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Angular Photogrammetric Facial Analysis of Adults in Njikoka Local Government Area, Anambra State

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Abstract **Original Research**

Facial analysis plays a vital role in anthropometry, clinical practice, forensic identification, and aesthetic evaluation. This study aimed to determine the angular facial characteristics of adults in Njikoka Local Government Area of Anambra State, Nigeria, using photogrammetric analysis, and to assess the presence of sexual dimorphism. A cross-sectional descriptive study design was adopted, involving 140 participants comprising 70 males and 70 females aged between 18 and 45 years. Standardized facial photographs were obtained using a digital camera under controlled conditions, with subjects positioned in the Frankfurt horizontal plane. Relevant demographic data were collected using a structured questionnaire. Five facial angles; nasofrontal, nasolabial, nasofacial, nasomental, and mentocervical, were measured using image analysis software. Data obtained were analyzed using descriptive and inferential statistics, and a Z-test was employed to compare differences between sexes at a significance level of $p < 0.05$. The results revealed that females had significantly higher mean values of the nasofrontal and nasolabial angles compared to males ($p < 0.05$), while males exhibited a significantly higher mentocervical angle ($p < 0.05$). No statistically significant differences were observed in the nasofacial and nasomental angles between sexes ($p > 0.05$). These findings indicate the presence of sexual dimorphism in specific angular facial parameters within the studied population. In conclusion, this study provides baseline facial angular data for the Njikoka population and highlights the effectiveness of photogrammetric analysis as a non-invasive and reliable method for facial assessment. The results have important implications for clinical, forensic, and anthropological applications.

Keywords: Photogrammetry, Facial Analysis, Sexual Dimorphism, Anthropometry, Njikoka Population.

INTRODUCTION

Facial analysis continues to play a central role in biometric identification, human-computer interaction, forensic science, and medical diagnosis. In recent years, the increasing need for highly accurate and non-invasive facial imaging has encouraged a shift from conventional two-dimensional image-based approaches to more

advanced three-dimensional and reflectance-sensitive methods. Among these, angular photometric facial analysis has emerged as a valuable technique for capturing subtle facial details by using photometric information obtained under multiple lighting angles (Woodham, 1980). This approach supports not only geometric reconstruction but also detailed assessment of skin reflectance, texture differences, and structural deformation, all of which are particularly relevant in adult facial morphology because of age-related skin changes and individual variation (Schroff et al., 2015).

Angular photometric facial analysis is grounded in photometric stereo, a method first described by Woodham (1980), in which surface characteristics are estimated from images taken under different lighting directions while the camera remains fixed. Photometric stereo can recover dense and highly precise normal maps, even in areas with little texture. When extended into angular analysis, the method becomes more robust and informative, making it possible to detect very fine facial details such as pores, wrinkles, and anisotropic reflectance patterns, which are especially important in studies of adult faces (Beeler et al., 2010).

The human face, particularly in adults, displays non-Lambertian reflectance because of the layered nature of the skin, the presence of sebum, and differences in hydration. These factors cause deviations from ideal diffuse reflection, thereby reducing the accuracy of conventional Lambertian-based photometric analysis. Improved reflectance models that incorporate subsurface scattering have enhanced understanding of skin reflectance (Hanrahan & Krueger, 2023), while recent machine learning approaches, including deep photometric stereo methods, now allow more accurate estimation of surface normals under non-Lambertian conditions (Santo et al., 2017). In adults, these differences are further intensified by age-related features such as nasolabial folds, pigmentation changes, and soft tissue sagging, making precise, reflectance-aware imaging techniques essential (Schroff et al., 2015; Georgopoulos et al., 2018).

The applications of these methods in adults are extensive. They include biometric recognition that accounts for age-related facial changes, cosmetic and dermatological evaluation for assessing skin texture and asymmetry, and medical diagnosis for non-invasive examination of facial conditions. These techniques also contribute to facial aging research and support realistic digital modeling for use in entertainment and virtual environments (Angulu et al., 2018; Georgopoulos et al., 2018). Consequently, angular photometric analysis has become increasingly significant in both clinical and technological contexts where accurate facial characterization is required.

Several studies have shown the value of photometric and angular facial analysis in different Nigerian populations. Oghenemavwe et al. (2010), in their photometric study of the soft tissue facial profile of adult Urhobos, reported that the vertical and angular variables used in defining the soft tissue profile were sexually dimorphic. Ukoha et al. (2012), in a study of facial features and qualities among Igbo Nigerian adult males using photometry, described a shorter middle face than lower face, a moderate glabella, a projected nose, and a less prominent chin. The facial morphometry of the Ikwerre people in Rivers State has also been studied (Okoseimiema et al., 2021). They reported that the male values of all the facial dimensions measured were significantly higher than those of the female values. Okoseimiema and Paul (2021) assessed the relationship between facial height and nasal height among the Ikwerre people and found a positive correlation between the two variables.

Additional evidence of sexual dimorphism has been reported in other ethnic groups. Ukoha et al. (2017) observed significant differences in the mean values of some craniofacial angles among Igala males and females from standardized facial profile photographs, especially in the nasofrontal, nasomental, and nasofacial angles of facial convexity, with males showing a higher value only in the nasofacial angle. Likewise, Ezeuko and Eboigbe (2015) reported statistically significant sexual dimorphism in the nasofrontal, nasofacial, and nasomental angles among the Bini, while Osunwoke and Omin (2014) also recorded significant sexual differences in photometric analysis

among the Okrika people of Rivers State. Despite the importance of angular photometric facial analysis in facial reconstruction, plastic surgery, rhinoplasty, and orthodontic treatment, literature on the Njikoka people remains limited. This gap provides the basis for the present study, which aims to determine the facial features and qualities of adult Njikoka males and females using facial photometric analysis.

METHODOLOGY

This study adopted a cross-sectional descriptive research design to evaluate the facial features of adults from Njikoka Local Government Area of Anambra State, Nigeria. A total of 140 participants were recruited for the study, comprising 70 males and 70 females who were randomly selected from the study population. The age range of the participants was restricted to 18-45 years to ensure that only adults were included in the analysis.

Participants were included in the study based on specific criteria. Eligible individuals were adults within the specified age range, natives of Njikoka Local Government Area with both parents originating from the area, free from any observable facial abnormalities, history of facial surgery, or trauma, and willing to provide informed consent. Individuals who did not meet these criteria were excluded from the study. Prior to participation, each subject was given a detailed explanation of the study's objectives and procedures, after which informed consent was obtained.

Data collection was carried out using standardized photographic techniques. A digital camera mounted on a tripod was used to capture facial images. Participants were instructed to stand in an upright position with arms relaxed by their sides, eyes fully open, lips at rest, mouth closed, and head oriented in the Frankfurt horizontal plane. The camera was positioned at a distance of 120 cm from the subject to ensure consistency in image acquisition. Additionally, a structured questionnaire was administered to collect demographic information such as age, sex, and place of origin. The facial parameters measured included the nasofrontal angle, nasolabial angle, nasofacial angle, nasomental angle, and mentocervical angle.

Figure 1: Nasomental angle (from the present study).

Figure 2: Nasofacial angle (from the present study).

Figure 3: Mentocervical angle (from the present study).

Figure 4: Nasolabial angle (from the present study).

Figure 5: Nasofrontal angle (from the present study).

The captured images were analyzed using the IMG Pro image analyzer, and the resulting data were subjected to both descriptive and inferential statistical analysis. A Z-test was employed to compare differences between male and female participants. Statistical significance was set at an alpha level of 0.05 with a 95% confidence level; therefore, a p-value less than 0.05 ($p < 0.05$) was considered statistically significant.

RESULTS

It was observed that females had a significantly higher value in the nasofrontal and nasolabial angle than that of the males (P<0.05). it was also observed that the male had a significantly higher value in the mentrocavical angle than that of the females (P<0.05).

Table 1: Comparison of the measured variables between sexes.

	Males (n=70)	Females (n=70)		
Parameters	**Mean ± SD**	**Mean ± SD**	**p-value**	**Inference**
Nasofrontal angle	129.60 ±15.03	131.07±12.46	P<0.05	Significant
Nasolabial angle	76.01 ±7.86	82.38±9.71	P<0.05	Significant
Nasofacial angle	37.97 ±6.40	36.15±3.98	p>0.05	Not Significant
Nasomental angle	126.36 ±15.33	126.94±15.56	p>0.05	Not Significant
Mentocervical angle	88.76 ±8.54	87.66±4.21	P<0.05	Significant

n= Sample Size; SD= Standard Deviation; p= Level of significance at 0.05

Table 2: Comparison of the measured parameters with other population studies in male subjects.

Study	Population	Age range	NF	NFc	NL	NM	MC
Present study, 2025	Njikoka	18-45	37.97	129.60	76.01	126.36	88.76
Ukoha et al., 2017	Igala	18-45	40.18	127.73	79.48	125.99	
Eliakim-Ikechukwu et al., 2013	Igbo	18-35	37.80	127.10	76.10	125.90	88.60
Eliakim-Ikechukwu et al., 2013	Yoruba	18-35	37.30	127.90	77.00	125.60	85.90
Oghenemavwe et al., 2010	Urhobos	18-35	40.77	117.70		121.60	93.33
Ezeuko and Eboigbe, 2015	Benin	18-30	35.50	128.00	76.20	126.90	

Osunwoke and Onyeriodo, 2014	Khana	18-45	33.54	133.46	86.21	128.99	93.25

NF= Nasofrontal Angle; NL= Nasolabial Angle; NFc= Nasofacial Angle; NM= Nasomental Angle; MC= Mentocervical Angle

Table 3: Comparison of measured parameters with other population studies in female subjects.

Study	**Population**	**Age range**	**NF**	**NFc**	**NL**	**NM**	**MC**
Present study, 2025	Njikoka	18-45	36.15	131.07	82.38	126.94	87.66
Ukoha et al., 2017	Igala	18-45	40.18	127.73	79.48	125.99	
Eliakim-Ikechukwu et al., 2013	Igbo	18-35	36.30	131.70	82.50	125.10	87.50
Eliakim-Ikechukwu et al., 2013	Yoruba	18-35	35.50	134.30	84.00	126.80	85.60
Oghenemavwe et al., 2010	Urhobos	18-35	35.60	127.85		126.55	90.88
Ezeuko and Eboigbe, 2015	Benin	18-30	34.30	133.80	75.90	128.10	
Osunwoke and Onyeriodo, 2014	Khana	18-45	32.09	137.36	91.72	130.97	93.76

NF= Nasofrontal Angle; NL= Nasolabial Angle; NFc= Nasofacial Angle; NM= Nasomental Angle; MC= Mentocervical Angle

DISCUSSION

The present study showed that adult Njikoka males and females differ significantly in some facial angular measurements, indicating the presence of sexual dimorphism in this population. Specifically, females recorded significantly higher nasofrontal and nasolabial angles, whereas males had a significantly higher mentocervical angle. On the other hand, the nasofacial and nasomental angles did not show significant sex-related differences. These results reinforce the usefulness of angular photometric assessment in describing facial profile variation and in establishing population specific facial standards. The Powell analysis, which comprises the nasofrontal, nasolabial, nasomental, nasofacial, and mentocervical angles, remains a well-established framework for assessing ideal facial profile relationships (Powell & Humphreys, 1984; Ukoha et al., 2017).

The significantly greater nasofrontal angle observed among females in this study agrees with findings from other Nigerian populations. Ezeuko and Eboigbe (2015) similarly reported a significantly higher nasofrontal angle in Bini females than in

males, while Osunwoke and Omin (2014) also documented significant sex differences in facial photometric analysis among the Okrika, with females showing a higher nasofrontal angle. The higher nasolabial angle in females in the present study is also consistent with the pattern reported among the Bini, where females had a slightly higher nasolabial angle than males, although the difference was not significant (Ezeuko & Eboigbe, 2015). Together, these findings suggest that the upper and middle regions of the facial profile may more consistently favor females across Nigerian populations.

The significantly higher mentocervical angle in males in this study further confirms sexual dimorphism in the lower facial profile. Oghenemavwe et al. (2010), in their study of adult Urhobos, likewise reported sexual dimorphism in facial profile variables and found a higher mentocervical angle in males than in females. This may reflect the more pronounced lower facial projection and stronger chin contour that are commonly associated with male facial characteristics. Such differences are clinically important because the mentocervical angle contributes to the aesthetic evaluation of the jaw and neck profile, which is relevant in orthodontics, plastic surgery, and facial reconstruction.

The lack of significant sex differences in the nasofacial and nasomental angles in the present study suggests that these measures may be relatively more stable in the Njikoka population than the nasofrontal, nasolabial, and mentocervical angles. This pattern is partly comparable to the findings of Ukoha et al. (2017), who observed that although several craniofacial angles showed sexual dimorphism among the Igala, not all of the measured parameters differed significantly. Their study also indicated that the nasofacial angle had the greatest degree of sexual dimorphism, showing that this parameter may vary across ethnic groups. In a related study, Ukoha et al. (2012) reported that Igbo adult males had a projected nose, a moderate glabella, and a less prominent chin, emphasizing that facial profile characteristics vary among populations even within the same country.

When the present findings are compared with those of other population studies, the Njikoka values fall within the wider range reported among Nigerian ethnic groups, though with some notable differences. For instance, the male and female nasofrontal values in the present study were similar to those reported among the Igbo by Eliakim-Ikechukwu et al. (2013), but differed from the higher values documented among the Khana and Okrika populations. Likewise, the female nasolabial angle in the present study was comparable to that reported for Igbo females, but lower than the values recorded among the Khana and Yoruba. These differences may be explained by variations in ancestry, genetic inheritance, environmental adaptation, and population history. Richmond et al. (2018) noted that facial phenotypes across populations are influenced by multiple interacting factors, including genetic inheritance, migration, mate selection, climate, and evolutionary pressures related to survival.

Overall, this study provides valuable baseline data for the adult Njikoka population and adds to the growing evidence that facial angular measurements vary across sexes and ethnic groups. The observed sexual dimorphism has important implications for facial reconstruction, aesthetic surgery, orthodontic planning, and forensic identification. It also supports the value of photogrammetric analysis as a non-invasive, practical, and reliable method for documenting facial morphology. In addition, photogrammetric analysis offers clear advantages in angular assessment because it is non-invasive, unaffected by photographic enlargement, and provides permanent digital records that can be analyzed with computer software (Sforza & Ferrario, 2006; Weinberg et al., 2009). Given the limited published data on the Njikoka people, this study offers useful reference values for future comparative and clinical research.

The present study demonstrated that adult Njikoka males and females exhibit measurable differences in selected facial angular parameters, confirming the presence of sexual dimorphism in this population. Specifically, females had significantly higher nasofrontal and nasolabial angles, while males showed a significantly higher mentocervical angle.

In contrast, the nasofacial and nasomental angles did not differ significantly between sexes. These findings support the view that angular photometric assessment is a valuable method for describing facial profile variation and establishing population-specific facial norms. The Powell analysis, which includes the nasofrontal, nasolabial, nasomental, nasofacial, and mentocervical angles, is widely recognized as a useful framework for evaluating ideal facial profile relationships (Powell & Humphreys, 1984; Ukoha et al., 2017).

The significantly higher nasofrontal angle in females observed in the present study is consistent with earlier reports in other Nigerian populations. Ezeuko and Eboigbe (2015) also found a significantly higher nasofrontal angle in Bini females than in males, while Osunwoke and Omin (2014) reported significant sex differences in facial photometric analysis among the Okrika, with females showing a higher nasofrontal angle. The higher nasolabial angle in females in the present study is also in agreement with the pattern reported among the Bini, where females had a slightly higher nasolabial angle than males, although the difference was not significant (Ezeuko & Eboigbe, 2015). These findings suggest that the upper and middle facial profile may show a more consistent female predominance across Nigerian populations.

The significantly higher mentocervical angle in males in this study further supports the concept of sexual dimorphism in lower facial profile angles. Oghenemavwe et al. (2010), in their study of adult Urhobos, likewise reported sexual dimorphism in facial profile variables and found a higher mentocervical angle in males than females. This may reflect the stronger lower facial projection and more prominent chin contour typically associated with male facial morphology. Such differences are clinically relevant because the mentocervical angle contributes to the aesthetic assessment of the jaw and neck profile, which is important in orthodontics, plastic surgery, and facial reconstruction.

The absence of significant sex differences in the nasofacial and nasomental angles in the present study suggests that these parameters may be relatively more stable within the Njikoka population than the nasofrontal, nasolabial, and mentocervical angles. This pattern is partly similar to the findings of Ukoha et al. (2017), who observed that although several craniofacial angles showed sexual dimorphism among the Igala, not all measured angles differed significantly. Their study also showed that the nasofacial angle had the highest index of sexual dimorphism, indicating that this parameter may vary across ethnic groups. In contrast, Ukoha et al. (2012) reported that Igbo adult males had a projected nose, a moderate glabella, and a less prominent chin, highlighting that facial profile values differ among populations even within the same country.

When the present findings are compared with other population studies, the Njikoka values fall within the broader range reported for Nigerian ethnic groups, but with some notable distinctions. For example, the male and female nasofrontal values in the present study were close to those reported among the Igbo by Eliakim-Ikechukwu et al. (2013), but differed from the higher values recorded among the Khana and Okrika populations. Similarly, the female nasolabial angle in the present study was comparable to the values reported for Igbo females, but lower than those reported for the Khana and Yoruba. These variations may reflect differences in ancestry, genetic inheritance, environmental adaptation, and population history. Richmond et al. (2018) noted that facial phenotypes across populations are shaped by multiple interacting factors, including genetic inheritance, migration, mate selection, climate, and survival-related evolutionary pressures.

The present study therefore provides useful baseline data on the adult Njikoka population and adds to the growing body of evidence showing that facial angular dimensions vary across sexes and ethnic groups. The observed sexual dimorphism has important implications for facial reconstruction, aesthetic surgery, orthodontic planning, and forensic identification. It also supports the usefulness of photogrammetric analysis as a non-invasive, practical, and reliable method for documenting facial morphology. In addition, photogrammetric analysis offers clear advantages in angular assessment because it is non-invasive, not affected by photographic enlargement, and provides permanent

digital records that can be analyzed with computer software (Sforza & Ferrario, 2006; Weinberg et al., 2009). Given the scarcity of published data on the Njikoka people, this study contributes valuable reference values that may be used in future comparative and clinical studies.

CONCLUSION

This study established baseline angular facial parameters for adults in Njikoka Local Government Area of Anambra State and demonstrated the presence of sexual dimorphism in selected facial angles. Females exhibited significantly higher nasofrontal and nasolabial angles, while males showed a significantly higher mentocervical angle, with no significant differences observed in the nasofacial and nasomental angles. These findings indicate that although some facial parameters are sex-dependent, others remain relatively stable across sexes within this population. The results contribute valuable population-specific data and highlight the usefulness of photogrammetric analysis as a reliable, non-invasive method for facial assessment, with important applications in clinical practice, forensic identification, and anthropological research.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this study.

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REFERENCES

Angulu, R., Tapamo, J. R., & Adewumi, A. O. (2018). Age estimation via face images: A survey. *EURASIP Journal on Image and Video Processing*, 2018(1), 42.

Beeler, T., Bickel, B., Beardsley, P., Sumner, B., & Gross, M. (2010). High-quality single-shot capture of facial geometry. In ACM SIGGRAPH 2010 papers (pp. 1-9).

Eliakim-Ikechukwu, C., Ekpo, A., Etika, M., Ihentuge, C., & Mesembe, O. (2013). Facial aesthetic angles of the Ibo and Yoruba ethnic groups of Nigeria. IOSR J Pharm Biol Sci, 5(5), 14-17.

Ezeuko, V. C., & Eboigbe, P. O. (2015). Angular photogrammetric analysis of the facial profile of the adults of Bini ethnicity of Nigeria. Annals of Bioanthropology, 3(1), 14.

Farkas, L. G., Katic, M. J., & Forrest, C. R. (2005). International anthropometric study of facial morphology in various ethnic groups/races. *Journal of Craniofacial Surgery*, 16(4), 615–646.

Georgopoulos, M., Panagakis, Y., & Pantic, M. (2018). Modeling of facial aging and kinship: A survey. *Image and Vision Computing*, 80, 58–79.

Georgopoulos, M., Panagakis, Y., & Pantic, M. (2018). Modeling of facial aging and kinship: A survey. *Image and Vision Computing*, 80, 58–79.

Hanrahan, P., & Krueger, W. (2023). Reflection from layered surfaces due to subsurface scattering. In Seminal Graphics Papers: Pushing the Boundaries, Volume 2 (pp. 279-288).

Jain SK, Anand C, Ghosh SK. (2004). Photometric facial analysis- A baseline study.Journal of Anatomical Society of India, 53(2), 11-13.

Oghenemavwe E. L., Osunwoke A. E., Ordu S. K., Omovigho O. (2010).Photometric analysis of soft tissue Facial Profile of Adult Urhobos. AsianJournal of Medical Sciences, 2(6), 248-252.

Oladipo, G. S., & Olotu, J. E. (2006). Anthropometric comparison of cephalic indices between the Ijaw and Igbo tribes. Global journal of pure and applied sciences, 12(1), 137-138.

Okoseimiema, S.C., Amadi, K & Paul, J.N(2021). Sexual Dimorphism in Facial, Nasal, Mandibular, Maxillary and Orofacial Heights of the Ikwerre People in Rivers State. *Sch Bull, 7(5):* 130-133.

Okoseimiema, S.C. & Paul, J.N. (2021). Is there a relationship between the Facial and Nasal Height of the Ikwerre People? *Sch Int J Anat Physiol, 4(5)*: 59-64

Osunwoke, E. A., & Omin, E. (2014). Photometric facial analysis of soft tissue profile of Okrika adults. Annual Research & Review in Biology, 4(12), 1980-1987.

Osunwoke, E. A., & Onyeriodo, G. (2014). Angular photometric analysis of Khana people in Rivers State, Nigeria. Trans Clin Bio, 2(1).

Powell N. and Humphreys B. (1984). Proportions of Esthetic Face. New York, USA:Thieme Medical Publishers, 123.

Richmond, S., Howe, L. J., Lewis, S., Stergiakouli, E., & Zhurov, A. (2018). Facial genetics: a brief overview. Frontiers in genetics, 9, 462.

Santo, H., Samejima, M., Sugano, Y., Shi, B., & Matsushita, Y. (2017). Deep photometric stereo network. In Proceedings of the IEEE international conference on computer vision workshops (pp. 501-509).

Schroff, F., Kalenichenko, D., & Philbin, J. (2015). FaceNet: A unified embedding for face recognition and clustering. *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 815–823.

Sforza, C., & Ferrario, V. F. (2006). Soft-tissue facial anthropometry in three dimensions: from anatomical landmarks to digital morphology in research, clinics and forensic anthropology. J Anthropol Sci, 84, 97-124.

Ukoha, U. U., Udemezue, O. O., Oranusi, C. K., Asomugha, A. L., Dimkpa, U., & Nzeukwu, L. C. (2012). Photometric facial analysis of the Igbo Nigerian adult male. Nigerian Medical Journal, 53(4).

Ukoha, U., Ekezie, J., Okeke, C., & Osmond, A. I. (2017). Angular craniofacial photometric analysis of the facial profile of Igalas in Nigeria. Anthropol Open J, 1-6.

Weinberg, S. M., Naidoo, S., Govier, D. P., Martin, R. A., Kane, A. A., & Marazita, M. L. (2006). Anthropometric precision and accuracy of digital three-dimensional photogrammetry: comparing the Genex and 3dMD imaging systems with one another and with direct anthropometry. Journal of Craniofacial Surgery, 17(3), 477-483.

Woodham, R. J. (1980). Photometric method for determining surface orientation from multiple images. Optical engineering, 19(1), 139-144.