elevation and particular nasofacial characteristics within a given geographic area. The scatter diagram is an essential graphical aid that illustrates the variation in nose length caused by elevation and provides important details.

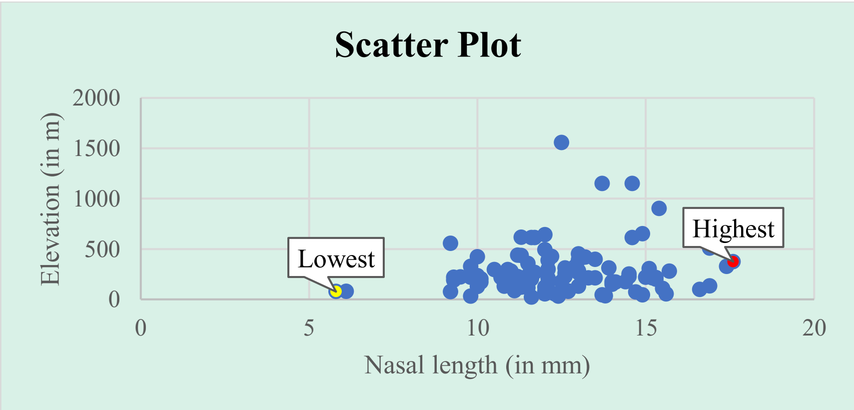


Figure 17- Scatter plot of elevation and nasal length

The study provide evidence of high reliability for several nasofacial parameters and shows a positive significant relationship between base bony width and elevation. This shows the increment of base bony width with the increase in elevation. And also shows a negative correlation with lower facial height and upper lip length. Therefore, the Rhinobase software is reliable and easy to use for nasofacial measurements.

In conclusion, this research investigates the human nasofacial area and solves its riddles by fusing cultural ecology, geographical determinism, and population migration concerns. The goal of the study was to identify the geographic influences on facial traits with the use of Rhinobase software, nasofacial analysis elevates our investigation and provides a sophisticated comprehension of the spatial details that shape the human face. By doing this, the study creates a route towards a more thorough understanding of the regional impacts on the variety of human face characteristics and advances the interdisciplinary conversation between geography and facial morphology.

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Declaration of interest
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Consent
Participants in this study were informed about the process related to the objective, procedure, benefits, and risks of the study. The respondents who agreed to participate in the study gave consent for photography, including permission for publication. All photographs were taken by the same researcher, with the same camera and the same standardization.

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