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REVIEW ARTICLE

The Influence of Age, Sex and Facial Size on Facial Asymmetry in Hausa Population of Kano and Kaduna States, Nigeria

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Abstract

A substantial body of literature has reported a quantified level of facial symmetry but major gaps persist, with nearly all data originating from Western industrialized populations. The aim of this study was to determine the influence of age and sex on facial asymmetry of the Hausa ethnic group of Nigeria. The faces of 426 (215 males, 211 females) Hausa subjects of northern Nigeria were scanned using a 3D surface laser scanner. Facial asymmetry data were generated from the resulting virtual 3D models. The Mean whole face asymmetry (WFACE), the asymmetry around the eyes (EYES), the whole face surface area (WFSA) and the mean age were determined in both male and female subjects.

The results showed that males were 12% more facially asymmetric than the females and males were 15% more asymmetric around the eyes than females. It also demonstrates that males' faces were 20% larger than the females'. The *Mann Whitney U test* indicated a statistically significant sexual dimorphism ($p<0.0001$) in all the tested variables. In females, *linear regression analyses* indicate statistically significant positive association between WFACE & age ($F=5.32$, $P=0.0221$), and EYES & age ($F=5.10$, $P=0.0249$) but not between WFACE and WFSA or between EYES and WFSA. Similarly**,** in males, there was a statistically significant positive association between WFACE & age ($F=6.61$, $P=0.0108$), but none between EYES & age ($F=1.41$, $P=0.2365$). Again, there was a statistical significant positive association between WFACE & WFSA, and between EYES & WFSA. The results however reveal that as the men get older, their whole face asymmetry increases, and as their faces grow their whole face asymmetry and asymmetry around the eyes also increase. However, it is important to note that, although some relationships are statistically significant, all are weak, with no r^2 value higher than 0.05.

KeyWords: Face, Asymmetry, Age, Sex, Hausa

Introduction

Facial asymmetry can be seen as a measure of developmental stability, and it is expected to differ between males and females since in the morphology of animal taxa (including humans), sexual dimorphism is widespread, and evolves "when characters that confer an advantage in competition for mates or mate choice are selected for within one sex" as proposed by Darwin's sexual selection hypothesis [1]. It may also evolve from food competition between the sexes or variations between the reproductive roles of males and females, which is regarded as the 'dimorphic niche' hypothesis [1, 2].

Several studies have been conducted on different populations to determine sexual dimorphism in the human face **[**3-7] under different environmental conditions (e.g, [8] or the same environmental conditions [5, 9]. However, the literature is deficient on information concerning facial asymmetry outside the Western industrialised countries. The aim of this study is to examine the influence of Age, Sex, and Facial Size on Facial Asymmetry amongst young adults (18-25 years) of the Hausa ethnic group in Nigeria. The hypotheses with regards to this are that: 1. Men will have higher facial asymmetry than women. 2. Younger men will be less asymmetrical than the older ones 3. People with larger faces will have higher facial asymmetry than those with the smaller faces.

Materials and Methods

The study recruited 427 pure Hausa people from Kano and Kaduna States in Nigeria by simple random sampling. The participants' age range was restricted to between 18-25 years to minimize the effects of both ongoing ontogenetic development and aging on facial asymmetry.

Subjects 'faces were scanned using Exascan 3D Laser surface scanner (Figure 1) from Creaform (www.handyscan3d.com), and saved in a computer for analyses. The scanner was (before scanning) calibrated to correct any optical or electronic distortions and the sensor configured for dark skin. Prior to scanning, positioning targets were placed on the face of the participant, from the hair line down to the chin, and along each side of the face including the ears. Test scans were conducted with the participant lying supine with or without the use of a dough-nut shaped head rest and with the subject sitting down

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Figure 1: ExaScan surface laser scanner

(Manufacturer: Creaform, USA, Class II eye safe, 0.04 mm resolution, 0.04 mm accuracy)

still. The results were better with the subjects sitting rather than lying down, so this position was chosen for all further scans. Scanning was done with each participant seated in an upright position, asked to sit still on a chair with the head facing up (neck extended) at a slight angle of about 45 degree relative to the floor, as this position was found to be the most comfortable to scan in while the researcher was standing, avoiding the need to bend down a lot if the participants were to be looking straight ahead. Participants were instructed to keep their eyes closed to avoid discomfort from the laser beams. During the scanning process, the 3D digital scan is generated on the computer screen in real time, allowing the researcher to continue scanning until a satisfactory scan has been created (Figure 2). Good quality 3D facial scans were obtained with the subject maintaining a natural pose with neutral facial expression (see [10]. In a situation where the position or pose of the subject distorted the face, or if the facial expression was not neutral, the scans were discarded as the inclusion of non-neutral facial expressions would have affected morphological comparisons between subjects (see [10]. Each of the obtained scan was then trimmed and cleaned of any mesh (e.g., Figure 3) before the analyses.

Most of the statistical analyses were conducted using *R-statistic software version 3.1.2* [11] but few were done with SPSS version 22.

Results

Descriptive statistics of WFACE, EYES, and WFSA were conducted separately for males and for females using SPSS version 22.

Mean differences in WFACE, EYES, and WFSA were compared between sexes, using Mann Whitney U-tests in R-statistic software version 3.1.2 [11] because the distribution of WFACE and EYES both departed somewhat from normality. The relationship of WFACE, or EYES and WFSA were tested using linear regression analyses in R-statistic software version 3.1.2 [11]

Independent two sample t-test was conducted to test sexual dimorphism in WFACE, or EYES were also conducted using R-statistic software version 3.1.2 [11].

Descriptive Statistics for the Facial Asymmetry

Table 1 shows the descriptive statistics and Mann Whitney U-test for WFACE, and EYES. In the table, the females' mean age was 20.6 years ± 2.4 years, while it was 21.8 years ± 2.1

Figure 2: Un-cleaned scanned face

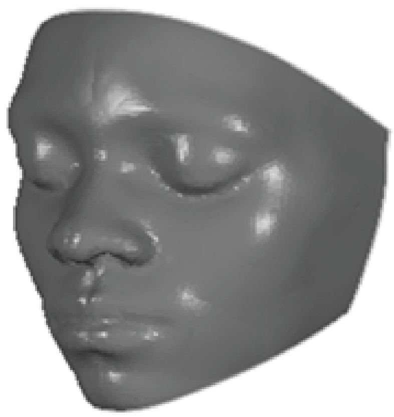

Figure 3: Cleaned scanned face

Table 1: Descriptive statistics and Mann-Whitney U test for Age, WFACE and EYES and WFSA.

Variable	Female (n=211) Mean± STD	Female Min-Max	Male(n=215) Mean± STD	Male Min-Max	W	P-Value
AGE (years)	20.6±2.4	18-25	21.8±2.1	18-25		
WFACE (mm)	0.31±0.1	0.22-0.05	0.35±0.1	0.22-0.05	13134.5	5.70E-14
EYES (mm)	0.20±0	0.11-0.49	0.23±0.1	0.11-0.47	16024.5	1.60E-07
WFSA (mm^2)	33543±4020	22353-47053	40160±3357	31263-50153	4752	2.20E-16

years for males and therefore males were a little 5% older than the females (from the ratio of ratio, 1:1.05) although they both had the same age range. The females' mean of the WFACE was 0.31 mm (range, 0.22 mm-0.50 mm), whereas it was 0.35 mm (range, 0.22 mm-0.53 mm) for males.

This shows that males were 12% more facially asymmetric than the females (from the ratio of, 1:1.12) although the range was similar in both sexes. The mean values of EYES in females was 0.2 mm (range, 0.11 mm-0.49 mm) while it was 0.23 mm (range, 0.11 mm-0.47 mm) for males. Again, males were 15% more asymmetric around the eyes than females (from the ratio of, 1:1.15) both of which have similar range. The mean WFSA was 33,543 mm^2 (range, 22353 mm^2-47053mm^2) for females and 40,160 mm^2 (range, 31263 mm^2-50153 mm^2) in males. This also demonstrates that males' faces were 20% larger faces than the females' (from the ratio of, 1:1.20) with the minimum value recorded in females but the maximum recorded in males. In summary, males were older, heavier, and taller, with higher WFACE and EYES and larger faces than the females.

Mann-Whitney U test and linear regression analyses: on facial asymmetry and age

The Mann Whitney U test indicated a statistically significant sexual dimorphism ($p<0.0001$) in all the tested variables, that is, age, WFACE, EYES, and WFSA as shown in Table 1.

In females, linear regression analyses indicate statistically significant positive association between: WFACE & age (F=5.32, P=0.0221). However, there was no association between WFACE & WFSA (F=0.87, P=0.3518) as shown in Table 2. A statistically significant positive relation was found between EYES & age (F=5.10, P=0.0249). No relation was found between EYES and WFSA (F=0.074, P=0.7864) as shown in Table 2.

The results however reveal that in males, linear regression analyses also indicate statistically significant positive association between: WFACE & age (F=6.61, P=0.0108), and WFACE & WFSA (F=8.39, P=0.0042). Statistically significant positive relation was found between EYES & WFSA (F=11.63, P=0.0008), but none between EYES & age (F=1.41, P=0.2365). The results however reveal that as the men get older, their whole face asymmetry increases, and as their faces grow their whole face asymmetry and asymmetry around the eyes also increases. However, it is important to note that, although some relationships are statistically significant, all are weak, with no r^2 value higher than 0.05.

Multivariate analyses of covariates (MANCOVA) with WFACE as the dependent variable, and age as the independent variables with WFSA and sex as covariates [Call: lm (formula = WFACE ~ AGE + WFSA +SEX)] yielded a statistically significant model (*F= 17.63, P= 7.286e-16*) with an adjusted r-squared value of *0.1636*.

However, through model optimisation by manual elimination method, a statistically significant best (minimal) model with slightly lower adjusted r-squared (0.1618) but with much higher p-value (F=28.35, P=2.2e-16) than the maximal model was obtained. The best (minimal) model [Call: lm(formula = WFACE ~ AGE + SEX)] was a linear model of WFACE on AGE, & SEX, meaning that 16.2% of the variation in WFACE is due to age, and sex and that these variables predict whole face asymmetry across both sexes (Tables 3). Similarly, multivariate analyses of covariates of the EYES as the dependent variable, and age, as the independent variables, with WFSA and sex as covariates [Call: lm (formula = EYES ~ AGE + WFSA + SEX)], revealed a statistically significant (maximal) model (F= 8.591, P= 9.204e-08) with an adjusted r-squared value of 0.082, but the minimal model was more statistically significant (F= 38.01, P= 6.578e-16) with much higher r-squared value (0.1483) than the maximal model. The minimal model [Call: lm (formula = EYES ~ AGE+ SEX)]

Table 2: Linear regression analyses: WFACE or EYES regressed against age, and WFSA.

Variables	Sex	Adjusted R^2	Fstatistic	DF	P-Value
WFACE & AGE	F	0.0201	5.32	1 and 209	0.0221
	M	0.0256	6.61	1 and 213	0.0108
EYES & AGE	F	0.0193	5.10	1 and 209	0.0249
	M	0.0019	1.41	1 and 213	0.2365
WFACE & WFSA	F	-0.0006	0.87	1 and 209	0.3518
	M	0.0334	8.39	1 and 213	0.0042
EYES & WFSA	F	-0.0044	0.074	1 and 209	0.7864
	M	0.0473	11.63	1 and 213	0.0008

Table 3: Minimum model of Multivariate analyses between WFACE, EYES with AGE, & SEX

WFACE	Estimate	SE	t-value	P-Value
(Intercept)	0.069782	0.059599	1.171	0.2423
AGE	0.003645	0.001188	3.067	0.0022
SEXM	0.026582	0.006804	3.907	0.0001
EYES				
(Intercept)	0.221554	0.024783	8.94	< 2e-16
AGE	0.004066	0.001188	3.422	0.0007
SEXM	0.037967	0.005495	6.91	1.79e-11

was a linear model of EYES on age and sex, meaning that AGE and sex predict EYES (Table 3).

Discussion

There have been numerous studies concerning sexual dimorphism on facial skeletal structures [12-15] in contrast to those on facial soft-tissue structures and the estimation of facial sexual dimorphism (an outcome of sexual selection) is very important in understanding facial morphology and the influence of sexual selection on the face. Different authors reported different results with some demonstrating no sexual dimorphism on the face [16-19].

Studies which demonstrated facial sexual dimorphism have indicated that males mostly have higher facial asymmetry values as compared to females e.g., [7, 8, 20]. Similarly, the current study also found a statistically significant sexual dimorphism in whole face asymmetry and asymmetry around the eyes region, similar to the findings of some authors [21] and [8]. Similar to the previous studies, this study also shows that males have higher whole face asymmetry and higher asymmetry around the eyes region than females. Why males have higher facial asymmetry values might simply be because they are known to be more exposed to environmental stress and more susceptible to infectious diseases than females [22].

Facial asymmetry is expected to vary across ages since absolute and relative FA was demonstrated to differ in a cross-sectional sample of 680 human participants aged 2-18 years [23]. In the study, authors showed that asymmetry decreases with age until age 11, followed by an increase that peaks at 13 years in males and 14 years in females. From age 15 a decrease in fluctuating asymmetry is maintained until age 18. They further suggested that this pattern could be explained as the result of the interaction of rapid growth and high metabolic rate in children, and that an increase in fluctuating asymmetry in adolescence may be due to sex steroid secretion.

However, in the literature, several studies have shown no association between facial asymmetry and age in either sex [6, 24-25] whether in cross-sectional [5, 19] or in longitudinal studies [17]. The results were the same irrespective of the sample size. For example, a study of Farkas and Cheung (1981), with lower sample than the present study, evaluated 308 Caucasian children, adolescents and young adults (6-, 12-, and 18-year-olds) on the degree of facial asymmetry (by direct facial anthropometric measurements), but they did not observe any statistically significant age-related influence on the prevalence and extent of the facial asymmetry. Similarly, another study with a higher sample than the current study, examined 720 normal children (6–18year-old), similar cohort with Farkas and Cheung (1981), also revealed no change with age in the extent of facial asymmetry in both sexes [26]. Furthermore, the results were similar irrespective of the methodology, because one study used surface laser scanner to examine 60 Caucasian Finnish children aged 10-13 years longitudinally, but no statistically significant age difference was demonstrated on facial asymmetry [27]. Additionally, Primozic et al., (2012) also used 3D surface laser scanner to scan the faces of 27 Caucasian children in Slovenia, with age ranged 4.9-6.2 years, but again, no age variation observed in facial asymmetry [6]. However, the findings of those studies are not in keeping with what was found in the present study, even though, they commonly examined pre-pubertal and pubertal subjects. The current study examined post-pubertal subjects (18-25 years) and there was a positive association observed between whole facial asymmetry and age in both males and females and a positive association was also found between age and the asymmetry around the eyes.

The age group of the participants in this study was similar to one of the groups in the study that collected three-dimensional co-ordinates of 16 standardized soft tissue landmarks on 314 healthy white northern Italian subjects, adolescents (12-15 years), young adults (18-30 years), and adults (31-56 years) using stereophotogrammetry in order to assess the effects of gender and age on soft tissue facial asymmetry [19] but they were not able to observe a statistically significant difference in facial asymmetry based on age. In the current study, height and age were found to be strong predictors of facial asymmetry in both sexes, and weight was a strong predictor of asymmetry around the eyes.

Conclusion

The results of this study indicate that facial asymmetry is sexually dimorphic and that age, and WFSA are correlates of facial asymmetry, whereas age, and WFSA are correlates of EYES. None of the relationships are strong, however, as indicated by the low proportion of overall variance explained by each of them.

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