OSTEOMETRIC ASSESSMENT OF 20TH CENTURY SKELETONS FROM THAILAND AND HONG KONG

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Susan R. Loth, Department of Anthropology, and has been approved by the members of his supervisory committee. It was submitted to the faculty of The Schmidt College of Arts and Humanities and was accepted in partial fulfillment of the requirements for the degree of Master of Arts.

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ABSTRACT

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Cranial and postcranial research on East and Southeast Asians has shown population variability between and within these two regions. Moreover, as populations vary by sex, sex differences vary by population. The purpose of this study is to provide the first descriptive and comparative analysis of two recently curated samples of complete, documented, contemporary skeletons from Thailand (N=104) and Hong Kong (N=94) that have not been previously studied. Sex differences reveal Hong Kong males and females as larger but less dimorphic than Thais. Stepwise discriminant function analysis of the Thai humerus and femur allowed 94%-96% sex classification accuracy. In conclusion, this research has increased our knowledge of sex and population differences in Asia and has important applications to demographic and medicolegal investigations.

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CHAPTER I

INTRODUCTION

It is essential to learn as much as possible from the human skeleton, because it contains the key to a better understanding of many subjects such as human anatomy, growth and development, odontology, paleontology, paleopathology, demography, sexual dimorphism, and population variation. From the anthropological perspective, the value of skeletal collections is immense. For example, metric, morphologic, and nonmetric studies have contributed to our understanding of interrelationships among populations and to biological comparison of prehistoric peoples with their living descendants, and have been a major source of information on ancient diseases, trauma, etc. Skeletal collections also permit the study of age, sex, stature, and biological affiliation differences from skeletal features – both metrical and morphological – as well as the study of sexual dimorphism within and between populations. Only from the assessment of known skeletal series can standards be established to interpret remains from the past and identify forensic cases of today and tomorrow.

Population Origins

Within the region of Southeast Asia and East Asia (Figure 1), many researchers have demonstrated regional discontinuity (Brace, Brace, and Leonard 1989; Hanihara 1996; Howells 1973, 1989, 1990; Lahr 1995; Pietrusewsky 1984, 1990a,b, 1995; Turner 1985, 1986, 1989, 1990). Early explanations for this variability have frequently pointed to a north to south migration from East Asia resulting in interbreeding or complete replacement of aboriginal Southeast Asians (Pietrusewsky 1988a). Although, this is not supported archaeologically because of the lack of evidence of Upper Paleolithic technologies in Southeast Asia (Pope 1988), genetic data indicates a clustering of Eurasian groups that would point to such gene flow (Nei and Roychoudhury 1993). The possibility of such a reversal of said migration has also been raised (Pietrusewsky 1988a, 1992; Turner 1992).

Theories of population differentiation and migration from Southeast and East Asia abound (Bellwood 1979, 1985; Stoneking et al. 1990; Turner 1987; Zhao and Lee 1989). Bellwood (1985) proposed two major prehistoric migrations into Southeast Asia with the first as an ancient "Australoid" migration from the Indo-Malaysian Archipelago about 40 kya and second, a more recent "Southern Mongoloid" or "Austro-Melanesian" migration from Fujian or Zhejian provinces of China around 4-6 kya (Ballinger et al. 1992:139). A slightly different conclusion was made by Turner (1983, 1985, 1987), who used dental morphological traits to hypothesize that two migrations originated from Central China about 20-30 kya. One group, the sundadonts, was characterized by <u>low</u> frequencies of incisor shoveling, double shoveling, lower first molar cusp 6, lower second molar cusp 5, and 3-rooted first molars, and had generalized cranial morphology and additional Mongoloid features like facial flatness and a broad vault (Turner 1985). These peoples

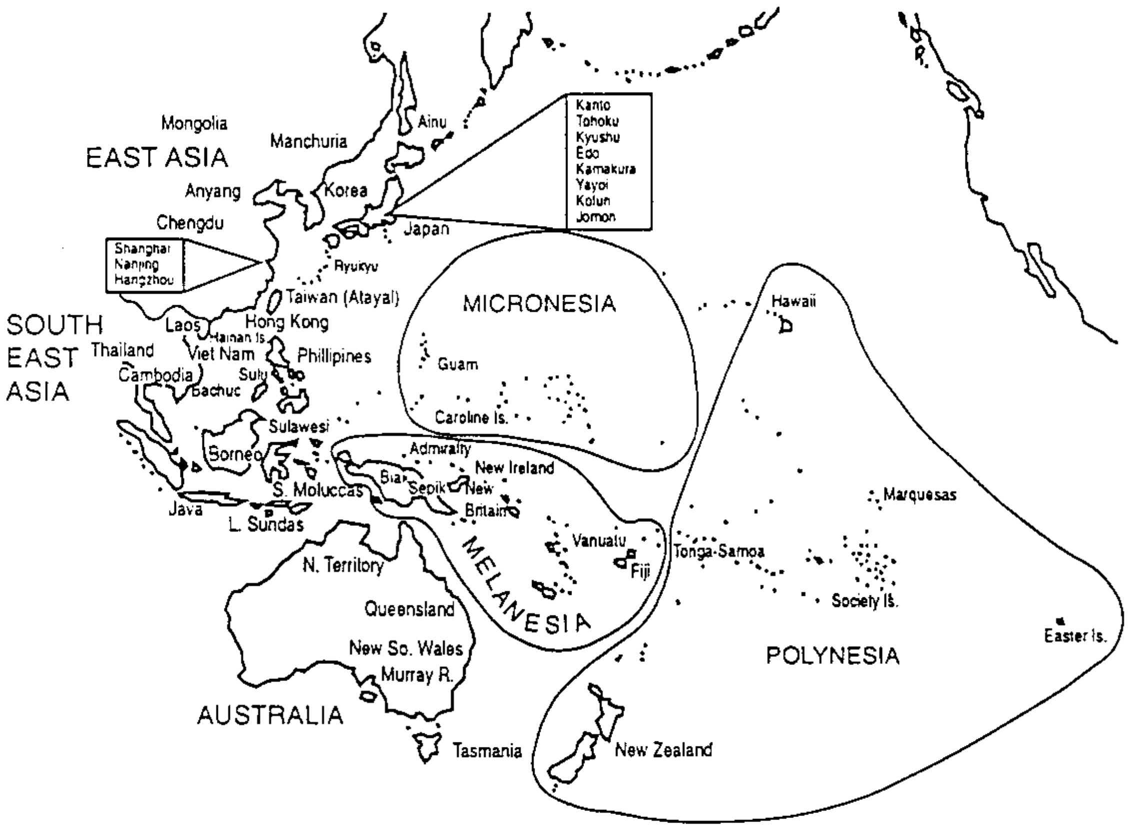

Figure 1
Map showing the approximate regional breakdown of Asia and the Pacific by biological affinity.
(From Pietrusewsky 1997:122)

inhabited Southeast Asia, Indonesia, Melanesia, Micronesia, and Polynesia, and reached as far as Japan (Jōmon and Ainu). Evolutionary factors such as genetic drift and gene flow may have led to a more specialized morphological pattern, with intensified expression of certain dental features (sinodonty).

In contrast, the sinodont dental pattern is established with high frequencies of incisor shoveling, double shoveling, 3-rooted first molars, lower first molar 6; and the crania characterized by facial flatness, broad vaults, tall faces and orbits, high cheekbones and comparatively narrow noses. This sinodont pattern expanded northward into China, Siberia and across the Bering land bridge to the New World (Turner 1985). As Turner (1987) notes, differentiation of dental morphology must have occurred before 17 kya for it is present in several fossil remains. Gracilization seems to have occurred somewhat later (Bellwood 1985). This early population has been called "southern Mongoloids." These findings are consistent with multivariate analyses of cranial form and support the consensus that Southeast Asians are less specialized morphologically, thus contributing to the possible conclusion that Mongoloids originated in the South (Hanihara 1993a,b; Harihara et al. 1992; Pietrusewsky 1992).

It has also been argued that within the last 5,000 years, the spread of agriculture has contributed greatly in the formation of clinal variation between Southeast and East Asia (Bellwood 1985, 1987). It is suggested that as farming began along the Yangtze River delta, the migration of peoples and large scale rice cultivation eventually reached Thailand about 1,000 years (Yen 1977) to as early as 4,000 years before present. This agricultural revolution would have resulted in admixture from the newly settled agriculturalists and migrating foraging groups creating a clinal pattern of morphology. Such variation has been identified in the frequencies of sinodont and sundadont traits among Hong Kongers, southern Chinese, and Taiwanese populations (Turner 1990).

In the Pacific, it is commonly thought that Polynesians and Micronesians share common ancestral ties with Southeast Asia and East Asia (Chen et al. 1992; Hanihara 1992a,b,c,d; Hanihara, Hanihara, and Koizumi 1993; Howells 1989, 1990; Pietrusewsky 1990a,b, 1992, 1994a; Turner 1987, 1989, 1990). There has also been general agreement that mainland and Southeast Asia as well as Pacific groups have Sundaland origins (Bellwood 1985; Birdsell 1977; Brace and Hinton 1981; Hanihara, Hanihara, and Koizumi 1993; Pietrusewsky 1990a,b, 1992, 1994a, 1995; Hanihara 1989a,b,c, 1990a,b, 1992a,b,c). In a different light, Brace and associates suggested a "Jōmon-Pacific cluster" (Brace, Brace, and Leonard 1989; Brace et al. 1990). The cluster emphasizes a direct line of descent from the ancient Japanese (Jōmonese) to Polynesia and Micronesia. Studying skeletal morphology, Katayama (1990) suggested that the Lapita culture of Polynesia was closely aligned with the Jōmonese (Hanihara, Hanihara, and Koizumi 1993).

Between Thailand and China, metric studies have shown both differences and similarities in their biological affinities. Numerous researchers have conducted craniometric and dental studies (using predominately male samples) that exposed apparent divergence between Southeast and East Asians (Brace, Brace, and Leonard 1989; Brace et al. 1990; Hanihara 1993a,b; Li et al. 1991; Matsumura 1995; Nakbunlung 1994; Pietrusewsky 1988a,b, 1992, 1994a,b, 1995; Pietrusewsky et al. 1992; Sangvichien 1970; Turner 1989, 1990, 1992). For example, it was found that variation was most pronounced in facial and frontal breadth, minimum cranial breadth, vault and facial height, and concluded there is a recognizable subdivision between Southeast and East Asian populations (Pietrusewsky et al. 1992). Also, Nakbunlung (1994) found similar results in her study of archaeological and modern Thai and Chinese samples, and determined that interorbital breadth is the most distinguishing factor in differentiating the populations in both males and females. She further noted that facial height and nasal height and breadth differed significantly between males and cranial and orbital breadth between females of these populations.

Sexual Dimorphism

Sexual dimorphism in the human skeleton and dentition have been studied extensively (Bennett 1981; Bogin 1988; Brace 1972; Brace and Ryan 1980; De Villiers 1968; Finkel 1982; Frayer 1977; Frayer and Wolpoff 1985, Ghesquiere, Martin, and Newcombe 1985; Hunter and Garn 1972; İşcan 1989; Keen 1950; Krogman and İşcan 1986; Loth 1990, 1996; McCown 1982; Ross and Ward 1982; St. Hoyme and İşcan 1989; Thieme and Schull 1957; Van Gerven 1972; Wolpoff 1976). By studying dimorphism, the plasticity or magnitude of differences between males and females, between and within groups, plus the degree of geographic variability can possibly lead to clues concerning long term selection in a region. Moreover, the study of sexual dimorphism includes the study of growth and of the factors that modify growth patterns (Bogin 1988; Eveleth 1975; Eveleth and Tanner 1990; Gray and Wolfe 1980; Hall 1982; Ji and Ohsawa 1992; Stini 1975; Tanner 1962, 1988; Tobias 1975).

A basic principle of sexual dimorphism is that size, along with other morphologic and metric traits, of each population changes over time (Bogin 1988; Eveleth and Tanner 1990; Hall 1982b). A population (also termed local population) is defined as a group of panmictic individuals tied together by bonds of parentage and mating that share a common gene pool (Mayr 1970) and thus serves as the *a priori* unit for the study of natural selection and genetic variation (Lewontin 1972). It was these mechanisms that Garn (1965) and Lewontin (1972) regarded as most important to the study of the forces of evolution. Furthermore, at the genetic level the greatest amount of variation is found within the local population, rather than by population affinity or geographic region (Lewontin 1972; also see Frayer and Wolpoff 1985).

As Hall (1982a,b) and Bogin (1988) pointed out, sexual dimorphism is affected by cultural, nutritional, and environmental factors. Furthermore, while these factors do not affect growth and size in the sexes identically. It has been postulated that genetic variation contributed more to sexually dimorphic variation than environmental or cultural factors (Eckhardt 1989; Eveleth 1975; Frayer and Wolpoff 1985; Hall 1982a; Stini 1975; Tobias 1975). Thus, a compromise from this environmental versus genetic dichotomy views sexual dimorphism as a result of a variety of factors (Gray and Wolfe 1980). Results by Gray and Wolf (1980:455) "indicate that societies with poor protein availability are characterized by low mean height and low degree of sexual dimorphism in stature." However, these authors also found that sexual dimorphism varied greatly in populations with high protein availability. Therefore, when nutrition is adequate, sexual dimorphism must be genetically regulated.

Skeletal Characteristics

The determination of demographic characteristics of a population is of primary concern to paleodemographers and forensic anthropologists (Krogman and İşcan 1986). By encompassing many of the latest techniques, more information can be extracted from skeletal remains (İşcan 1989; İşcan and Helmer 1993; İşcan and Kennedy 1989). As noted by İşcan and Loth (1997), it is from this information that we are now able to determine with a high degree of accuracy, sex and race with certainty, age within about 5 years, and stature within a standard error of about 3.5cm.

Biological affinity

Observable biological characteristics or phenotypes between people show obvious variation. These differences can be assessed metrically and morphologically (Gill 1986; Gill and Rhine 1990; Hinkes 1990; Howells 1970; İşcan 1990; İşcan and Cotton 1990; Krogman 1955; Krogman and İşcan 1986; Napoli and Birkby 1990; Rhine 1990). This determination is essential because population variation extends to every demographic assessment.

Probably the oldest craniometric indicators used to determine biological affinity were indices (Brues 1992). Introduced by Europeans to help explain the great range of variation within Europe, these methods were extended globally.

Discriminant function analysis was formally introduced by Fisher (1936, 1938), but Barnard (1935) was the first to apply the method (see Howells 1973). Since then, numerous studies using many different bones have been attempted (Krogman and İşcan

1986). The earliest discriminant function formulae for racial classification in identification were published by Giles and Elliot (1962). These metric methods are popular because it is widely assumed that quantification is easier to apply than morphologic techniques (Loth 1996). The methodology involves a 3-way discrimination between American blacks, American whites, and American Indians, with the data for the first two groups from the Terry Collection and the third from Indian Knoll (Snow 1948). The success rate using this method ranges from 77-100%. Measurement based techniques however, are problematic because of the inevitable interracial overlap of dimensions; results are often equivocal when the amount of divergence is close to the boarder of two affinities (Birkby 1966). Midface variation has also been investigated (Curran 1990; Gill 1984; Gill and Gilbert 1990; Gill et al. 1988; Hughes 1980; Morant 1927; Woo and Morant 1932, 1934). Woo and Morant (1932, 1934) presented one of the earliest studies of Asian Mongoloids to craniometrically assess affinity. These studies were innovative for the time since they incorporated 3-point measurements called subtenses in an attempt to measure the flatness of the face and nasal region – a method which was found to significantly discriminate between Europeans and Asians as well as between other Asians.

In the postcranium, early work by Todd (1929) concluded that flaring of the ilium is narrower in blacks, and that blacks have a "pedestaled" pelvis for a narrow torso, while in whites it is "basket-shaped" for a broad torso. Also, in a series of studies by Trotter and Gleser (Trotter and Gleser 1952, 1958, 1977) proportions of limb bones to stature were shown to be greater in blacks when compared to whites. Also prior to 1980, work was done on the pelvis (Derry 1923; Howells and Hotelling 1936; Strauss 1927; Torpin 1951), long bones include, (Flower 1879; Gilbert 1976; Hrdlička 1942; Krogman 1955; Munter 1936; Schultz 1937; Stewart 1962; Walensky 1965;). More currently, the femur (DiBennardo and Taylor 1983; Gilbert and Gill 1990**)**, tibia (Farrally and Moore 1975; İşcan and Cotton 1990; İşcan and Miller-Shaivitz 1984a,b), sternal end of the rib (İşcan, Loth, and Wright 1987; Loth 1990) and pelvis (DiBennardo and Taylor 1984; İşcan 1982, 1983; İşcan and Cotton 1985, 1990; İşcan and Derrick 1984; Schulter-Ellis and Hayek 1984) also show significant race differences. As a whole, postcraniometric studies are comparable to these from the skull.

Studies of Mongoloid populations were conducted by Woo and Morant (1932, 1934) who used a coefficient of Racial Likeness (now referred to as Penrose's Distance) as well as standard measurements to compare Asians with each other. They latter focused on the amount of facial "flatness" by measuring the degree of prognathism and nasal size and shape. Hanihara (1967) was responsible for the earliest Japanese publications in Asia that dealt with a possible racial classification system. It was from this work that Professor Hanihara coined the term Mongoloid Dental Complex, which would later be revised by Turner (Turner 1983). Additional studies include craniometric analyses from Han (1988), Wang (1987), and Zhang (1988), and one postcranial analysis dealing with the shape of the scapula (Chao and Huanjiu 1986). It must be kept in mind that races are not homogeneous units (Brace 1994; Brues 1990, 1992; Loth 1996; Sauer 1992). There is a great deal of variation between populations within each racial phenotype that must be accounted for in skeletal assessments.

Sex determination

Although nearly all bones show some form of metric and morphologic sexual dimorphism (Holland 1991; Krogman and İşcan 1986; Wu 1989b), the pelvis is the most obvious anatomic site from which to identify sex (İşcan and Derrick 1984; Kimura 1982a,b; Novotný, İşcan, and Loth 1993; Phenice 1969; Schulter-Ellis et al. 1983; Schulter-Ellis, Hayek, and Schmidt 1985; St. Hoyme 1957; Strauss 1927; Suchey and Brooks 1990; Washburn 1949; Wu, Shao, and Wang 1982). However, as the pelvis is not always 100% accurate nor is it always present or intact, the need for other standards has led to research on nearly every bone in the body (Krogman and İşcan 1986). Besides the pelvis, research includes the face and neurocranium (De Villiers 1968; Giles 1964, 1970; Giles and Elliot 1963; Hanihara 1959; İşcan, Yoshino, and Kato 1995; Kieser and Groeneveld 1986; Loth 1996; Loth and Henneberg 1996; Steyn and İşcan 1997), the rib (Allen 1997; Çöloğlu et al. 1997; Dupras and Pfeiffer 1996; İşcan 1985; İşcan, Loth, and Wright 1984, 1985; Loth 1990), the femur (Black 1978; DiBennardo and Taylor 1979; İşcan and Miller-Shaivitz 1984c; Trancho et al. 1997), the tibia (İşcan and Miller-Shaivitz 1984a,b; Kieser, Moggi-Cecchi, and Groeneveld 1992; Singh, Singh, and Singh 1975), and even the talus and calcaneus (Steele 1976; Pickering 1986).

The highest reported accuracies regardless of population are from morphologic characteristics of the pelvis at 95% (Krogman and İşcan 1986) and ramus flexure of the mandible at 94% (Loth and Henneberg 1996). Osteometric techniques must be used on long bones. The femur and tibia provide the greatest accuracy (83-97%), but even the humerus can yield percentages as high as 97% (see Table 28). As in any skeletal analysis, problems exist. Moreover, discriminant function analysis, based on metric analysis are highly population specific. Sample size, and even the choice of variables can all affect the results (St. Hoyme and İşcan 1989).

Several studies of sexual dimorphism have been conducted in Asia. Japanese sexing methods from the skull were developed by Hanihara (1958, 1959, 1967, 1981); Hoshi (1962); Inoue (1990); Inoue and associates (1992); İşcan, Yoshino, and Kato (1995); Matsumura (1995); Tanaka, Hanihara, and Koizumu (1979). From China, cranial researchers on sexing include Bao and Wang (1984); Ding and associates (1992); Li (1991, 1992); Wang and Bao (1984, 1988); Song, Lin, and Jin (1992); Wang (1989); Yang and co-workers (1987); Yang, Wu, and Tai (1988); and Zhu and associates (1985). In other parts of the body, Japanese studies have focused on the long bones (Hanihara 1958, 1959; İşcan, Yoshino, and Kato 1994; Kimura 1971; Tagaya 1987, 1992) and the pelvis (Hanihara and Suzuki 1978; Kimura 1982a,b). Chinese postcranial research has been carried out in long bones (Chao and Xi 1986; Du 1984; İşcan and Ding 1995a,b; Ren 1986, 1987; Sheng 1985; Wu 1989a,b; Wu, Shao, and Wang 1982; Wu, Yang, and Tai 1989; Zheng 1987; Zheng and Pang 1988), and the pelvis (Wu, Chen, and Xu 1988; Sun and Qu 1986; Wu, Shao, and Wang 1982). All of this work is based on metric evaluation. Research on sexual dimorphism has clearly revealed that this characteristic both varies over time and by population within a racial phenotype.

Stature

When attempting to draw a picture of what an individual looked like when living,