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Research Article

Sexual dimorphism using Gonial Angle in children related to diet and environment in Surabaya, Indonesia

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ABSTRACT

Background: In forensics, sex estimation is an important step in identification process which can be seen from gonial angle. The purpose of this study was to identify sexual dimorphism in gonial angle based on the difference of external factors such as diet and environment in children, and to assess their capacity as a sex estimator. **Study design:** The present study consists of 104 subjects (51 males and 53 females) between 7 to 12 years of age which were divided into 2 groups, with prolonged sun exposure-hard diet (Group A) and low sun exposure-soft diet (Group B). The measurements were made using goniometer directly to the subjects. **Results:** The mean gonial angle in females is higher than in males and shows significant difference. However, there is no significant difference between Group A and B. Obtained logistic regression achieves an overall accuracy of 68% with cutoff value of 0.46, where the discriminative ability values are not higher than 0.80. **Conclusions:** Although there is a significant difference in sex, external factor such as sunlight exposure does not influence in gonial angle. Current results indicate that using mean gonial angle as sex estimation parameter is not advised for children aged 7-12 years.

Keywords: Forensic dentistry, Sex estimation, Gonial angle

INTRODUCTION

When there is no ante mortem (AM) data acquired, a post mortem (PM) dental profiling is established to acquire missing person characteristics which are most likely narrowing down the search in AM data leading to identification. The primary purpose of forensic identification is to determine human identity, including gender, race and ages (1). Sex estimation is the foremost steps of an identification process that enables forensic experts to obtain proper data to identify a person (2).

It has been generally accepted that there is sexual dimorphism observed in mandible (3–5) such as symphysial shapes (6), corpus growth (4,7), ramus (8), and gonial angle (GA) (9). These data mostly acquired from an orthopantomograph (OPG), whilst in some cases, a PM OPG is not viable (10). Hence, a direct examination needs to be conducted.

GA development has been associated with sexual dimorphism and can be measured without an OPG in skeletal and mutilated bodies (10,11), however, internal and external factors need to be considered. The GA changes are obtuse at birth and fluctuate throughout life, especially in the growth spurt phase. Growth spurt process occurs during mixed dentition, around 7 to 9 years for females and 8 to 11 years for males respectively (12,13). On the other hand, external factors such as occlusal loading from food textures and intake of vitamin D from sunlight exposure may affect GA measurements (14–16).

Considering the problem above, this study was conducted to identify sexual dimorphism based on GA in 2 different sample groups which have different condition in diet and environment.

MATERIALS AND METHODS

Study was designed as a cross sectional observational in 104 subjects (51 M, 53 F) aged 7-12 years. Ethical clearance No. 051/HRECC.FODM/II/2019 was obtained from the Ethical Clearance Committee for Health Research, Faculty of Dental Medicine, Universitas Airlangga. The inclusion criteria of the subjects were absence of genetic and physical abnormalities, absence of cross-bite and median-

line shift incisors. Before the study, parents/guardians had signed an agreement.

Subjects were divided into group A and B based on the interview and observation about their dietary and outdoor habits. Parents/guardians are given a questionnaire to clarify the information given by the subjects. Subject with prolonged sun exposure for at least 30 minutes/day of 12 months which had a hard diet was included in Group A and subject with low sun exposure which had a soft diet was included in Group B (14,15).

Left (L) and right (R) GA was measured using goniometer. Four reference points which would improve the measurement accuracy were placed along in the mandibular corpus inferior and mandibular ramus posterior.

All measurement was done by two examiners. To test the reliability of inter-intra observers, 10 percent of the subject was randomly selected and reassessed after 1 month. All data was collated using Excel (version 2013 Microsoft, Redmond, USA) and statistical analysis was done using IBM ® SPSS ® Statistics version 23.0 (IBM, Armonk, New York, USA).

Data Analysis

First, data were tested with Kruskal-Wallis. And then, the difference between left (L) and right (R) GA was checked with Mann-Whitney test. The difference between GA for each sex and group in the entire was checked with Independent t-test.

The resulting data for each significant ($p<0.05$) measurements were included in final regression to estimate sex using GA variable. Furthermore, the obtained regression formula performance will be examined using the area under curve (AUC) to interpret how well logistic regression model distinguish between two categories.

RESULTS

Samples F and M have a mean age of 9.19 and 9.16 with a standard deviation (S.D) of 1.55 and 1.61 years, respectively. In group A, there are 28 M and 23 F, while in group B there are 23 M and 30 F. The measurements between examiners indicate no differences ($p>0.05$). Due to a high correlation of coefficient between the left and right GA ($r=0.85$, $p>0.05$), the regression model was made separately with 3 predictor variables; Left GA, Right GA, and Mean GA (Table 1). Furthermore, significant difference was observed between F and M in all 3 GA values ($p< 0.05$) (Table 2), and there are no significant differences when comparing mean GA between Group A and B ($p>0.05$) (Table 3). Hence, logistic regression model was made without considering the Group with y represents the sex estimation score, and x represents the considered GA value. Results are presented in Table 4 with the highest accuracy was found to be 0.75 using left GA variable with adjusted cut-off value of 0.45 and an area under curve (AUC) of this left GA model regression was 0.7.

DISCUSSION

The difference in the mandible is reflected in its shape and size which is different between M and F (17). When comparing the mean L and R GA values of the entire sample between M and F, there are no significant differences. Shahabi et al., found a similar finding in their study involving 70 orthodontic patients (48 F and 22 M) aged 15-30 years, that there are no significant differences between the mean values of L and R GA in the panoramic radiograph and lateral cephalogram (18). Many work suggested that GA was 2.2-3.6 degrees greater in lateral cephalogram than panoramic radiography (19). However, this insignificant difference will affect the logistic regression accuracy and is shown as three different GA measurements affecting accuracy and discriminatory capability (Table 4).

Various studies with different age ranges indicate that GA is reliable in various age groups (20–23), while others found there are no significant differences in the mean of GA between M and F (24). The mean of GA has been shown to be a useful predictor in estimating sex, since it has significant differences between M and F (129.3° and 132.4°, $p=0.002$), while currently we have found that the method for estimating sex should be carefully tested in children as they are still in growth spurt phase.

Study carried out by Hichijo et al., and Kono et al., in the soft-diet group is significantly higher in GA than in the hard-diet group. Soft diet intake has had a negative effect on the development of the jaw bone (14,16). This eating pattern may affect the function of the mastication muscles which influence the growth of the craniofacial structures because the mechanical loads on the skull are related to the masticating forces (25–27). The effects of sun exposure on bone health may also have a positive effect on bone structure and the hormones that regulate bone mass (28). Kanemura et al., reported a significant increase in bone mineral density (BMD) in all patients with sunlight exposure duration of 28.8 minutes/day and no bone fractures in all patients after beginning of sunlight exposure during the 2 years observational period (15). However, in this study, we found no significant differences when comparing the mean GA values between group A and B. It is necessary to add other variables such

as race (29), oral habits (30,31), and body mass index (BMI) (32) to the questionnaire.

Goniometer was chosen as a primary method for collecting GA data, since it can be used directly on the patient`s face, simple, inexpensive, and safe (33). Still, the use of goniometer has some drawbacks, such as measurements are carried out one by one for each variable (34) and difficulties in finding the border of the mandibular corpus inferior and mandibular ramus posterior. Gungor et al., found that orthopantomograph (OPG) can be used to measured GA because are very accurate via directly from skeletal remains (35). If only mandibular skeleton is found, OPG measurements cannot be used. Therefore, a direct measurement method is needed because in some cases a PM OPG is not possible (11).

In this analysis, the highest accuracy of logistical regression for sex estimation is using left GA, which is 0.75 with adjusted cutoff value of 0.45. Jambunant et al., suggested using two variables (GA and Bigonial width) with 66% accuracy was found (20). Furthermore, our current AUC is 0.7, while Capitaneanu et al., stated that a formula appropriate if the AUC values is higher than 0.80 (36). Consequently, in this research, logistic regression is considered to be used carefully to estimate sex among children aged 7-12 years.

CONCLUSION

In summary, our study shows that mean GA between M and F in children aged 7-12 years has a significant difference. Inclusion and exclusion criteria need to be revised for further analyze of external effect on mandibular development. Our model suggests that the use of GA variable with direct sex should be used carefully in children aged 7-12 years due to its low discriminative ability.

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Conflict of Interest

We have no conflict of interest.

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Table 1 Gonial angle measurement on right and left sides

	N	Mean	Std. Deviation	p-Value	r
GA R	104	130.93°	5.23	0.858	0.82
GA L	104	130.94°	5.93		

GA R = Gonial Angle Right, GA L = Gonial Angle Left with p-value obtained from calculating the significance between GA R and GA L, r = Correlation coefficient

Table 2 Mean gonial angle Measurements in Male and Female

	Male		Female		P-Value
	Mean	Std. Deviation	Mean	Std. Deviation	
GA R	129.4	5.47	132.4	4.57	0.004
GA L	129.2	6.19	132.6	5.18	0.003
Mean GA	129.3	5.58	132.5	4.59	0.002

Table 3 Gonial angle value between Group A and Group B

	N	Mean	Std. Deviation	p-Value
Group A	51	130.4°	6.73	0.285
Group B	53	131.5°	3.43	

Table 4 Logistic regression model for 3 gonial angle value measurement

	Regression Model	Null Deviance	Residual Deviance	Area Under Curve	Accuracy	Adjusted Cut-off Value
GA L	$y = 14.55 - 0.11x$	144.14	134.71	0.70	0.75	0.45
GA R	$y = 15.55 - 0.12x$	144.14	135.57	0.67	0.67	0.47
Mean GA	$y = 16.87 - 0.13x$	144.14	134.14	0.68	0.68	0.45

y represents the value of estimated sex, and x represents the GA measurement used in the regression model. Values greater than the cut-off indicate M and values lesser than cut-off indicate F.