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SEXUAL DIMORPHISM IN MODERN JAVANESE CRANIA: A METRIC APPROACH

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Abstract

Establishing the biological profile of an unknown skeleton is one of forensic anthropologist main tasks; sex is one of them. In sexing the skulls, specific standard assessment designed for each population can improve the accuracy rate due to its population-specific traits. This study aims to describe the sexual dimorphism in contemporary Javanese crania while employing metric methods. The measurements of 50 male and 37 female crania were traditionally collected from nine craniometric points (i.e., g-op, eu-eu, ft-ft, zy-zy, n-pr, n-ns, apt-apt, go-go, n-gn) using calipers. This study found that out of nine measuring points, two (ft-ft, apt-apt) variables does not differ significantly between the male and female samples. This indicates that, in accordance with previous studies, ft-ft and apt-apt are not good predictors for sex. Future studies observing the non-metric sexual dimorphism on Javanese crania would serve as a meaningful aid in improving the accuracy and reliability when sexing Javanese crania.

Keywords: sexual dimorphism, population-specific, Javanese, sex estimation.

INTRODUCTION

In forensic anthropology, determining the sex of the found skeletons is essential. Methods used to estimate the sex generally rely on the expression of human sexual dimorphism. Pelvic bones possess the highest sexual dimorphism due to its role in human reproductive system. A study suggests that pelvic bones are the most reliable bones when it comes to sexing adult skeletons (Gonzalez et al., 2009). However, in dismemberment cases where lower limbs are absent, skull should be considered as the alternative. Using the non-metric approach to assess the sex from skulls will provide the accuracy of 70%-80%, and up to 90% if the assessment is performed by experts (Berg, 2013; White & Folkens, 2005). This proven high accuracy rate makes skull the second most reliable bones for sex estimation (Berg, 2013).

Despite its relatively high accuracy rate, studies argue that sexual dimorphism is population-specific, especially for skulls (Oikonomopoulou et al., 2017). Walker (2008) in his study found that the degree and expression of several traits in skull vary across populations and geography. Therefore, it is always best to estimate the ancestry prior to sex (Garvin et al., 2014;

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Green & Curnoe, 2009; Macaluso & Lucena, 2014). White & Folkens (2005) recommended using comparative populations that are genetically and temporally related with the samples being identified. Accuracy of sexing skulls from known population could go up to 94% (Garvin et al., 2014).

Due to its population-specific characteristics, standard sex assessment should be specifically developed for each population. Applying other's population standards to estimate the sex of other population's skeletons would potentially lower the accuracy, leading to a misclassification (Kotěrová et al., 2017). A number of studies have been conducted to describe the sexual dimorphism of the skull for each separate population (Krüger et al., 2015; Steyn & İşcan, 1998; Franklin et al., 2005, 2006; Ibrahim et al., 2017; İşcan et al., 1995; Krüger et al., 2015; Marinescu et al., 2014; Steyn & İşcan, 1998). While prehistoric Javanese crania have been repeatedly studied (Baab, 2011; Baba et al., 2003; Y Kaifu et al., 2008; Yousuke Kaifu et al., 2015; Pearson et al., 2021), we have not found any work attempting to describe the sexual dimorphism in modern Javanese population. Hence, the purpose of this study is to describe the sexual dimorphism in Javanese skulls using the metric approach. Despite there is one study observing the sexual dimorphism in East and Southeast Asian samples claimed to be compatible to be applied to other Southeast Asian populations (Tallman, 2019), individual standard assessment for Javanese population is still necessary in order to provide the highest accuracy while sexing the Javanese skulls. Such standard assessment methods should be of practical use for forensic anthropologists working in Indonesia.

METHODS

This study measured 87 Javanese adult skulls, 50 were identified as male and the rest 37 were female. The skull samples in this study belong to the Faculty of Medicine, Universitas Airlangga, Surabaya. Each skull has the information regarding its sex and age of death, which aids in excluding subadult crania from this study. Some of the samples are in incomplete conditions, and some are mildly broken in specific areas.

The measurements were taken from nine craniometric points i.e., g-op, eu-eu, ft-ft, zy-zy, n-pr, n-ns, apt-apt, go-go, n-gn (Table 1). To improve the reliability, measurements were done twice in the same week, as recommended by Hrdlicka (1920) and DeCarlo et al. (1998). The collected measurements were then tested for the normality before being analyzed using SPSS and the 2-Sample Kolmogorov-

Smirnov test was applied to test if there are any significant differences between the sex. This study used the 95% confidence interval, meaning any *p* value that falls below 0.05 is considered statistically significant. The non-parametric test was chosen as the data were not normally distributed.

Measurements were also calculated using these formulas to define the indices as below (Bass, 1971):

1. Cephalic index: $\frac{(eu-eu)x\ 100}{(g-op)}$, results of the calculation were classified into seven categories: ultradolichokran (<64,9), hyperdolichokran (65,0-69,9), dolichokran (70,0-74,9), mesokran (75,0-79,9), brachykran (80,0-84,9), hyperbrachykran (85,0-89,9), dan ultrabrachykran (>90,0).
2. Transverse frontoparietal index: $\frac{(ft-ft)x\ 100}{(eu-eu)}$, results of the calculation were classified into three categories: stenometop (<65,9), metrimetop (66,0-68,9), dan eurymetop (>69,0).
3. Nasal index: $\frac{(apt-apt)\ x\ 100}{(n-ns)}$, results of the calculation were classified into four categories: leptorrhin (<46,9), mesorrhin (47,0-50,9), chamaerrhin (51,0-57,9), hyperchamaerrhin (>58,0).

RESULTS

The data were not normally distributed. Therefore, the non-parametric test was employed.

The descriptive statistics along with the results of 2-Sample Kolmogorov-Smirnov test is provided in Table 2 as below. The male skulls have generally larger average measurements in all variables compared to the female counterparts. Highest variability was shown by the male samples in n-gn measurements, with the standard deviation of 7.62 mm.

Table 2

Results of 2-Sample Kolmogorov-Smirnov analysis

Variable	Sex	n	SD	Mean	2-sample KS	
					KS Z	Asymp. Sig. (2-tailed)
n-pr	Male	42	4.99	65.33	1.777	0.004
	Female	33	3.90	61.33		
n-ns	Male	46	3.10	49.04	2.373	0.000
	Female	35	2.98	46.26		
ft-ft	Male	47	4.08	91.49	1.059	0.212
	Female	36	4.35	89.33		
apt-apt	Male	46	2.47	26.80	1.138	0.150

	Female	35	2.09	24.92		
n-gn	Male	22	7.62	114.36	2.407	0.000
	Female	12	4.56	101.50		
go-go	Male	27	6.06	97.07	1.702	0.006
	Female	15	4.94	89.53		
eu-eu	Male	46	4.71	139.64	1.382	0.044
	Female	31	6.34	135.10		
zy-zy	Male	45	5.40	128.51	2.054	0.000
	Female	33	6.11	122.48		
g-op	Male	43	6.40	170.29	2.453	0.000
	Female	32	6.41	163.56		

Out of the nine variables, two variables are not statistically significant (*p* value > alpha = 0.05), meaning the measurements on ft-ft and apt-apt of both groups do not exhibit any significant differences between the male and female groups. The difference between male and female based on variables such as n-pr, n-ns, n-gn, go-go, eu-eu, zy-zy, and g-op appeared to be statistically significant. Variable with the highest differences, determined by the KS Z score, is the maximum skull length, or the distance between glabella and opistocranion (Table 2).

Table 3 shows that brachycranic category (47.6%) is the most frequently observed category in male cranium samples. None of the male samples belong to ultrabrachycranic category. Among the female samples, brachycranic is the most frequent category, making up to 50% of all female crania used in this study. Ultradolichocranic and hyperdolichocranic categories were not observed in both sample groups.

Table 3
Sample distribution in cephalic index categories

Category	**Male**		**Female**	
	n	**%**	**n**	**%**
Ultradolichocranic	0	0%	0	0%
Hyperdolichocranic	0	0%	0	0%
Dolichocranic	1	2.4%	2	6.7%
Mesocranic	12	28.6%	5	16.7%
Brachycranic	20	47.6%	15	50%
Hyperbrachycranic	9	21.4%	6	20%
Ultrabrachycranic	0	0%	2	6.7%
Total	**42**	**100%**	**30**	**100%**

The sample distribution in transverse frontoparietal index categories is presented in the following table (Table 4). Stenometope is the dominant category in both male (52.2%) and female (45.2%) sample group. On the other hand, eurymetope is the least frequently observed category among the samples used in this study, making up only 15.2% of the male samples and 16.2% of the female samples.

Table 4
Sample distribution in transverse frontoparietal index categories

Category	**Male**		**Female**	
	n	**%**	**n**	**%**
Stenometope	24	52.2%	14	45.2%
Metrimetope	15	32.6%	12	38.7%
Eurymetope	7	15.2%	5	16.1%
Total	**46**	**100%**	31	**100%**

Table 5 below presents the distribution of the sample in nasal index categories. According to the calculation, chamaerrhin is the most frequent nasal index category possessed by both male (41.3%) and female (52.9%) Javanese crania, followed by hyperchamaerrhine category which is indicated in 28.3% and 29.4% of the male and female sample, respectively.

Table 5
Sample distribution in nasal index categories

Category	**Male**		**Female**	
	N	**%**	**n**	**%**
Leptorrhine	4	8.7%	4	11.8%
Mesorrhine	10	21.7%	2	5.9%
Chamaerrhine	19	41.3%	18	52.9%
Hyperchamaerrhine	13	28.3%	10	29.4%
Total	**46**	**100%**	**34**	**100%**

DISCUSSION

As mentioned earlier, males typically have larger crania compared to females. This statement has been discussed in several published works on different populations (Bibby, 1979; Garvin et al., 2014; İşcan et al., 1995; Steyn & İşcan, 1998). One work furtherly suggests that the same pattern was observed in all age groups being studied (18-92 years old) (Velemínská et al., 2021). Yet, the dimorphism is significantly less noticed in senile crania (Musilová et al., 2016).

Current study employing comparative test is intended to analyze which craniometric points are the most sexually dimorphic in Javanese crania. According to previous studies, width measurements as in go-go and zy-zy contributed the most to the sexual dimorphism in Japanese crania (İşcan et al., 1995). However, another study suggests that bizygomatic breadth alone yielded lower correct classification rate (80.2 %) compared to when the classification is based on combined craniometric points (cranial length, bizygomatic breadth, basion-nasion, basion-bregma, nasal height, and nasal breadth) which provides the accuracy of 85.7% (Steyn & İşcan, 1998). A study on Western Australian population supports the earlier findings, reporting that the bizygomatic breadth (zy-zy) and the maximum length of the cranium (g-op) contributed significantly to sex discrimination (Daniel Franklin et al., 2013). Other study using non-metric approach also found that more prominent zygomatic arches, along with elongated skulls were associated with masculine skulls (Musilová et al., 2016). Similar findings were demonstrated in the current study, with the cranial length showing the most difference, followed by nasal height, bizygomatic breadth, and bigonial breadth.

As the distance between the two frontotemporale (ft-ft) does not show significant sexual dimorphism in this study, similar results were also reported by Franklin et al. (2013) and Perlaza (2014). Perlaza found no significant differences between male and female's frontal bone measurements. However, the same study reported that the significant differences were observed in the glabellar region instead. In addition to glabellar prominence, other study found that frontal inclination angle was one of the most sexually dimorphic traits in human frontal bone (Petaros et al., 2017).

The absence of statistically significant difference between the male and female's nasal aperture (apt-apt) in this study was also supported by other published works (de Oliveira Coelho Dutra Leal et al., 2019; Mahakkanukrauh et al., 2015; McDowell et al., 2015). McDowell et al. (2015) found no influence of sex on nasal aperture. The study, instead, found that nasal aperture is strongly influenced by ancestry.

Since the three indices were not statistically tested, this study cannot determine whether the Javanese male and female skulls shape significantly differ from each other. However, similar trend was indicated in Thai skulls, where most crania (42.7%) fall into brachycranic category (Woo et al., 2018).

CONCLUSION

It is commonly recognized that skull possesses many sexually dimorphic traits. However, assessment standards specifically designed for each population is important due to its population-specific characteristics. This study found that the measurements on n-pr, n-ns, n-gn, go-go, eu-eu, zy-zy, g-op shows a statistically significant difference between the two groups, indicating that those variables will more likely yield higher accuracy rates than the other two (ft-ft, apt-apt) when used to aid in sexing skulls. The findings also confirm previous studies that maximum nasal aperture width is poorly correlated with sex; therefore, we suggest that it is unnecessary to involve nasal aperture measurements to estimate the sex of Javanese skulls.

Future observations on different measurement points would be a great contribution to the study of contemporary Javanese crania. Developing non-metric methods shall be considerable as well in adding more information regarding this population.

REFERENCES

Baab, K. L. (2011). Cranial Shape in Asian Homo erectus: Geographic, Anagenetic, and Size-Related Variation. In *Asian Paleoanthropology* (pp. 57–79). https://doi.org/10.1007/978-90-481-9094-2_6

Baba, H., Aziz, F., Kaifu, Y., Suwa, G., Kono, R. T., & Jacob, T. (2003). Homo erectus Calvarium from the Pleistocene of Java. *Science*, *299*(5611), 1384–1388. https://doi.org/10.1126/science.1081676

Bass, W. M. (1971). *Human osteology: a laboratory and field manual of the human skeleton* (Vol. 2). Missouri Archaeological Society.

Berg, G. E. (2013). Determining the sex of unknown human skeletal remains. In M. T. Tersigni-Tarrant & N. R. Shirley (Eds.), *Forensic Anthropology: An Introduction* (p. 139).

Bibby, R. E. (1979). A cephalometric study of sexual dimorphism. *American Journal of Orthodontics*, *76*(3), 256–259. https://doi.org/10.1016/0002-9416(79)90022-8

de Oliveira Coelho Dutra Leal, M., Daruge, E., Francesquini, L., Costa, S. T., Delwing, F., Espejo, M. A. J., Jodas, C. R. P., & Line, S. R. P. (2019). Estimation of sex in Brazilian samples with cross-validation in populations of different regions. *Forensic Science International: Reports*, *1*, 100030. https://doi.org/10.1016/j.fsir.2019.100030

DeCarlo, D., Metaxas, D., & Stone, M. (1998). An anthropometric face model using variational techniques. *Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, 67–74.

Franklin, D., Freedman, L., & Milne, N. (2005). Sexual dimorphism and discriminant function sexing in indigenous South African crania. *HOMO*, *55*(3), 213–228. https://doi.org/10.1016/j.jchb.2004.08.001

Franklin, D., Freedman, L., Milne, N., & Oxnard, C. E. (2006). A geometric morphometric study of sexual dimorphism in the crania of indigenous southern Africans : research article. *South African Journal of Science*, *102*(5), 229–238. https://doi.org/10.10520/EJC96545

Franklin, Daniel, Cardini, A., Flavel, A., & Kuliukas, A. (2013). Estimation of sex from cranial measurements in a Western Australian population.

Forensic Science International, *229*(1–3), 158.e1-158.e8. https://doi.org/10.1016/j.forsciint.2013.03.005

Garvin, H. M., Sholts, S. B., & Mosca, L. A. (2014). Sexual dimorphism in human cranial trait scores: Effects of population, age, and body size. *American Journal of Physical Anthropology*, *154*(2), 259–269. https://doi.org/10.1002/ajpa.22502

Gonzalez, P. N., Bernal, V., & Perez, S. I. (2009). Geometric morphometric approach to sex estimation of human pelvis. *Forensic Science International*, *189*(1–3), 68–74. https://doi.org/10.1016/j.forsciint.2009.04.012

Green, H., & Curnoe, D. (2009). Sexual dimorphism in Southeast Asian crania: A geometric morphometric approach. *HOMO*, *60*(6), 517–534. https://doi.org/10.1016/j.jchb.2009.09.001

Hrdlicka, A. (1920). *Practical Anthropometry*. Wistar Institute of Anatomy and Biology.

Ibrahim, A., Alias, A., Nor, F. M., Swarhib, M., Abu Bakar, S. N., & Das, S. (2017). Study of sexual dimorphism of Malaysian crania: an important step in identification of the skeletal remains. *Anatomy & Cell Biology*, *50*(2), 86. https://doi.org/10.5115/acb.2017.50.2.86

İşcan, M. Y., Yoshino, M., & Kato, S. (1995). Sexual dimorphism in modern Japanese crania. *American Journal of Human Biology*, *7*(4), 459–464. https://doi.org/10.1002/ajhb.1310070407

Kaifu, Y, Aziz, F., Indriati, E., Jacob, T., Kurniawan, I., & Baba, H. (2008). Cranial morphology of Javanese Homo erectus: New evidence for continuous evolution, specialization, and terminal extinction. *Journal of Human Evolution*, *55*(4), 551–580. https://doi.org/10.1016/j.jhevol.2008.05.002

Kaifu, Yousuke, Kurniawan, I., Kubo, D., Sudiyabudi, E., Putro, G. P., Prasanti, E., Aziz, F., & Baba, H. (2015). Homo erectus calvaria from Ngawi (Java) and its evolutionary implications. *Anthropological Science*, *123*(3), 161–176. https://doi.org/10.1537/ase.150702

Kotěrová, A., Velemínská, J., Dupej, J., Brzobohatá, H., Pilný, A., & Brůžek, J. (2017). Disregarding population specificity: its influence on the sex assessment methods from the tibia. *International Journal of Legal Medicine*, *131*(1), 251–261. https://doi.org/10.1007/s00414-016-1413-5

Krüger, G. C., L'Abbé, E. N., Stull, K. E., & Kenyhercz, M. W. (2015). Sexual dimorphism in cranial morphology among modern South Africans. *International Journal of Legal Medicine*, *129*(4), 869–875. https://doi.org/10.1007/s00414-014-1111-0

Macaluso, P. J., & Lucena, J. (2014). Estimation of sex from sternal dimensions derived from chest plate radiographs in contemporary Spaniards. *International Journal of Legal Medicine*, *128*(2), 389–395. https://doi.org/10.1007/s00414-013-0910-z

Mahakkanukrauh, P., Sinthubua, A., Prasitwattanaseree, S., Ruengdit, S., Singsuwan, P., Praneatpolgrang, S., & Duangto, P. (2015). Craniometric study for sex determination in a Thai population. *Anatomy & Cell Biology*, *48*(4), 275. https://doi.org/10.5115/acb.2015.48.4.275

Marinescu, M., Panaitescu, V., Rosu, M., Maru, N., & Punga, A. (2014). Sexual dimorphism of crania in a Romanian population: Discriminant function analysis approach for sex estimation. *Romanian Journal of Legal Medicine*, *22*(1). https://doi.org/10.4323/rjlm.2014.21

McDowell, J. L., Kenyhercz, M. W., & L'Abbé, E. N. (2015). An evaluation of nasal bone and aperture shape among three South African populations. *Forensic Science International*, *252*, 189.e1-189.e7. https://doi.org/10.1016/j.forsciint.2015.04.016

Musilová, B., Dupej, J., Velemínská, J., Chaumoitre, K., & Bruzek, J. (2016). Exocranial surfaces for sex assessment of the human cranium. *Forensic Science International*, *269*, 70–77. https://doi.org/10.1016/j.forsciint.2016.11.006

Oikonomopoulou, E.-K., Valakos, E., & Nikita, E. (2017). Population-specificity of sexual dimorphism in cranial and pelvic traits: evaluation of existing and proposal of new functions for sex assessment in a Greek assemblage. *International Journal of Legal Medicine*, *131*(6), 1731–1738. https://doi.org/10.1007/s00414-017-1655-x

Pearson, A., Polly, P. D., & Bruner, E. (2021). Temporal lobe evolution in Javanese Homo erectus and African Homo ergaster: Inferences from the cranial base. *Quaternary International*, *603*, 5–21. https://doi.org/10.1016/j.quaint.2020.07.048

Perlaza, N. A. (2014). Sex Determination from the Frontal Bone: A Geometric Morphometric Study. *Journal of Forensic Sciences*, *59*(5), 1330–1332. https://doi.org/10.1111/1556-4029.12467

Petaros, A., Garvin, H. M., Sholts, S. B., Schlager, S., & Wärmländer, S. K. T. S. (2017). Sexual dimorphism and regional variation in human frontal bone inclination measured via digital 3D models. *Legal Medicine*, *29*, 53–61. https://doi.org/10.1016/j.legalmed.2017.10.001

Steyn, M., & İşcan, M. Y. (1998). Sexual dimorphism in the crania and mandibles of South African whites. *Forensic Science International*, *98*(1–2), 9–16. https://doi.org/10.1016/S0379-0738(98)00120-0

Tallman, S. (2019). Cranial Nonmetric Sexual Dimorphism and Sex Estimation in East and Southeast Asian Individuals. *Forensic Anthropology*, *2*(4). https://doi.org/10.5744/fa.2019.1010

Velemínská, J., Fleischmannová, N., Suchá, B., Dupej, J., Bejdová, Š., Kotěrová, A., & Brůžek, J. (2021). Age-related differences in cranial sexual dimorphism in contemporary Europe. *International Journal of Legal Medicine*, *135*(5), 2033–2044. https://doi.org/10.1007/s00414-021-02547-6

Walker, P. L. (2008). Sexing skulls using discriminant function analysis of visually assessed traits. *American Journal of Physical Anthropology*, *136*(1), 39–50. https://doi.org/10.1002/ajpa.20776

White, T. D., & Folkens, P. A. (2005). *The Human Bone Manual*. Elsevier. https://doi.org/10.1016/C2009-0-00102-0

Woo, E. J., Jung, H., & Tansatit, T. (2018). Cranial index in a modern people of Thai ancestry. *Anatomy & Cell Biology*, *51*(1), 25. https://doi.org/10.5115/acb.2018.51.1.25