

# Morphoscopic Examination to Estimate Sex in Forensic Anthropology: An Approach in Laboratory Teaching

Min Zhang<sup>1\*</sup>, Emmanuel Atta-Obeng<sup>2</sup>

<sup>1</sup>*Department of Criminal Justice, College of Behavioral and Social Sciences, Coppin State University, 2500 W. North Avenue, Baltimore, Maryland 21216*

<sup>2</sup>*Department of Natural Sciences, College of Arts & Sciences, and Education, Coppin State University, 2500 W. North Avenue, Baltimore, Maryland 21216*

\*corresponding author: [mzhang@coppin.edu](mailto:mzhang@coppin.edu)

**Abstract:** Morphoscopic examination is an important task in forensic anthropology sex estimation. Sexually dimorphic traits on skeletal structures are studied to complete this task. How to locate, observe, and compare the sexually dimorphic traits in males and females is critical in forensic anthropology teaching. The existing teaching modalities, facilities, and access to teaching sources of forensic anthropology courses vary among institutions. This article introduces a straightforward approach to morphoscopic examination based on Kiales et al. and Walker's methods in teaching. Sexually dimorphic traits identification on the anatomical skull and pelvic models and comparison on the computer-assisted 3D skull and pelvic models are included in this approach. The teaching purposes include locating and identifying the sexually dimorphic traits on the skull and pelvic anatomical models and comparing the differences of sexually dimorphic traits via computer-assisted 3D skull and pelvic models. The proposed approach aims to serve the morphoscopic examination sex estimation laboratory teaching purposes under various teaching modalities with appropriate considerations.

**Keywords:** morphoscopic examination, sex estimation, sexually dimorphic traits, Sketchfab

## Introduction

Sex estimation is one of the key assignments in biological profile estimation along with age, ancestry, and stature estimation. Estimating an unknown's sex is essential for the biological profile estimation because it affects how other factors, including age and stature, are analyzed (1). The fundamental behind sex estimation is that the size and shape of the skeleton vary in males and females. Sexual dimorphism is the term used to describe this distinction. The areas of the human skeleton that exhibit the most obvious sexual dimorphism are the pelvis and skull. Because of reproductive and hormonal considerations, the pelvis is considered superior to the skull in terms of sex estimation (2). The pelvis and skull are often examined to complement each other in sex estimation, or in situations where one of two structures is unavailable for analysis or gives confusing signals (3).

Morphoscopic examination and metric analysis are two of the examination techniques used in sex estimation. Observations of the existence, absence, or level of expression of specific skeletal features or traits are referred to as morphoscopic examination; while the distance or angle measurements between different landmarks are common metric analysis methods (1). Regardless of the discussion of which

technique is more accurate in sex estimation (4), the morphoscopic examination is often done prior to metric analysis in common practice (5). Sex estimation is a significant part not only of forensic anthropology practice but also of teaching. Accordingly, locating and identifying the sexually dimorphic traits on the skeleton, and comparing the trait differences in males and females are essential learning objectives for student learners. Here, we introduce a simple and straightforward approach to morphoscopic examination using anatomical models and computer-assisted three-dimensional (3D) models to provide a reference in general forensic anthropology teaching.

## Methods

### *Sexually dimorphic traits identification on the anatomical pelvic model*

The anatomical pelvic model was used to locate and identify the three sexually dimorphic traits ventral arc (VA), subpubic concavity (SPC) and medial aspect (MA).

*Sexually dimorphic traits comparison on the computer-assisted 3D pelvic model*

Sketchfab software (6) was used to compare male and female pelvic 3D models. The male and female 3D pelvic models were obtained from the Sketchfab databank and then observed by using Sketchfab's 360-degree rotation function. The ischiopubic ramus on male and female 3D pelvic models were both exposed and observed from the same oblique views. VA, SPC, and MA on male and female pelvic 3D models were identified by arrow identifiers and compared.

*Sexually dimorphic traits identification on the anatomical skull model*

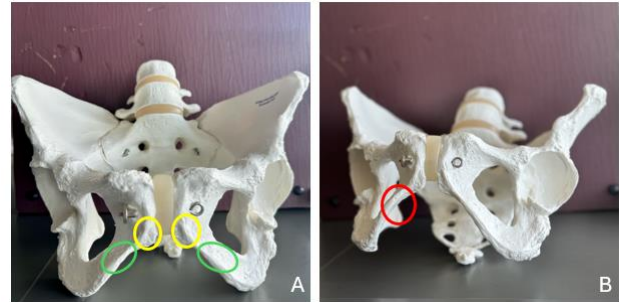
The anatomical skull model was used to locate and identify the five sexually dimorphic traits nuchal crest (NC), mastoid process (MP), supraorbital margin (ORB), glabella/supra-orbital ridge (GL), and mental eminence (ME).

*Sexually dimorphic traits comparison on the computer-assisted 3D skull model*

The same software was used in this comparison. The male and female skull 3D models were obtained from the Sketchfab databank and then observed by using Sketchfab's 360-degree rotation function. The male and female skull 3D models were both exposed and observed from the lateral view to observe NC, MP, ORB, and GL traits; the above four traits were identified by arrow identifiers and compared. The male and female skull 3D models were both observed from the anterior view to study their respective ME traits; then the ME traits were identified by arrow identifiers and compared.

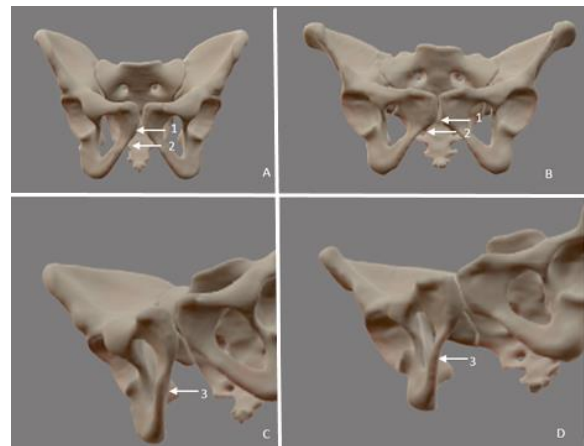
**Results**

1. Sexually dimorphic traits were identified on the anatomical pelvic model, as shown in **FIGURE 1**. VA is a dimorphic trait on both ischium bones, it starts at the contact points to the mid part of the pubic symphysis and descends inferiorly, arcing across the lines of the pubic arch and merging with the ischiopubic ramus' medial border. VA can be observed from the anterior view. SPC is located in the upper 1/3 to 1/2 pubic arch line area on both ischium bones, it can be observed from the anterior view. MA is the surface below the symphyseal surface on the ischiopubic ramus, it can be observed from the oblique view.



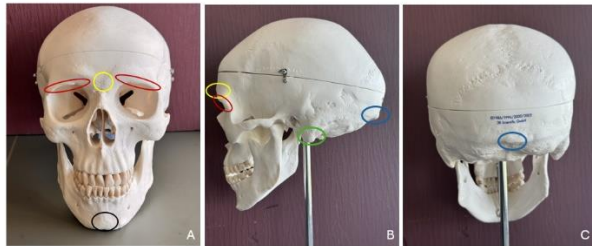
**FIGURE 1** Sexually dimorphic traits identification on the anatomical pelvic model. A: anterior view to locate and identify VA and SPC traits. The yellow circles indicate VA on the left and right ischiums, and the green circles indicate SPC on the left and right ischiums. B: oblique view to locate and identify MA. The red circle indicates MA on the right ischiopubic ramus.

2. Sexually dimorphic traits were observed and compared on the computer-assisted 3D pelvic model. As in **FIGURE 2**, female VA shows a squared shape with the extra triangle of bone, while male VA shows a slope inferior ridge; female SPC is relatively concave below the symphyseal face, while male SPC does not show concave compared with female's; female MA has a sharp ridge, while male's MA is much wider.



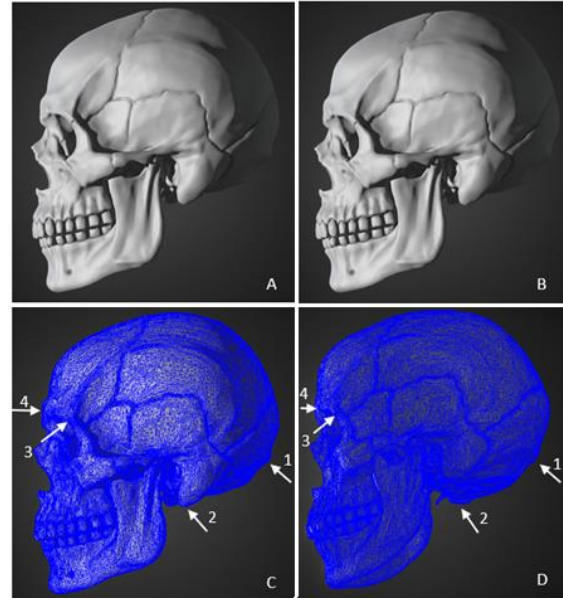
**FIGURE 2** Sexually dimorphic traits comparison on the computer-assisted 3D pelvis model. A & C: Anterior and oblique views of male (18y) pelvis. B & D: Anterior and oblique views of female (32y) pelvis. Arrow 1: VA; arrow 2: SPC; arrow 3: MA. The 3D models were obtained and compared by using Sketchfab. Original 3D model credits: Biological anthropologist Terrie.

3. Sexually dimorphic traits were identified on the anatomical skull model, as shown in **FIGURE 3**. NC is a prominent feature on the lower back of the skull and it can be observed from the lateral and posterior view. From the right lateral view, NC is the furthest area to the right of the occipital bone; from the posterior view, it is located above the foramen magnum. MP is located at the base of the temporal bones on each side of the skull, it can be observed from the lateral view. ORB is the upper orbital rim area of the square-shaped aperture at the front of the eye socket, it can be observed from the anterior and lateral views. GL is the prominence above the nasal bone and between the bone under the eyebrow areas, it can be observed from the anterior and lateral views. ME is a bony prominence located on the front part of the mandible, it can be observed from the anterior view.

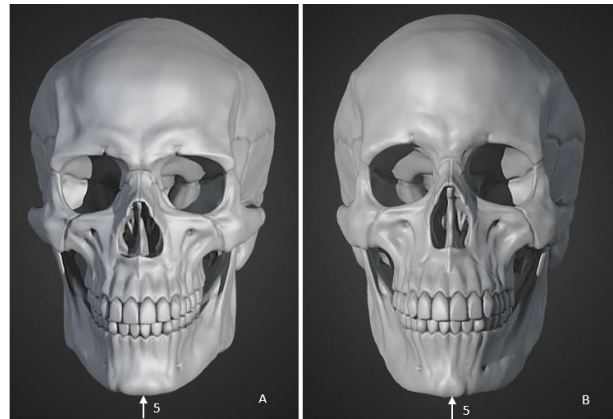


**FIGURE 3** Sexually dimorphic traits identification on the anatomical skull model. A: Anterior view to locate and identify ORB, GL and ME traits. The red circles indicate ORB, the yellow circle indicates GL and the black circle indicates ME. B: Lateral view to locate and identify NC, ORB, GL, and MP ME. The red circle indicates ORB, the yellow circle indicates GL, the blue circle indicates NC and the green circle indicates MP. C: Posterior view to locate and identify NC as the blue circle indicates.

4. Sexually dimorphic traits were observed and compared on the computer-assisted 3D skull model. As in **FIGURE 4**, female NC is smoother compared with male NC; male MP is larger and longer than that of the female; female ORB is relatively blunt and broad, and male ORB is pointed and thin; Male GL is larger than female GL, and male GL shows a rounded loaf-shaped projection but female GL does not show this feature. In **FIGURE 5**, male ME is more pronounced than female ME.



**FIGURE 4** Lateral view of sexually dimorphic traits comparison on the computer-assisted 3D skull model. A: Lateral view of male skull. B: Lateral view of female skull. C: B: Bule wireframe of A (male skull) with better visualization of four traits. D: Bule wireframe of B (female skull) with better visualization of four traits. Arrow 1: NC; arrow 2: MP; arrow 3: ORB; arrow 4: GL. The 3D models were obtained and compared by using Sketchfab. Original 3D model credits: Ruslan Gadzhiv.



**FIGURE 5** Anterior view of sexually dimorphic traits comparison on the computer-assisted 3D skull model. A: Anterior view of male skull. B: Anterior view of female skull. Arrow 5: ME. The 3D models were obtained and compared by using Sketchfab. Original 3D model credits: Ruslan Gadzhiv.

## Discussion and Conclusion

The morphoscopic method in sex estimation involves a visual assessment of skeletal features that tend to vary between males and females. The method typically involves observations of the presence, absence, or degree of expression of a particular feature or trait. The pelvic traits studied in this protocol include VA, SPC, and MA which were proposed by Klales et al. (7); and the cranial traits included the NC, MP, ORB, GL, and ME which were first described by Walker (8). These pelvic and skull traits are also commonly recorded and studied in current teaching and research trends (1) (9). The proposed sex estimation laboratory teaching approach utilized anatomical 3D models to locate and identify the abovementioned traits on the pelvis and skull, then reviewed and compared all traits in the computerized male and female virtual 3D models. The learning objective and corresponding outcome of identifying significant sexually dimorphic traits are shown in **FIGURES 1 and 3**; the learning objective and corresponding outcome of comparing the significant sexually dimorphic traits in males and females are shown in **FIGURES 2, 4, and 5**. The disparities of sexually dimorphic traits in males and females found in this approach are consistent with the findings from the previous studies (7) (8), suggesting that the proposed approach can serve the morphoscopic examination sex estimation laboratory teaching purposes.

A previous study (10) suggested that despite the availability of increasingly 3D models for use by students undergoing anatomy and osteology training, forensic anthropology teaching and learning still frequently rely on two-dimensional (2D) images. Not only in the learning context but also in other forensic anthropology contexts, such as the courtroom, 3D models have also been found to be helpful for comprehension. A recent forensic laboratory lab manual (11) addressed the consideration of students' diverse backgrounds, various laboratory settings based on the institutions' resources and teaching modalities, student numbers in the classrooms, and ethical issues in using real bones. The manual also described a laboratory teaching methodology that applies to the lower division undergraduate level regardless of the budgetary situation at any specific college or university. The proposed approach in this study aligns well with the advocated teaching philosophy. While this study strongly agrees that real bone osteology can not be replaced by any artificial teaching models, the results also indicate that detailed anatomical 3D human skeletons can help with the observation of the dimorphic traits and locating the

traits without damage or contamination concerns as when using real bone models.

The existing teaching modalities, facilities, and access to teaching sources of forensic anthropology courses vary among institutions (12). The proposed approach applies to various modalities including the in-person format by using the physical anatomical models, the virtual format by using computerized virtual 3D models, or the hybrid format by using both models. A previous study showed that although past 3D experience did not affect confidence levels with os coxa-sex, it did affect confidence levels in the estimation of skull-sex and os coxa-age models (13). In addition, a study using the same software suggested that the 3D models were more consistent in their performance and reported an increase in confidence regardless of prior experience (10). The results from the proposed approach also suggest that it is feasible to use computerized virtual 3D models via the same platform to compare the sexually dimorphic traits in the learning environment.

It is worth noting that the most likely biogeographical origin of a person can be estimated through ancestry estimation, and this information is important for sex estimation. The pelvic and skull traits recommended in this approach were mostly developed using Black and White samples from the United States, which could lead to misclassifications when applied to other populations. For example, when the Klales et al. and Walker methods were applied to Hispanic individuals, misclassifications were found especially with the skull traits method (14); when the pelvic traits in the Klales et al. method were applied to a worldwide population, sex estimation accuracy disparities were also found in different populations (15). Therefore, the ancestry-specific limitation and corresponding validation and recalibration data should be considered in laboratory teaching to objectively implement this approach. In addition, Klales et al. and Walker methods included respective scoring systems to estimate the sex, this approach does not include the scoring systems considering the focus of this protocol is the morphoscopic traits locating and comparison, no real human remains are used in this approach, and there are instructions and automatic scoring systems (16) available for direct estimation. With respect to the teaching context, the corresponding scoring systems can be used as a complementary tool to this approach.

The proposed laboratory approach can serve the morphoscopic examination sex estimation laboratory teaching purposes under various teaching modalities. With the consideration of students' diverse backgrounds, various laboratory settings based on the institutions' resources and teaching modalities,

student numbers in the classrooms, and ethical issues in using real bones, the proposed approach provides a reference for sex estimation laboratory teaching with the adoptive possibilities based on different institutions' teaching needs.

### Acknowledgments

We thank 3D biological anthropologist Terrie Simmons-Ehrhardt for her technical assistance and Sketchfab 3D models. Additionally, we appreciate the insightful feedback each reviewer provided on the manuscript.

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