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Forensic Anthropology Population Data

Testing the applicability of six macroscopic skeletal aging techniques on a modern Southeast Asian sample☆

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ABSTRACT

Most macroscopic skeletal aging techniques used by forensic anthropologists have been developed and tested only on reference material from western populations. This study examined the performance of six aging techniques on a known age sample of 88 Southeast Asian individuals. Methods examined included the Suchey–Brooks method of aging the symphyseal face of the os pubis (Brooks and Suchey, Hum. Evol. 5 (1990) 227), Buckberry and Chamberlain's, Am. J. Phys. Anthropol. 119 (2002) 231 and Osborne et al.'s, J. Forensic Sci. 49 (2004) 1 revisions of the Lovejoy et al., Am. J. Phys. Anthropol. 68 (1985) 15 method of aging the auricular surface of the ilium, İşcan et al.'s, J. Forensic Sci. 29 (1984) 1094, İşcan et al.'s, J. Forensic Sci. 30 (1985) 853 method of aging the sternal end of the fourth rib, and Meindl and Lovejoy's, Am. J. Phys. Anthropol. 68 (1985) 57 methods for aging both lateral-anterior and vault sutures on the cranium. The results of this study indicate that application of aging techniques commonly used in forensic anthropology to individuals identified as Asian, and more specifically Southeast Asian, should not be undertaken injudiciously. Of the six individual methods tested here, the Suchey–Brooks pubic symphysis aging method performs best, though average age estimates were still off by nearly 10 years or greater. Methods for aging the auricular surface perform next best, though the Osborne et al. method works better for individuals below 50 years and the Buckberry and Chamberlain method works better for those above 50 years. Methods for age estimation from the sternal ends of the fourth rib and vault and lateral-anterior cranial sutures perform poorly and are not recommended for use on remains of Southeast Asian ancestry. Combining age estimates from multiple indicators, specifically the pubic symphysis and one auricular surface method, was superior to individual methods. Data and a worked example are provided for calculating the conditional probability that an individual belongs to a particular age decade, though overall age estimates may still be broad.

1. Introduction

When presented with an unknown set of human skeletal remains, a forensic anthropologist must attempt to discern sex, ancestry, age, stature, and any individualizing characteristics. Of these traits, estimation of age at death remains one of the most difficult tasks facing even experienced investigators [1]. While dental development is valuable for age estimation in subadults and epiphyseal union may be utilized through early adulthood, once skeletal maturity is reached age at death must be estimated through either histological quantification of skeletal/dental traits or the use of macroscopic methods based upon the deterioration of skeletal structures. Macroscopic techniques for age estimation are more commonly employed because they are quicker, cheaper, non-destructive, and do not require any specialized equipment. However, these techniques are not without criticism, as they often yield rather broad age estimates and older ages are regularly truncated into estimates of 50 or 60+ years.

Compounding the concerns over accuracy of age estimation methods is the question of applicability of such methods to

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differing populations. Best practices in estimating age at death include using population-specific methods when they are available [2], though such standards are not available for many populations around the world. By necessity, age estimation methods are developed on osteological reference samples of known demographics [3], often limited to those of European and African American descent. The application of such methods to different populations requires an assumption of uniformitarianism—that age-related morphological alterations are the same in populations across time and geography [4]. Such an assumption, however, may be intrinsically flawed because while senescence itself is a universal phenomenon, the manner in which each individual experiences it is determined by a complex set of interactions between genetics, environment, and culture [5].

This study sought to test the uniformitarian assumption of skeletal aging through a comprehensive approach, applying six macroscopic age estimation methods to an identified sample of Southeast Asian origin. Specifically we investigated the Suchey–Brooks method of aging the symphyseal face of the os pubis [6], Buckberry and Chamberlain's [7] and Osborne et al.'s [8] revisions of the Lovejoy et al. [9] method of aging the auricular surface of the ilium, İşcan et al.'s [10,11] method of aging the sternal end of the fourth rib, and Meindl and Lovejoy's [12] methods for aging both lateral-anterior and vault sutures on the cranium. These methods were chosen because they represent elements from throughout the human skeleton, include some of the methods most commonly employed by forensic anthropologists, and none except the Suchey–Brooks method have ever been tested in a skeletal sample of Asian origins.

2. Materials and methods

The material used for this study was from the osteology collection housed at Khon Kaen University School of Medicine in Thailand. The collection contains approximately 800 skeletons, and demographic information was recorded for each individual at the time of body procurement. The majority of individuals were born during the twentieth century, though some of the earliest decedents (less than 2% of the collection) were born in the late nineteenth century. Most of the collection was built from a body donation program, although some material is derived from individuals who were Thai military, monks, or unclaimed bodies. The majority of individuals were lifelong inhabitants of the rural Isaan region of northeast Thailand although some may have distant Laotian or Chinese ancestry (Mann R.W., pers. comm., 03/06/2014).

To minimize bias in the data structure, an age/sex balanced data collection protocol with an equal number of males and females from each decade of life was desired. Unfortunately, the demographic structure of the collection made this impossible. For example, there are only four females included in the 20–29 age range, which is fewer than in any other age range of the sample. These four females, though, were only four from this age range present in the Khon Kaen skeletal collection at the time data was collected. In total, 88 individuals of known age were examined (Table 1). A larger sample would have been desirable, but unfortunately the authors' had less than one week for data collection. Furthermore, a larger sample would have exacerbated differences in sample sizes for each age cohort. Males ranged from 20 to 78 years (mean = 48.3, SD = 17.6), while females ranged from 24 to 97 years (mean = 52.9, SD = 17.6); the sexes did not significantly differ in age distributions (Mann–Whitney *U*-test, $p = 0.293$).

To minimize bias in data collection, observers collecting data (MEI, AK, MTCH) were blinded to known age of decedents in the skeletal collection. However, sex was known in order to utilize sex-specific phase descriptions of the sternal rib method and sex-specific images of the Suchey–Brooks method. All skeletal aging methods investigated were applied as detailed in the original publications. For the Suchey–Brooks, Osborne et al., and İşcan et al. methods, this meant assigning the skeletal element under investigation into a phase, while composite scores were calculated for elements using the Buckberry and Chamberlain and Meindl and Lovejoy methods. For the Buckberry and Chamberlain method, the composite score was then translated into a stage score. Differences between left and right pubic symphyses [13], auricular surfaces [14], and sternal ends of the fourth rib [15] have been shown to be insignificant, therefore methods were applied to either side while taking care to avoid any damaged or pathological elements. Because of differential preservation of some individuals, all aging techniques could not be applied to every individual in the sample. Data was collected by three of the authors, each of whom had considerable prior experience with the application of the aging methods tested. Each data collector analyzed a set of human remains in its entirety, meaning one observer applied all six aging techniques to a single set of remains. Admittedly this approach may result in some level of partiality for an observer, where having assigned an age by one method might influence the age assigned in applying the subsequent aging methods. However, this approach was still adopted in this research not only for its efficiency, but also because it reflects many real-world analytical settings wherein an observer is responsible for examining an entire set of remains, rather than a separate observer being responsible for applying a separate aging technique.

Table 1
Age and sex distribution of the study sample.

Known age (years)	Male (*n*)	Female (*n*)	Total *n*
20–29	9	4	13
30–39	7	7	14
40–49	7	10	17
50–59	7	7	14
60–69	7	9	16
70+	7	7	14
Total *n*	44	44	88

The mean age reported for each phase/stage or composite score in the original literature was then used as a point age estimate for each individual. However, crania that demonstrated either no suture closure (fully open) or complete suture obliteration (fully closed) were not assigned a point age estimate as Meindl and Lovejoy [12] suggest an age range with these conditions rather than providing a mean age. Point age estimates derived from each method were compared to known age at death through calculations of bias, inaccuracy, and correlation, which are common when testing the accuracy of aging methods in different populations (e.g. [13,16–18]). Bias is the mean over- or under-estimation of age [Σ(estimated age − known age)/*n*]. Inaccuracy is the mean absolute error of the estimation [Σ|estimated age − known age|/*n*] and therefore does not account for the directionality of error in age estimation. Spearman's rank correlation coefficients were also calculated to compare estimated age to known age. Furthermore, the proportion of cases in which the known age was within ±two standard deviations of the mean age reported for a phase/stage/composite score was also evaluated [20].

In addition to individual techniques, three different combination strategies were assessed: the first averaged point age estimates from all six methods, the second averaged point estimates from the three pelvic aging methods, and the third averaged the Suchey–Brooks age estimate and the Osborne et al. age estimate if the pubic symphysis was found to be in phases I–IV, but averaged the Suchey–Brooks age estimate and the Buckberry and Chamberlain estimate if the pubic symphysis was found to be