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An assessment of sexual dimorphism and sex estimation using cervical dental measurements in a Northwest Coast archeological sample

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ABSTRACT

Our goal with this research is to test the consistency of two approaches for the development of sample specific sex prediction methods in fragmentary remains using a Northwest Coast archeological sample from cervical tooth measurements. T-tests and percentage of sexual dimorphism were used to quantify the amount of sexual dimorphism present in the sample (n = 42), then, sample specific sex prediction methods were developed using logistic regression formulae where sex was previously assessed from morphological traits of the pelvis (Black, 1978b) and using the sectioning point approach (Albanese et al., 2005). The best performance was achieved by the mesiolingual–distobuccal diameter of the mandibular first molar (LM1MLDB) and the mesio-distal diameter of the mandibular left second molar (LLM2MD), with logistic regression and sectioning point methods showing 86.7% and 85.71% of total consistent sex classifications, respectively. Small sample sizes eliminated the most potentially sexually dimorphic measurements from the analysis and unbalanced sex samples prevented more reliable estimates of consistent sex classification accuracy. However, these findings highlight both the potentials of developing sample specific sex prediction methods in fragmentary archeological samples from cervical tooth measurements, and the pitfalls of relying on small samples when bioarcheologists do not have any other means for sex estimation.

1. Introduction

Sexual dimorphism of the skeleton allows for estimations of sex to be made based on human skeletal remains. The estimation of sex is extremely important in the identification of an unknown individual in forensic investigations or for paleodemographic and paleoepidemiological studies in archeological populations. Sexual dimorphism of the skeleton is often expressed as a difference in size and shape between male and female bones. A sex difference in size has also been observed in the dentition and this underlies the assumption that sex estimation can be made based on the size of teeth, especially the size of tooth crowns. An advantage of being able to estimate sex based on the size of teeth is due to their ability to resist shape change and alterations due to poor preservation where bones will often be altered. Sex estimation using the size of teeth is usually done by measuring the tooth crown and then quantifying the differences between the sexes using a metric approach that will best separate males and females based on size. Subsequently, this method will allow allocation of an unknown in one of the sexes. One of the problems with such a metric approach is that, although sexual dimorphism is species specific, slight variations are seen between populations in humans (Hall, 1978). Population variation is then an important issue to address when developing or using metric methods of sex estimation based on the skeleton (Meindl et al., 1985; Walrath et al., 2004; Bruzek and Murail, 2006) or dentition (Teschler-Nicola and Prossinger, 1998; Vodanović et al., 2007), due to variations in size and sexual dimorphism in size across human populations. This variation will raise the concern of whether a specific method can be used or is accurate beyond its reference population. This is a particular problem in archeological populations because the known sex reference samples used to develop metric sex estimation methods are all modern and likely very different from most archeological assemblages.

Although modern reference samples of known sex and age skeletons are unlikely to be a good representation of archeological populations, currently there are two general approaches that allow bioarcheologists to develop sample-specific sex estimation methods to use in archeological studies, without relying on known sex modern samples. One is the sectioning point method (Albanese et al., 2005) and the other is a method that relies on previous sex assessments made from morphological traits of the pelvis (Black, 1978b). These two approaches are particularly useful because they rely exclusively on the skeletons from the archeological samples being studied and can generate sex estimation methods that are internally consistent with the sexual dimorphism of the sample. They can, in fact, be described as general approaches that can be used to develop whichever sample-specific method is required to a particular archeological sample. In addition, methods developed using these approaches can be potentially used to estimate the sex of other closely related samples from other similar

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archeological sites, whenever preservation or sample size does not allow for the development of sex estimation methods specific to those samples.

Due to the geology of the sites, Northwest Coast archeological samples tend to show an overall poor preservation of bone, which seriously impairs morphological and metric sex assessments. Many samples consist of primarily fragmented remains and it is impossible to determine true population size (Carlson, 1993; Dale, 1994). In these circumstances odontometrics would be an excellent source of information for the estimation of sex, but unfortunately loss of tooth tissue due to attrition, which is often observed even in young individuals; is also very common, seriously limiting the ability to use teeth as a means to predict sex. In many cases the crowns of the teeth are completely or near completely worn and tooth crown dimensions are almost impossible to measure. There has been, however, some recent work done using dental cervical measurements, which have been suggested to have measurement accuracies comparable to crown measurements (Hillson et al., 2005; Aubry, 2014). These cervical dimensions have been devised to replace crown measurements where the crown is too damaged by attrition, breakage or any other process. Therefore, cervical measurements are ideal to replace the crown measurements in such cases as Northwest Coast samples, where the tooth crowns cannot be measured.

Currently, there are no sex estimation techniques that address the specificity of Northwest Coast archeological samples. This lack of methods coupled with poor bone preservation and excessive dental attrition makes it difficult to reconstruct population structure from these samples, and methods devised in other samples may not be accurate. This is where the two general approaches for developing sample-specific sex prediction methods can be helpful. We wish to assess and quantify the amount of sexual dimorphism within the cervical crown dental measurements of a Northwest Coast archeological sample, and determine whether they can be used reliably to develop sex prediction methods that are specific to this sample. Even if teeth show considerable wear they usually preserve well and can be measured easily in their cervical dimensions. In this paper, the sectioning point method (Albanese et al., 2005; Cardoso, 2008) and the method that relies on previous sex assessments made from morphological traits of the pelvis (Black, 1978b) are used to devise sample-specific sex prediction methods based on cervical tooth dimensions, using a skeletal sample from the Pender Island archeological site in British Columbia, Canada.

2. Materials and methods

The sample used in this study consists of 42 individuals from the Pender Island skeletal collection, currently residing at Simon Fraser University under the supervision of Dr. Roy Carlson. The collection includes at least 121 individuals uncovered during the salvage archeological excavations of the Pender Island sites, conducted by Roy Carlson with joint co-operation under the Heritage Conservation Branch and Simon Fraser University between 1984 and 1986 (Carlson, 1993; Dale, 1994). The majority of the individuals in the sample were interned in the shell midden of the Main Midden period from the DeRt 2 site, and were interned between 4500 and 3000 BP (Carlson, 1993; Dale, 1994). The individuals were accompanied by deposits of Mayne and Locarno Beach artifacts (Carlson, 1993; Dale, 1994). The peoples inhabiting this area are suggested to be of the Coast Salish bands. The main form of subsistence for these peoples was fishing from the ocean as well as collecting shellfish from the sandy, muddy, and rocky beaches (Hanson, 1995). The 42 individuals in the sample all had teeth sufficiently preserved for measurement and were all adults with fully erupted third molars and no traces of bone fusion. Of these 42 individuals, 21 had pelvises which could be morphologically sexed.

All available permanent teeth were measured based on the descriptions provided by Hillson and colleagues (2005), using the modifications outlined by Aubry (2014). Aubry (2014) more clearly outlines markers for the measurements of mesial–distal and bucco-lingual dimensions of loose teeth and bucco-lingual measurements of teeth in the jaw. Cervical bucco-lingual (BL), and mesio-distal (MD) measurements were taken of all teeth excluding the third molars. Cervical mesiobuccal–distolingual (MBDL) and mesiolingual-distobuccal (MLDB) measurements were also taken diagonally across the molars excluding the third molars. Teeth from both sides of the dentition were measured, as well as maxillary and mandibular teeth. A list of all cervical measurements collected and the abbreviations used is provided in Table 1. Paired sample t-tests were calculated to determine if any measurements were significantly different by side (Harris and Smith, 2009). Intra- and inter-observer error rates were also calculated for each measurement using the technical error of measurement, the relative technical error of measurement calculated as a percentage, and the coefficient of reliability (Ulijaszek and Kerr, 1999). A sub-sample of 40 teeth were measured twice by one of the authors (PT) and re-measured by the other author (HFVC).

Morphological sex was assessed using the pelvis for the 21 individuals whose pelvis was well enough preserved to observe sexually dimorphic traits. Klales and co-workers' (2012) modification of the Phenice (1969) method observing the ventral arc (VA), the sub-pubic concavity (SPC), and the medial aspect of the ischio-pubic ramus (MA); as well as the greater sciatic notch (SN), pubic shape (PS), and the preauricular sulcus (PAS) (St. Hoyme 1984; Rogers and Saunders, 1994; Bruzek, 2002); and the composite arch (CA) described in Bruzek (2002) were used. The left pelvis was used in the assessment, however, when this side was not available for any trait the right side was used instead. Intra- and inter-observer error rates were also calculated for

Table 1
List of abbreviations for cervical tooth measurements. MD denotes mesio-distal, BL denotes bucco-lingual, MLDB denotes mesiolingual–distobuccal, and MBDL denotes mesiobuccal–distolingual.

Abbreviation	Measurement
URM2MD	Upper right second molar MD
URM2BL	Upper right second molar BL
ULM2MD	Upper left second molar MD
ULM2BL	Upper left second molar BL
UM2MLDB	Upper second molar MLDB
UM2MBDL	Upper second molar MBDL
UM1MD	Upper first molar MD
UM1BL	Upper first molar BL
UM1MLDB	Upper first molar MLDB
UM1MBDL	Upper first molar MBDL
UPM2MD	Upper second premolar MD
UPM2BL	Upper second premolar BL
UPM1MD	Upper first premolar MD
UPM1BL	Upper first premolar BL
UCMD	Upper canine MD
UCBL	Upper canine BL
UI2MD	Upper second incisor MD
UI2BL	Upper second incisor BL
UI1MD	Upper first incisor MD
UI1BL	Upper first incisor BL
LRM2MD	Lower right second molar MD
LLM2MD	Lower left second molar MD
LM2BL	Lower second molar BL
LM2MLDB	Lower second molar MLDB
LM2MBDL	Lower second molar MBDL
LM1MD	Lower first molar MD
LM1BL	Lower first molar BL
LM1MLDB	Lower first molar MLDB
LM1MBDL	Lower first molar MBDL
LPM2MD	Lower second premolar MD
LPM2BL	Lower second premolar BL
LPM1MD	Lower first premolar MD
LPM1BL	Lower first premolar BL
LCMD	Lower canine MD
LCBL	Lower canine BL
LI2MD	Lower second incisor MD
LI2BL	Lower second incisor BL
LI1MD	Lower first incisor MD
LI1BL	Lower first incisor BL