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Demographic structure of skeletal populations in historic Japan: a new estimation of adult age-at-death distributions based on the auricular surface of the ilium ☆

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Abstract

The reconstruction of past demographic structures from skeletal remains is one of the most important themes in the field of biological anthropology and bioarchaeology. However, the paleodemographic reconstruction is far from satisfactory in terms of providing reliable demographic structures of past populations. The purposes of this study are to examine demographic profiles from historic Japan, focusing on archaeological skeletal populations; to reconstruct adult age-at-death distributions using a new method for auricular surface aging [Buckberry, J.L., Chamberlain, A.T., 2002. Age estimation from the auricular surface of the ilium: a revised method. Am. J. Phys. Anthropol. 119, 231–239] and compare them with those of the traditional method [Lovejoy, C.O., Meindl, R.S., Pryzbeck, T.R., Mensforth, R.P., 1985. Chronological metamorphosis of the auricular surface of the illium: a new method of determining adult age at death. Am. J. Phys. Anthropol. 68, 15–28]; and to discuss whether paleodemographic data from skeletal remains provide important information concerning adult mortality patterns. This study analyzes well-preserved auricular surfaces of 114 individuals from the Chusei Shudan Bochi site and 99 individuals from the Hitotsubashi site, which are individuals of 15 years of age and above. The comparison of the results of the traditional and revised methods shows that the revised method has older age distributions with a majority of individuals being over 65 years and improves the age estimation for elderly individuals. A comparison between skeletal remains and historical census records strengthens the conclusion that the revised age estimation for elderly adults is more appropriate than the traditional method. The new method employed here brings technical innovations to allow us to reconstruct appropriate mortality profiles of past populations.

Keywords: Paleodemography; Age-at-death distribution; Auricular surface; Japan

1. Introduction

Paleodemographic studies of past human populations have a profound effect on the interpretation of human life history, human biology, and human evolutionary history (e.g., Hawkes, 2003; Caspari and Lee, 2004, 2006). The reconstruction of past demographic structures from skeletal remains is one of the most important themes in the field of biological anthropology and bioarchaeology, but this is far from satisfactory in terms of providing reliable demographic structures of past populations due to basic problems including assumption of demographic stationarity, sampling issue, methodological issue, and so on. Wood et al. (1992) pointed out three conceptual issues: demographic non-stationarity, selective mortality, and hidden heterogeneity in risks, which all lead to incorrect interpretations of paleodemographic estimators.

First, paleodemographic studies often assume stationary conditions of skeletal populations-conditions characterized by “closure to migration, constant age-specific fertility and mortality, zero growth rate, and an equilibrium age distribution”

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(Wood et al., 1992: 344). Alesan et al. (1999: 289) stated, "By associating the observed structure to a stationary life table, we can avoid the conjunctural or moment effect with the result that the mortality structure represents all the generations that lived in that community." Population growth is an important factor that has an effect on the interpretation of paleodemographic outcomes, because the demographic parameter will be biased if the stationary assumption is inappropriate (Sattenspiel and Harpending, 1983; Johansson and Horowitz, 1986; Eshed et al., 2004). However, one cannot know the actual status of an archaeological population.

Second, the selective mortality is the problem that we cannot obtain a representative sample of the dead due to poor preservation of fragile skeletons (Wood et al., 1992). In almost all cases, paleodemograhers cannot obtain a representative group of skeletons for a given population, due to the fact that the burial customs and taphonomic bias in preservation may have affected the sampling of skeletal material (Eshed et al., 2004). Infant under-representation has been cited as one source of census errors in age distributions from an archaeological sample (Angel, 1969; Weiss, 1973; Bocquet-Appel and Masset, 1982, 1985; Mensforth, 1990; Alesan et al., 1999; Jackes, 2000; Eshed et al., 2004; Curet, 2005; Nagaoka et al., 2006; Nagaoka and Hirata, 2007). As Mensforth (1990: 89) stated, "Selective cultural biases and mortuary practices at the time of death, differential postmortem preservation, selective recovery and curation practices, and variation in the degree to which age can accurately be inferred from fragmentary skeletal remains all increase the vulnerability of skeletal series to sampling errors."

Third, the hidden heterogeneity in risks is the problem that "the population which the skeletal series is drawn was made up of an unknown mixture of individuals who varied in their underlying fragility or susceptibility to disease and death" (Wood et al., 1992: 345). Aggregate level mortality data with the mixture of various individuals in fragility may provide a misleading picture of individual-level risks (Wood et al., 1992).

Forth and most importantly, the validity of age estimation techniques has been questioned (Bocquet-Appel and Masset, 1982, 1985, 1996; Buikstra and Konigsberg, 1985; Horowitz et al., 1988; Mensforth, 1990; Konigsberg and Frankenberg, 1992). The first three problems are related to unavoidable reasons, but this third problem is related to methodological fault. Skeletal age distribution differs from the distribution recorded in historical documents (Storey, 2007). That is, the age distributions of skeletal samples have high proportions of young adults and low proportions of elderly adults. The age estimation of adult skeletal remains is fundamental to skeletal biologists. The widely used age indicators for adult age estimations include cranial suture closure (Meindl and Lovejoy, 1985), dental attrition (Miles, 1963; Lovejoy, 1985), pubic symphysis (Todd, 1920; Brooks and Suchey, 1990), and auricular surface observation (Lovejoy et al., 1985). Age estimation is fairly accurate for subadults, but not for adults (Murray and Murray, 1991; Bocquet-Appel and Bacro, 1997; Milner et al., 2000).

Fortunately, recent works on age estimation for adults have focused on the Bayesian estimation (e.g., Konigsberg and Frankenberg, 1992; Buckberry and Chamberlain, 2002; Hoppa, 2002; Storey, 2007). "This method allows the calculation of the probability of age conditional on the stage of the age indicator, and the probability of a skeleton being a particular age at death, given the stage of the indicator" (Storey, 2007: 41). A consensus on procedures for estimating age-at-death from a skeletal sample, "Rostock Manifesto," advocated the Bayesian estimation to overcome the difficult problem of paleodemographic estimation (Hoppa, 2002). Buckberry and Chamberlain (2002) examined the Spitalfields reference sample, and applied the Bayesian theorem using uniform priors to their auricular surface aging technique. Storey (2007) used their posterior probability of age by auricular surface stage, assuming uniform priors, to estimate the adult age distribution for a Pre-Columbian Maya skeletal population, and found an age distribution with a significant number of older adults. The recent advance in paleodemography has been due to the employment of the Bayesian method and the development of the age estimation technique. However, there is no other study which employs the new technique or which reconstructs paleodemographic features of skeletal populations, and no study which applies to an Asian archaeological sample. The extensive application of the new approaches will test and strengthen the methodological basis of the new paleodemography.

The questions we have to ask here is whether the newly obtained age-at-death structure reflects real mortality patterns or not. The new approaches of the Buckberry and Chamberlain system will have great effects on the interpretation of the life history patterns of ancient populations. The purposes of this study are three: first, to examine demographic profiles from historic Japan, focusing on archaeological skeletal populations; second, to reconstruct adult age-at-death distributions using the new method for auricular surfaces and compare them with those of the traditional method; and finally, to discuss whether paleodemographic data from skeletal remains provide important information concerning adult mortality patterns.

2. Materials

This study analyzes well-preserved right auricular surfaces of 114 individuals from the Chusei Shudan Bochi site and 99 individuals from the Hitotsubashi site, which are individuals of 15 years of age and above. The auricular surface is more robust and resistant to deterioration than the pubic symphysis (Waldron, 1987; Stojanowski et al., 2002). They are kept at the Department of Anatomy, St. Marianna University School of Medicine (Kawasaki, Japan).

The Chusei Shudan Bochi site is located along the seashore of the southern end of Kamakura City in Japan (Fig. 1). The excavation of the Chusei Shudan Bochi site was undertaken between 2000 and 2001, and yielded multiple and individual burials of the 12–14th century. They were inhabitants of medieval Kamakura, an ancient capital where a military