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Original Article

Sex determination from different sternal measurements: A study in a Thai population

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ABSTRACT

Introduction: Estimation of sex is an important initial step for personal identification of unknown skeletal remains in forensic investigation. The aim of the present study was to evaluate the applicability of the sternum for sex estimation of adult skeletal remains by measuring the sternum of Thai individuals.

Methods: A study of 281 adult Thai dry sterna with known sex (192 males and 89 females) was carried out for sexing by using measurements. Discriminant function analysis was used.

Results: The results showed that all parameters included in this study were significantly sexually dimorphic except sternal width index. By using discriminant function analysis, it was observed that the best parameter was the combined length of manubrium and mesosternum yielded cross-validated sex allocation accuracy rate 85.8% (82.4% for male and 95.7% for female), followed by sternal area with classification accuracy rate 82.9% (79.2% for males and 91.2% for females) and the length of mesosternum with classification accuracy rate 81.1% (78.8% for males and 88% for females). A stepwise discriminant function, which included 5 linear measurements from both manubrium and mesosternum yielded highest classification accuracy rate of 86.4%.

Discussion: The results of the present study proved that the sternum is a reliable element for sex determination in Thai population and it may be a useful tool in forensic investigations.

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1. Introduction

In forensic investigations, one of the most important aspects is identification of human skeletal remains by creating biological profiles. The biological profile consists of individual's sex, age, stature, and ancestry. Accurate estimation of sex is important because other biological profiles, such as age, stature, and ancestry, are sex dependent.[1] Generally, forensic anthropologists rely mainly on sex assessment methods based on analyses of pelvis and skull, which are known to be highly accurate, but relying heavily on those two bones within a forensic context is limiting because they have been subjected to trauma, prone to taphonomic process, such as animal scavenging, burning, and dismemberment, or may not be present, at all.[2] Without skull and pelvis, it becomes difficult for the expert to judge the age and sex accurately. Therefore, it is of utmost need that an alternative element of the skeleton be investigated as potential indicators of sex.

The skeleton, which resists putrefaction for long time, is useful for sex determination. The sternum is one of such bones and is usually found together with anterior thoracic cage in forensic investigations. The human sternum consists of three parts, named superior to inferior, i.e. the manubrium, the body or mesosternum, and the xiphoid process. The xyphoid process is often varied, so only the manubrium and mesosternum are usually used for sexing purpose.[3] Numerous studies had shown that analyzing the sternum may lead to an accurate estimation of sex. However, most of the previously published methods showed the sternum is population specific signifying that the data would not prove useful in the Thai population.[1,2,4–8] This prompted us to develop osteometric standards for estimating sex from the sternum of a Thai population.

In Thailand, several parts of the skeletons have been used to determine sex, including the femur,[9] humerus,[10] vertebral column,[11] radius,[12] calcaneus,[13] mastoid process,[14] the metacarpals,[15] proximal hand phalanges,[16] and sternum.[17] A previous study of sexing the sternum in Thai population resulted in no significant sexual dimorphism and that finding was different from other previous studies conducted around the world. However, the populations may experience secular changes, after more than one decade, and thus require using new representative skeletal collections for the determination of sex. Hence, the main objective of this study was to evaluate the applicability of the sternum for sex estimation of adult skeletal remains by measuring the sternum of Thais.

2. Materials and methods

The adult dried human sterna of 281 Thai individuals of known sex (192 males and 89 females) were procured for the present study. The specimens were collected from the Forensic Osteology Research Center at Chiang Mai University, Thailand. The ages at death of the specimens used in the present study ranged between 28 and 96 years (mean age of 67.34 years for males and 65.84 years for females).

The definitions of measurements and calculated indices are described in Table 1 and correspond to the illustration provided in Fig. 1. Measurements of the sternum were provided by McCormick et al.[18] and Jit et al.[19] All the parameters were measured in millimeters by using Mitutoyo Digimatic Caliper®. Any sterna with signs of pathology, trauma or fracture, and deformity were excluded from the present study.

The data obtained were then analyzed by descriptive statistics, utilizing IBM SPSS® version 20.0 statistical package for window to find the mean, standard deviation, minimum, and maximum of all the data in each sex. The independent t-test was applied to test the significance of differences between mean values of various parameters in both sexes. One-Sample Kolmogorov–Smirnov Test was conducted for all parameters to determine whether the data were normally distributed. Five linear measurements from both manubrium and mesosternum were subjected to stepwise discriminant analysis to select the most important variable, which classify between males and females with higher correct percentage. Other stepwise discriminant functions were also generated for manubrium dimensions (two linear measurements) and mesosternum (three linear measurements). Lastly, direct discriminant function analysis was generated for all parameters to find out which

Table 1 – Definitions of the measurements used in the present study followed McCormick et al.[18] and Jit et al.[19] The measurements are illustrated in Fig. 1.

Measurement	Definition
1. Manubrium length (M)	Direct distance, from the anterior aspect and in the midline, from jugular notch to manubriosternal junction
2. Sternal body length (B)	Direct distance, from the anterior aspect and in the midline, from manubriosternal junction to mesoxiphoidal junction
3. Combined length of manubrium and body (CL)	Sum of the manubrium and sterna body lengths (M + B)
4. Manubrium width (MW)	Width between the left and right facets for the first costal cartilage
5. Corpus sterni width at first sternebra (CSWS1)	Minimum distance at the level of the line passing from the point between the facet for the second and third costal cartilage on each side
6. Corpus sterni width at second sternebra (CSWS2)	Minimum distance at the level of the line passing from the point between the facet for the third and fourth costal cartilage on each side
7. Corpus sterni width at third sternebra (CSWS3)	Minimum distance at the level of the line passing from the point between the facet for the fourth and fifth costal cartilage on each side
8. Sternal Index (SI)	Calculated as the division of M by B, multiplied by 100: [(M/B) × 100]
9. Sternal Area (SA)	Calculated by: [(M + B) × (MW + CSWS1 + CSWS3)/3]
10. Sternal Width Index (SWI)	Calculated as the division of CSWS1 by CSWS3, multiplied by 100: [(CSWS1/CSWS3) × 100]