A14 The Relationship of Enthesis Size to Muscle Size and Sexual Dimorphism in the Cranium and Clavicle in New Zealand and Thai Populations

Jade S. De La Paz, MS, University of Otago, Department of Anatomy, Dunedin, Otago 9016, NEW ZEALAND; Stephanie Woodley, PhD, University of Otago, Dunedin 9016, NEW ZEALAND; Hallie Buckley, PhD, University of Otago, Dunedin, Otago 9016, NEW ZEALAND; Siân Halcrow, PhD, University of Otago, Dunedin 9016, NEW ZEALAND; Nawaporn Techataweewan, PhD, Khon Kaen University, Khon Kaen, THAILAND*

Learning Overview: After attending this presentation, attendees will understand the relationship between entheses (muscle attachment sites) and muscle size from eight selected upper limb and neck muscles and how entheseal size relates to human skeletal sexual dimorphism in both the cranium and clavicle in two different populations.[1-3]

Impact on the Forensic Science Community: This presentation will impact the forensic science community by examining how muscle size may influence the associated entheseal area and whether entheseal measurements can predict sexual dimorphism at two skeletal landmarks on the cranium (the nuchal crest and mastoid process) and one on the clavicle (the rhomboid fossa).[1-3] This project is also relevant to the forensic science community as it will explore how entheseal measurements may inform the development of a metric sex estimation method from these landmarks.

The overall aim of this research is to create a valid and reliable method for estimating sex from the cranium and clavicle, and this will be achieved through the analysis of soft tissue anatomy and its relationship to sexually dimorphic areas of the skeleton. Reliable sex estimation is essential to identifying missing persons and to understanding archaeological populations, among other things. In the absence of a pelvis for sex estimation, cranial and postcranial elements can be used following existing metric and morphological methods.[1-4] However, morphological scoring requires experience, and these methods can be impacted by the subjectivity of the observer.[5-8] Although expertise is important in biological profile estimation, and subjectivity can never be fully eliminated, metric methods may help improve accuracy through the use of standardized measurements and population-specific equations.[4]

This presentation follows on from previous research presented at the 2020 AAFS meeting, which discussed the relationship between muscle size, sex, and the three key skeletal landmarks.[9] The muscles included in both studies were upper trapezius and semispinalis capitis (associated with the nuchal crest); sternocleidomastoid, splenius capitis, and longissimus capitis (associated with the mastoid processes); and the clavicular head of pectoralis major, sternohyoid, and subclavius (associated with the rhomboid fossa). The research presented here examines the specific relationship between muscle entheseal area and (1) muscle size and (2) the sexual dimorphism observed at the associated skeletal landmarks, scored using established methods.[1-3]

European New Zealand and Thai populations were represented in a sample of 20 bequeathed cadavers from the University of Otago (ethics reference, H18/113) and Khon Kaen University (ethics reference, HE621296). The head and necks were dissected to obtain the physiological cross-sectional area (fascicle volume/length), or overall size, of each muscle of interest (eight in total). Following the dissection of each muscle, the entheses were outlined on the skeleton using a grease pencil, and 3D scans were taken of the outlined entheses using a 3D scanner tablet attachment. Scans were then uploaded to a 3D animation program through which area measurements could be taken. Accuracy of 3D scans was assessed by completing some scans with a scale bar present and validating measurements for both length and area in the computer program.

Results from previously presented research showed differences in muscle size between males and females for all muscles studied, except for upper trapezius, right longissimus capitis, and right subclavius. However, preliminary results from this study show few significant differences between sex in relation to entheseal size. Of the 27 entheses measured, including entheses both directly related to the skeletal landmarks of interest as well as those only related to the muscles studied, 7 were significantly different, with entheseal size being larger in males compared to females. Interestingly, the right longissimus capitis showed a significant difference between sexes for enthesis size but not muscle size. This may suggest that muscle attachment size may not be related to sexual dimorphism as much as is assumed in sex estimation methods.[1-3] This further supports findings from the previously presented data, which showed that although there were significant differences between males and females in muscle size, there was no significant relationship between skeletal landmark scores and muscle size. Understanding the relationship of different factors to sexual dimorphism in the cranium and clavicle is an important element of discussing sex estimation in forensic anthropology and will help improve development of sex estimation methods in the future.

Reference(s):

1. Buikstra J.E., Ubelaker D.H. *Standards for Data Collection from Human Skeletal Remains*. Fayetteville, AR: Arkansas Archeological Survey, 1994.
2. Walker P.L. Sexing skulls using discriminant function analysis of visually assessed traits. *Am J Phys Anthropol.* 2008;136(1):39-50.
3. Rogers N.L., Flournoy L.E., McCormick W.F. The Rhomboid Fossa of the Clavicle as a Sex and Age Estimator. *J Forensic Sci*. 2000;45(1):61-7.
4. Spradley M.K., Jantz R.L. Sex estimation in forensic anthropology: skull versus postcranial elements. *J Forensic Sci*. 2011;56(2):289-96.
5. Bigoni L., Veleminska J., Bruzek J. Three-dimensional geometric morphometric analysis of cranio-facial sexual dimorphism in a Central European sample of known sex. *Homo*. 2010;61(1):16-32.
6. Garvin H.M., Ruff C.B. Sexual dimorphism in skeletal browridge and chin morphologies determined using a new quantitative method. *Am J Phys Anthropol*. 2012 Apr;147(4):661-70.
7. İşcan M.Y. Forensic anthropology of sex and body size. *Forensic Science International*. 2005;147(2):107-12.
8. Meindl R.S., Lovejoy C.O., Mensforth R.P., Carlos L.D. Accuracy and Direction of Error in the Sexing of the Skeleton: Implications for Paleodemography. *Am J Phys Anthropol*. 1985;68:79-85.
9. De La Paz J.S., Woodley S., Buckley H., Halcrow S.E., Techataweewan, N. The Relationship Between Soft Tissue Anatomy and Skeletal Sexual Dimorphism in the Cranium and Clavicle. 2020. *Proceedings of the American Academy of Forensic Sciences*, 72nd Annual Scientific Meeting, Anaheim, CA. 2020.

Sex Estimation, Sexual Dimorphism, Forensic Anthropology

Copyright 2021 by the AAFS. Permission to reprint, publish, or otherwise reproduce such material in any form other than photocopying must be obtained by the AAFS.

*Presenting Author