Legal Medicine xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Legal Medicine

journal homepage: www.elsevier.com/locate/legalmed

Estimation of sex in Japanese cadavers based on sternal measurements using multidetector computed tomography

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ARTICLE INFO

Article history:
Received 15 October 2014
Received in revised form 15 January 2015
Accepted 22 January 2015
Available online xxxx

Keywords:
Forensic anthropology
Multidetector computed tomography
Sternum
Japanese
Sex discrimination

ABSTRACT

This study assessed the sex-discrimination potential of the sternum in a Japanese population using three-dimensional (3D) computed tomographic (CT) images. A total of 200 cadavers (100 males, 100 females) who underwent postmortem CT and subsequent forensic autopsy between December 2011 and June 2014 were used. Five measurements of each sternum were performed on 3D CT reconstructed images that extracted only bone data, and two sternal dimensions and three indices were calculated. Univariate discriminant function analyses using these linear measurements and calculated sternal dimensions and indices yielded sex classification accuracy rates of 62.5–84.0%, and 63.0–90.5%, respectively. The results of this study indicate that sternal measurements may be useful for the forensic assessment of sex in Japanese individuals, particularly in cases where better predictors, such as the pelvis or skull, are unavailable.

1. Introduction

Accurate sex estimation of skeletal remains is an important part of medicolegal investigations, as it effectively reduces the pool of potentially matching identities and subsequently determines the most appropriate standard to apply for estimating other biological characteristics such as age, stature, and ancestry [1,2]. However, anthropologists often have difficulty in assigning sex to remains that are incomplete, fragmented, or damaged, which may result from incidents such as mass disasters, airplane crashes, fire, explosions, or physical violence [1,3]. Thus, reliable sex criteria based on isolated bony elements should be developed.

To date, the pelvis and skull have been primarily analyzed for sex assessment because they provide accurate estimates [4,5]. However, the pelvis, the most accurate indicator of sex, is fragile and is not always available for sex assessment [6]. In addition, sex discrimination based on the skull is less accurate than that using most bones of the postcranium [7]. Therefore, skeletal elements other than the pelvis and skull need to be evaluated to determine whether they are potential predictors of sex.

Previous researchers have investigated various linear dimensions of the manubrium and mesosternum in different populations and have reported that they are sexually dimorphic, establishing high diagnostic values for osteometric sex assessment [2,8–15]. According to the Forensic Anthropology Data Bank (FDB) (courtesy of Dr. Richard L. Jantz), which showed an inventory of skeletal remains including 1553 cases, the recovery rate of the manubrium and sternum is over 59%. This data indicates that the sternum is a potentially useful skeletal element in forensic anthropological analyses. However, discriminant function analysis based on sternal measurements in a Japanese population using three-dimensional (3D) multidetector computed tomographic (MDCT) images have not been conducted. Previous studies have revealed that while discriminant function analysis is extremely useful for establishing the identity of fragmentary remains using measurements of bone dimensions, such estimates are highly population-specific and not reproducible in other population groups [16,17]. This is particularly true with respect to indices and dimensions [10]. Therefore, different formulae are required for different populations.

Recently, postmortem computed tomography (PMCT) has routinely been performed using MDCT at some forensic departments and institutes and have been applied to forensic anthropology. PMCT imaging is a good method to depict osseous structures

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http://dx.doi.org/10.1016/j.legalmed.2015.01.003
1344-6223/

[18,19]. In addition, various authors have reported that metric bone measurements using CT scans yield the same accuracy as that of direct measurements of osteological bone traits of individuals by physical anthropologists [15,20]. Flanklin et al. [2] analyzed sternal sexual dimorphism in a sample of modern Western Australian individuals using 3D CT images. Changani et al. [21] also assessed the sexual dimorphism in the sternum based on the measurements of 3D CT images in a Gujarat population.

The aim of this retrospective study was to develop population-specific discriminant function equations for predicting sex based on sternal measurements in a contemporary Japanese population sample using 3D CT images.

2. Materials and methods

This study protocol was approved by the ethics committee of Chiba University, and the requirement for approval from subjects' relatives was waived.

A total of 723 Japanese subjects (500 males, 223 females) who underwent PMCT and subsequent forensic autopsy at the department of legal medicine of Chiba University between December 2011 and June 2014 were reviewed. Unidentified, child (less than 20 years old), sternum fracture, burning, thoracic trauma, resuscitation by cardiac massage, and acquired or congenital abnormalities were the exclusion criteria. Data for 200 subjects including 100 male cadavers (range, 24–90 years; mean age, 52.6 ± 16.6 years) and 100 female cadavers (range, 21–90 years; mean age, 52.6 ± 16.7 years) were collected.

PMCT was performed using a 16-row detector CT system (Eclos, Hitachi Medical, Tokyo, Japan). The scanning protocol was as follows: collimation, 1.25 mm; reconstruction interval, 1.25 mm; tube voltage, 120 kVp; tube current, 200 mAs; and rotation time, 1/s. A hard filter was used. Image data were processed on a workstation (Synapse Vincent, Fujifilm Medical, Tokyo, Japan) to obtain orthogonal multiplanar reconstruction images and volume-rendered images.

For assessment, a 3D CT reconstructed image that extracted only bones using CT value data was used. Measurements were performed to the nearest 0.1 mm using electronic cursors following the techniques described by Ashley [22] and McCormick et al. [23] (Fig. 1). The five measurements, two sternal dimensions, and three indices defined in the literature are shown in Table 1. If the manubrium was completely fused to the mesosternum, a landmark was placed at the midpoint of the articular facets of the second costal cartilage along the lateral borders of the sternum to differentiate the manubrium and the mesosternum [23]. Similarly, if the mesosternum was completely fused to the xiphoid process, a landmark was placed at the inferior margin of the two articular demifacets of the seventh costal cartilage along the lateral borders of the sternal body to differentiate the mesosternum and the xiphoid process [24].

On 20 images selected randomly from subjects, five linear measurements of the manubrium and mesosternum were performed repeatedly by the first researcher after an interval of a month from the time of the first measurements. For evaluation of intraobserver errors, the relative technical error of measurement (rTEM, %), and the coefficient of reliability (R) were calculated. The acceptance range of rTEM for intraobserver error was <5%, and an R value >0.75 was considered sufficiently precise [25,26].

All statistical analyses were performed on a personal computer using SPSS version 21.0 computer software (IBM, Armonk, NY, USA) and Excel software (Microsoft Office 2007, Microsoft, Redmond, WA, USA). The means, standard deviations, standard errors, and ranges of the ten variables were calculated for male and female

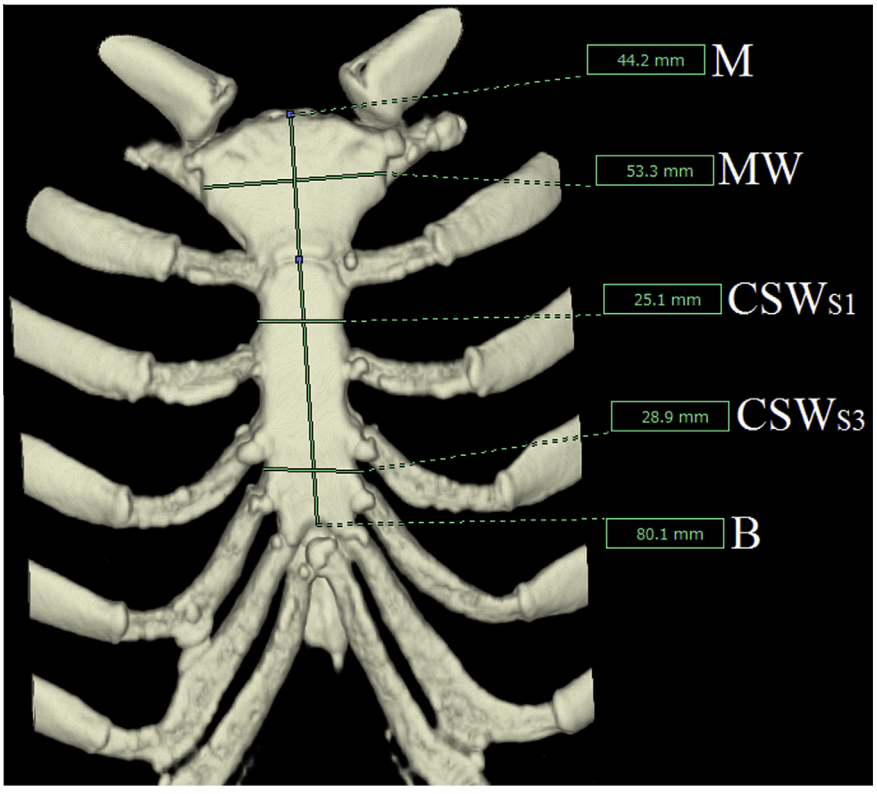

Fig. 1. A reconstructed three dimensional computed tomographic image showing five measurements of the sternum (M, manubrium length; B, sternal body length; MW, manubrium width; CSW_{S1}, corpus sternal width at first sternebra; and CSW_{S3}, corpus sternal width at third sternebra) in the coronal plane viewed from the anterior side of the body.

Please cite this article in press as: Torimitsu S et al. Estimation of sex in Japanese cadavers based on sternal measurements using multidetector computed tomography. Leg Med (2015), http://dx.doi.org/10.1016/j.legalmed.2015.01.003