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Forensic Anthropology Population Data

Morphometric sexual dimorphism of human sternum in a north Indian autopsy sample: Sexing efficacy of different statistical techniques and a comparison with other sexing methods

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ABSTRACT

Forensic anthropologists have proposed different sex determination methods based on metric and non-metric skeletal features of various bones. The main objective of the present investigation was to evaluate sexual dimorphism in human sternum and make comparative analysis based on studies by several workers who used different methodologies and techniques. For this study, 343 sternums were collected and examined from 252 male and 91 female cadavers of a north Indian population. Significant differences were noticed between the mean sternal measurements measured directly on bone specimens in present study and those measured indirectly on radiographs or CT scan images reported by previous researchers. Comparative analysis of absolute sternal measurements showed concordance with some earlier Indian studies but discordance with most other population studies conducted worldwide. Limiting points gave much higher sex accuracy levels than the demarking points. The calculated multivariate DFA equation ($y = -14.222 + 0.076MBL + 0.137WS\_1$) and regression equation ($y = 36.675 - 0.198MBL - 0.405WS\_1$) correctly estimated sex of 84.8% and 89.8% sternums, respectively. Multivariate analyses gave more striking results than the univariate ones. Though logistic regression analysis gave higher accuracy rates but discriminant function analysis was found to be a more reliable statistical tool for sex determination because of low sex biases. The sexing efficacies of the dry and wet sternums did not differ significantly, so bone specimens are equally reliable as the radiographs or CT scans for sex determination. The sternal area and the combined length were found the best parameters among all the criteria and methods considered. The changes in the body proportions, nutritional, environmental, climatic changes, etc., are attributable to secular changes in sterna measurements when compared to Jit et al. [13]. The osteometric techniques are better representative of biological identity of the deceased because of some inherent defects associated with radiographic methods. Like other sex-predictive bones of the human skeleton, the sternum can also be a valuable adjunct for sex determination of unknown subjects.

1. Introduction

Identification of the deceased from the skeletal remains is one of the most crucial problems faced by forensic experts. Sex determination, especially when the skull and pelvis are either missing or are highly damaged is a challenge in forensic work. Since, the recovery of sex predictive bones in the forensic context is a chance factor, forensic anthropologists have explored the possibility of using metric and/or non-metric features of other bones of the human skeleton for sex determination – the former being considered somewhat more reliable sex estimators than the latter ones for a particular bone as metric traits can be subjected to objective statistical analyses [1]. The differences in bone metrics are well documented and have been reported widely, not only among individuals of different population groups, but also between the two sexes. Such variations are due to various factors documented in the literature [2–4] and are considered a reliable cause of sexual dimorphism in different skeletal districts of human skeleton.

The anterior thoracic cage with the sternum in its median aspect is frequently encountered in the forensic anthropological contexts [5,6]. Morphometric sexual dimorphism in human sternum has been studied extensively, though few non-metric studies have also been reported [5–22]. These studies have been

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conducted either directly on the wet sternums collected from autopsied cadavers or on dry bones of prominent bone collections, or indirectly on the sternal images of chest-plate radiographs or computed tomographs of the living subjects.

Like other forensic disciplines, there is a lack of "consensus" on the applicability and use of different methods and statistical procedures in forensic anthropology [23]. The reliability of sexing methods decreases considerably when they are applied to some other unrelated population sample/s [24,25]. Thus, newer population-specific standards are the need of hour because of varied reasons like secular changes in bone metrics or differential activity-patterns, etc., which, in turn, infuse variations in the metric dimensions and non-metric features of human skeleton, and hence sexual dimorphism, among different population groups [1,26]. In this perspective, it becomes essentially advantageous to review and update the accuracy and precision of existing sexing methods which have become obsolete with the passage of time. Though most of the previous studies have reported considerable sexual dimorphism in human sternum [5–22], but all the researchers do not unanimously agree upon the relative usefulness of different sternal dimensions or the techniques/methodologies used for assessing sexual dimorphism, of an unknown or badly damaged/fragmented sternum.

More than three decades have elapsed since Jit et al. [13] had reported sexual dimorphism in dry human sternums of the same heterogeneous population considered in the present study. Due to secular trends and changed environmental or nutritional conditions, the standards proposed by Jit et al. [13] are considered obsolete today and hence are no longer applicable to present day population of this region. Besides changes in the body proportions, the study sample has suffered a number of nutritional, environmental and climatic changes since Jit et al. [13]. So this study attempts to investigate any secular changes in the sternal dimensions and their sexing efficacy since 1980, and to augment population data on the topic. The sample drawn from different states (also considered in the present study) was considered as one population sample by Jit et al. [13] based on their similarity in morphometric/physical dimensions and body proportions [13,27] and similar dietary patterns. The present study was conducted on freshly collected cadaveric sternums (wet in nature) from adult autopsies with the following aims and objectives:

- To report sexual dimorphism in the sternal measurements.
- To compare the sex determination efficacy of different conventional methods and the univariate/multivariate statistical analyses applied to different sternal measurements.
- To compare the study results with other previous studies conducted worldwide using different methodologies and techniques.
- To identify a comparatively better sex determination method among the other methods like discriminant function analysis, logistic regression analysis, limiting points, demarking points, etc., described in the literature.
- To formulate osteometric standards, discriminant functions and regression equations for prediction of sex based on various sternal measurements of the cadaveric subjects of Chandigarh region of north India.

2. Materials and methods

2.1. Population data

The present study was conducted using 343 intact adult sternums (aged 18–94 years), removed from the cadavers of known sex (males, 252 and females, 91) brought for medico-legal autopsy to the Department of Forensic Medicine, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India. The ethical clearance was obtained from the institute and written informed consent of next of kin of the deceased was sought in each case. The present study population is a heterogeneous sample of the subjects demographically belonging to the three north Indian States of India, i.e., Punjab, Haryana, Himachal Pradesh; Union Territory of Chandigarh and only the western part of the state of Uttar Pradesh. The entire area was once a part of erstwhile State of Punjab (now politically divided into four states). The sample belongs to the same distinctive cluster whose inhabitants share similar genetic, climatic and nutritional conditions, physical dimensions and body proportions, food habits, gene frequencies and other distinguishing traits, though with some morphological differences in appearances [7]. The sternums from the cadavers of other regions were discarded to avoid distortion in the sternal measurements as sternums of different regions of India have been reported to exhibit different dimensions (13–20), probably due to different genetic, environmental, dietary or occupational factors.

2.2. Methodology

Each sternum was disarticulated from the clavicles and separated from the ribs by giving incisions at the sterno-clavicular and costo-chondral junctions. The removed sternum was cleaned, washed and dried for taking measurements. Sternums with any visible fracture, pathology, surgical repairs, deformity/abnormality, etc., were excluded from the sample to maintain a good structural integrity of the sample. Specimens not showing fusion line between the three sternal elements were also not included. Caution was taken to ensure that the boiling and cleaning process did not cause separation of the three sternal segments. Muscular attachments, if any, remaining after boiling were carefully removed by scraping with a blunt scalpel. Each sternum was measured thrice and their average was recorded as the mean value of the variable. The two indices and sternal area were calculated. The sternum thus examined was replaced into the body after conduction of postmortem of each case as per the terms of the ethical clearance. Each linear measurement was measured on the anatomical position of the sternum

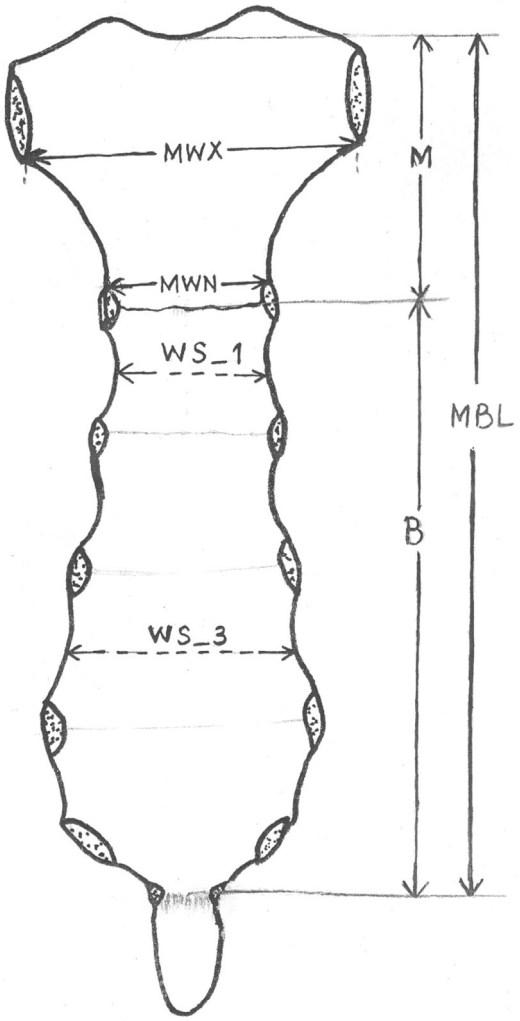

Fig. 1. Diagram showing landmarks for taking various sternal measurements.