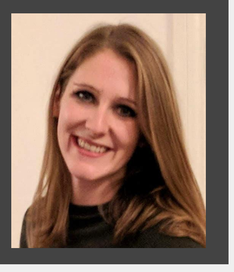
Making the Invisible Visible

A population-specific approach to non-adult sex estimation using odontometrics of the permanent canines

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Sex estimation of non-adult skeletal remains has long been regarded as a problematic or even an unacceptable practice within physical anthropology and forensic science due to the inconsistency of results within and between populations. Several recent studies of both modern and archaeological European populations have shown the crown and cervical measurements of the permanent canines to be sexually dimorphic to a statistically significant degree, allowing for statistical discrimination between the sexes [1, 2, 6-9]. As the permanent dentition forms during childhood and remains unchanged through to adulthood, statistical functions developed on the adult population can be applied to the non-adult population with acceptable rates of accuracy [1-9]. The patterning and degree of sexual dimorphism, however, differs between populations, requiring the development of specific discriminant functions for each population [1, 3, 4, 7-9].

A new approach using logistic regression analysis has been tested on the documented post-medieval sample of Middenbeemster, the Netherlands (see fig. 1). All 12 formulae developed attained accuracy rates above 75%, 8 achieving above 85% and 5 achieving 100% accuracy. Those that attained accuracy rates above 85% are presented here. It was demonstrated that as little as one dimension of the permanent maxillary or mandibular canine can be used to estimate sex with an acceptable level of confidence. Due to the necessity of a permanent canine, this method is only applicable to individuals aged five years and above at death, including adult individuals whose state of preservation does not allow for morphometric sex estimation by other means or whose sex estimate was indeterminate. By allowing reliable sex estimation in non-adult skeletal remains, this method makes it possible to gain insights into the past lives of non-adult individuals, who all too often seem invisible in archaeological and historical narratives.



Figure 1. The location of Middenbeemster within the Netherlands, indicated by the blue circle. (mapmaker.nationalgeographic.org)

Logistic regression models and equations

The measurements used in each logistic regression model were selected to explore the efficacy of varying combinations of measurements while attempting to create effective models suitable for archaeological application. Since individual dentitions are often variously preserved within archaeological collections, only models employing one tooth were developed so that, if successful, only a single tooth would be needed to estimate the sex of a non-adult individual. Similarly, a model was created for each measurement individually in order to identify any models with the potential to accurately classify sex from a single measurement. Multiple univariate and multivariate models within single teeth were developed on the much larger adult sample in order to recognize and create as many useful equations as possible, increasing the likelihood that at least one equation could be applied to each non-adult individual. This practice also creates the opportunity of applying several regression equations to a single individual, which can be used to more confidently estimate sex in undocumented populations.



Figure 3. Crania of Middenbeemster individuals S167V0270 (left) and S396V0877 (right) (photograph taken by the author).

Tooth	Measurement(s)	*N* adults	*N* non-adults	Accuracy on non-adults
Upper Canine	MDcrn BLcrn MDcerv BLcerv	29	6	100.0%
Lower Canine	MDcrn BLcrn MDcerv BLcerv	27	8	100.0%
Upper Canine	BLcrn MDcerv	28	6	100.0%
Lower Canine	MDcrn BLcrn	34	8	100.0%
Lower Canine	MDcerv BLcerv	53	8	87.5%
Lower Canine	BLcrn	64	8	87.5%
Lower Canine	MDcerv	58	8	100.0%
Lower Canine	BLcerv	59	8	87.5%

Table 1. Summaries and accuracy rates of logistic regression equations developed on the adult sample and blind-tested on the non-adult sample.

Conclusion

The results of the present research, in combination with previous studies, indicate that this method of osteological sex estimation can be reliably applied to any archaeological sample that includes a sufficient number of adult individuals for whom confident morphological sex estimation is possible. In addition to non-adult sex estimation, this approach can be used to estimate the sex of adult individuals for whom a decisive morphological sex estimate is not possible. Widespread adoption of this method would unearth a wealth of previously inaccessible information, such as more precise non-adult age estimates and gendered patterns of behaviour and experience as they relate to biological sex.

Measurements

The inclusion of cervical measurements, after Hillson and colleagues (2005), allowed for the measurement of teeth whose maximum crown diameters were affected by wear or ante- and post-mortem damage [2, 5, 7]. All measurements were taken as shown in figure 2 using digital callipers. The maximum mesio-distal crown (MDcrn), maximum bucco-lingual crown (BLcrn), mesio-distal cervical (MDcerv) and bucco-lingual cervical (BLcerv) dimensions were taken on each permanent canine where possible.

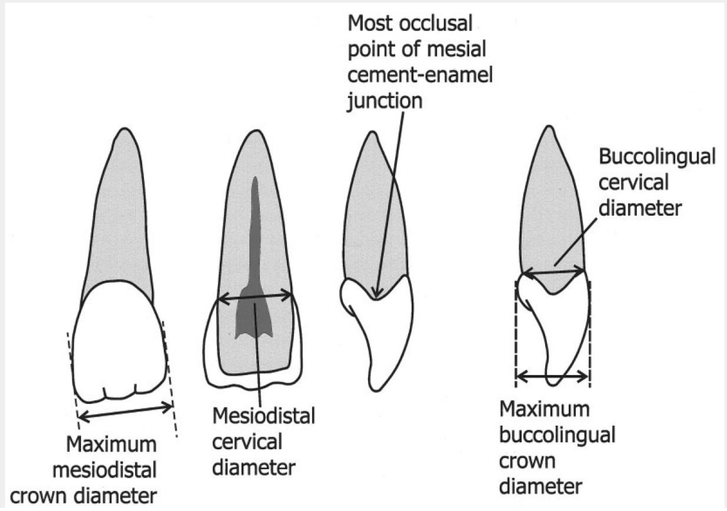


Figure 2. Locations of the maximum mesio-distal (MD) and bucco-lingual (BL) crown and cervical diameters. The same criteria also apply to canines (after Hillson *et al*. 2005).

Test

The results of the most promising equations blind-tested on the non-adult sample are presented in table 1. Though these results are likely inflated by the small sample sizes, they are nonetheless very promising. It was possible to reach a sex estimation for eight non-adult individuals of the documented Middenbeemster collection, two of whom are pictured in figure 3.

These results can only be achieved if the population under study has a substantial adult component whose sexes can be reliably estimated using established morphological methods. Hypothetically, this method can be applied to individuals from the age-at-death of approximately five years, as this is about the age at which the permanent canine crown has fully developed [3, 4]. In practice, however, it was found that though many younger individuals possessed a fully-formed canine crown and cervix, these were embedded in the alveolar bone, unextractable and therefore unmeasurable. In this study, therefore, it was only possible to estimate sex in individuals aged 7 years and above.

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