



Forensic Anthropology Population Data

Sexual dimorphism of the calcaneus in contemporary Cretans

Despoina Nathena^a, Effrosyni Michopoulou^{b,*}, Elena F. Kranioti^{b,c}^a Department of Forensic Sciences, University of Crete, Medical School, Heraklion, Greece^b Edinburgh Unit for Forensic Anthropology, School of History, Classics and Archaeology, University of Edinburgh, 4 Teviot place, EH8 9AG Edinburgh, UK^c Forensic Pathology Division Crete, Hellenic Republic Ministry of Justice and Human Rights, Heraklion, Crete, Greece

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ABSTRACT

During the past decade, several studies have been carried out using the calcaneus bone for sex estimation. This paper collected data using ten variables for metric characteristics of the calcaneus of 144 modern Cretans and examined their correlation with known sex. Secondly, the formulae developed by Peckmann et al. (2015) for modern Athenians was put to the test in order to investigate if it could be applied to this modern Cretan sample as well. Results showed a high correlation between the calcaneus metrics and the known sex of the individuals, however the formulae for Athenians do not seem to be suitable for the Cretans due to the high sex bias reported in this study. Thus, new standards were created for sex estimation from the calcanei in our sample. Bilateral asymmetry was noted in the majority of cases, thus formulae were developed for left, right and mean values. Maximum width (MAXW) was the variable that performed the best in the Cretan sample. Overall, the cross-validated accuracies for univariate and multivariate equations reached 84.2% with males most often correctly identified. The calcaneus was proved to be useful for sex estimation in this modern Cretan population. Further work will explore the suitability of the produced standards for other regions of mainland Greece and islands.

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1. Introduction

In the past several decades, forensic anthropology as well as bioarchaeological research have expressed a growing interest towards identifying the sex of an individual from its skeletal elements. Long bones, flat bones and the skull have been the subject of numerous studies based on different reference populations employing a vast variety of different measurements [1–5]. Amongst the sexually dimorphic bones of the human skeleton, the calcaneus, which is considered the most robust bone of the foot, is the focus of this study.

In humans, the calcaneus, or *heel bone* is a bone of the tarsus of the foot that constitutes the heel. The half of the bone proximal to the heel is the calcaneal tubercle. On its distal edge on either side are the lateral and medial processes, serving as the origins of the abductor hallucis and abductor digiti minimi muscles. The cuboid bone articulates with its anterior side, and on its superior side there are three surfaces for the articulation with the talus bone. At the

superior and anterior of the medial surface of the calcaneus, lies the sustentaculum tali, which serves as an attachment site [6–8].

The calcaneus has long been acknowledged as an important skeletal element due to its role in locomotion and weight transmission and because it serves as an indicator of body size in modern humans and other hominids [9–11]. More specifically, Neanderthal calcanei have a relatively larger articular surface, longer calcaneal body and very projected sustentaculum tali compared to modern humans [10,12,13].

Even amongst humans, morphological variation of the calcaneus has been noted since 1931 by Wells [14] who described such differences between Bantu, Bushman and Europeans [15]. Decades later, Bunning and Barnett [16] reported variation on the number of talar articular facets of the calcaneus (1–3 facets) between British, Indians, Nigerians and indigenous people from Sri-Lanka. Ever since, the calcaneus has been the subject of several population specific studies for sex, stature and ancestry estimation [15,17–26].

Sex estimation methods are traditionally based on osteometry but can also include more sophisticated tools in terms of data acquisition and analysis such as 3D reconstruction of bones from Computed Tomography or surface scans (white light, laser), geometric–morphometric methods, neural networks or decision trees. Following the current trends in forensic methodology

* Corresponding author at: Edinburgh Unit for Forensic Anthropology, School of History, Classics and Archaeology, University of Edinburgh, William Robertson Wing, Old Medical School, Teviot Place, Edinburgh, EH8 9AG, UK.
Fax: +44 131 650 2378.

E-mail address: e.michop76@gmail.com (E. Michopoulou).

radiographs [27] and CT scans of the calcaneus have also been employed for sex estimation [28].

This study focuses on the use of metric characteristics of the calcaneus in sex identification based on a contemporary sample from Crete, Greece. The calcaneus bone was used in the current study because it is often well preserved, as humans in modern societies tend to be found buried wearing shoes, which protect the heel from wear and post mortem erosion. Although standards for Greeks have been produced in the past [24], previous research suggests the existence of sex bias when the standards from mainland Greece are applied in the Cretan population [5]. The aim of this study is to explore the existence of sexual dimorphism in the Cretan calcaneus and to test the efficiency of the formulae produced for Athenians when applied in a contemporary

collection from Crete. The results of this study will provide an additional sex estimation method of unidentified remains for the island of Crete.

2. Materials and methods

The skeletal material for this study was selected from the Cretan collection [29,30]. The study population consists of individuals born in Crete between 1867 and 1956, and died between 1968 and 1998. Age and cause of death were obtained from the Heraklion City Hall census archives for only part of the skeletal material, while sex was inferred from the names written on the boxes that contained the remains and was cross-checked with pelvis morphology.

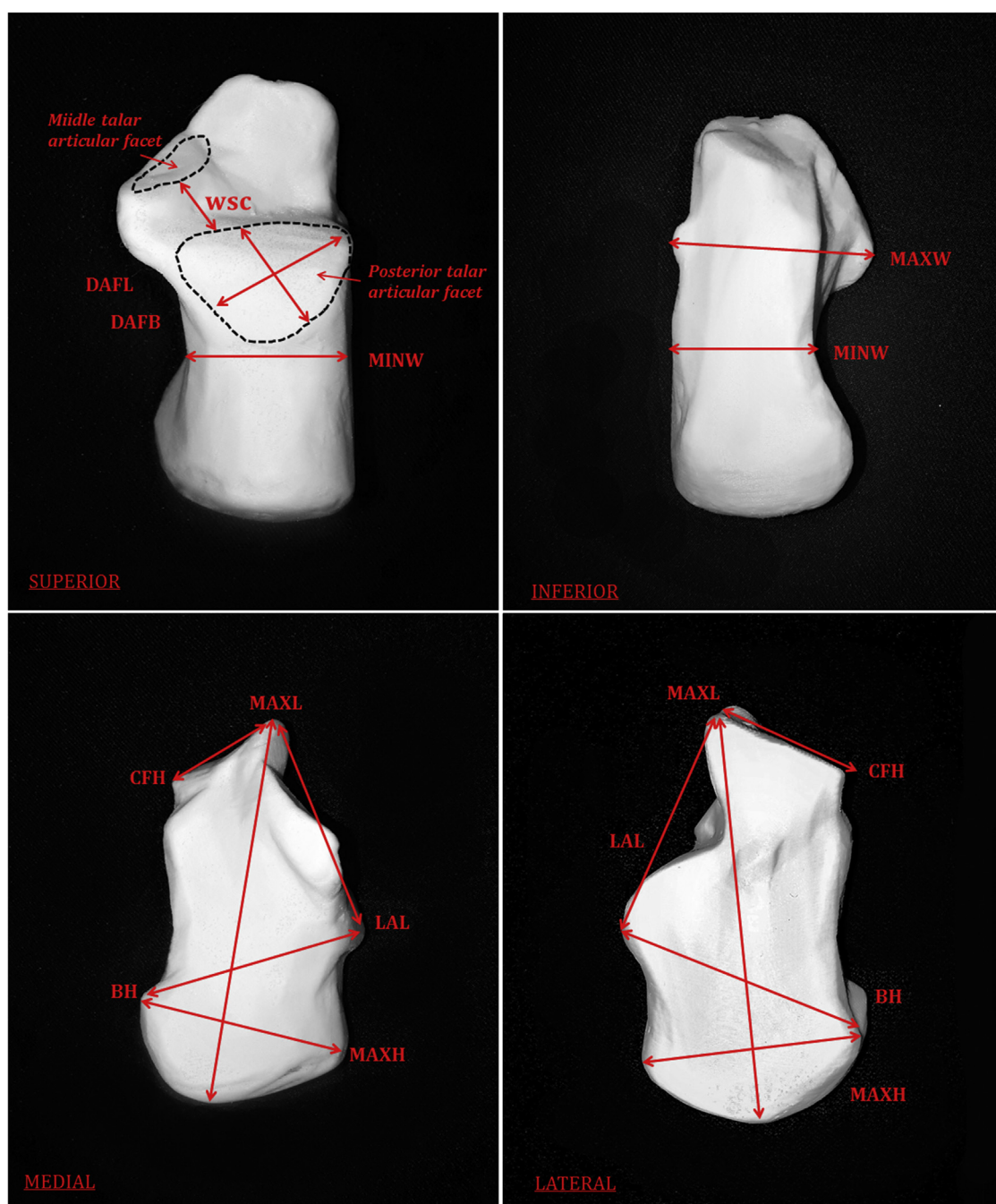


Fig. 1. Superior, inferior, medial and lateral views on a 3D printed right calcaneus bone. All ten measurements taken for this study are demonstrated using arrows.

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