Cranial and Pelvic Nonmetric Sexual Dimorphism in Modern Japanese and Thai Individuals*

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Introduction

Accurate biological profile methods require that they be developed, validated, and refined on contemporaneous skeletal assemblages that share a genetic history with the decedents. However, most methods currently used in skeletal biology were developed and refined in North America using documented skeletal collections established in the late 19th and early 20th centuries. Further, the composition of the collections historically available for skeletal biology research largely reflects the demographics of North America prior to the 1950s. That is, the collections are comprised mainly of individuals of African and European descent, and therefore most biological profile methods were developed on these two ancestral groups. Until fairly recently, large samples of documented Asian skeletons were not available to Western researchers, and it is unlikely that the methods developed on individuals of African and European descent can generate accurate biological profiles for Asian individuals.

The lack of biological profile methods developed from Asian populations is especially problematic in forensic contexts where Asian remains are likely to be recovered, including large U.S. cities, particularly in the west (Figure 1), and in international mass disaster contexts. While the U.S. census classification for Asian (6%) encompasses a geographically and genetically diverse group originating from 19 countries, more than 26% of Asian individuals living in the U.S. originate from East and Southeast Asia (U.S. Census Bureau 2010).

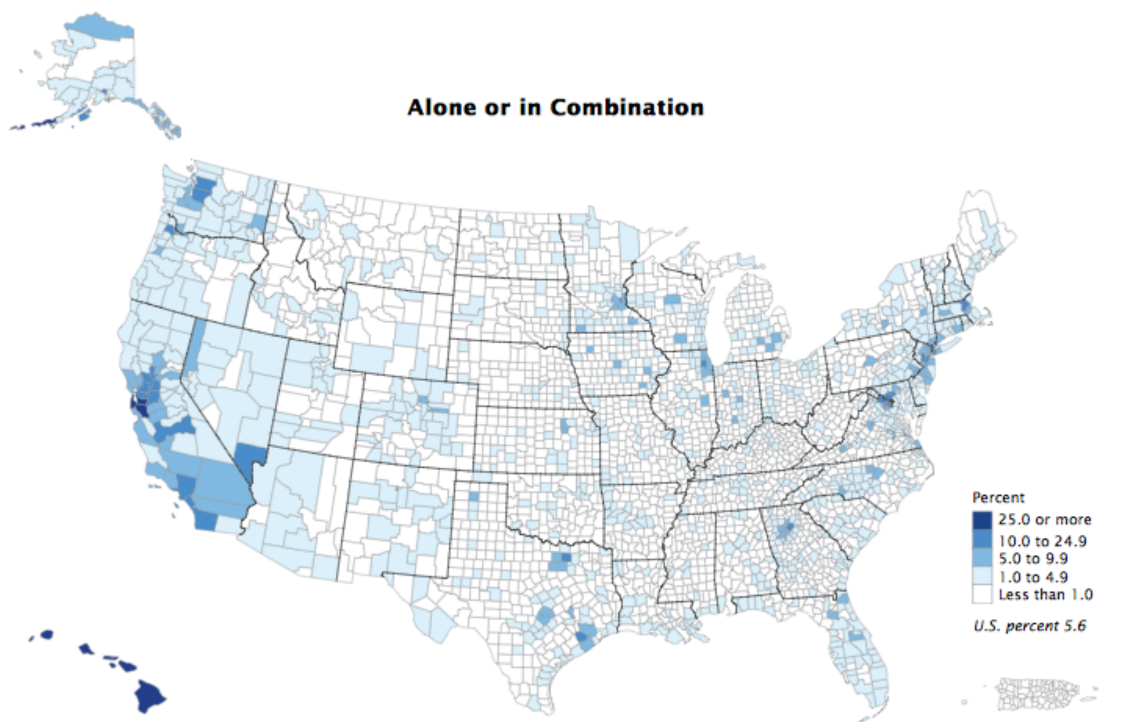

Figure 1. 2010 U.S. Asian population (U.S. Census Bureau 2010).

The current study seeks to determine how the nonmetric sex assessment methods using the cranium and pelvis that were developed on individuals of African and European descent perform in classifying **1,397 modern Japanese and Thai individuals 17-96 years of age**. The cranial and pelvic nonmetric sex assessment methods have been applied to numerous populations throughout the world, demonstrating that significant differences in sexual dimorphism exist between populations. However, few studies have applied these methods to Asian populations. Sex assessment is particularly important as it impacts the methods used in age, ancestry, and stature estimations. Moreover, the continued refinement of nonmetric sex assessment methods is of the utmost importance in the current judicial climate, which requires methods used by expert witnesses to be empirically tested, peer reviewed, maintained by operational standards, accepted by the scientific community, and have known error rates (*Daubert v. Merrell Dow Pharmaceuticals, Inc. 1993*).

Materials and Methods

The Japanese sample consists of **781 (f = 219; m = 562)** known individuals from the greater Tokyo region who died during the late 19th/early 20th centuries (Chiba University) and those who died during the 1960s/1970s (Jikei University). The Thai sample is composed of **616 (f = 198; m = 418)** known individuals from northern Thailand who died in very recent decades (Khon Kaen University; Chiang Mai University). The cranial (nuchal crest, mastoid process, supraorbital margin, glabella, and mental eminence) and pelvic (ventral arc, subpubic concavity, ischiopubic ramus ridge, sciatic notch, and preauricular sulcus) traits were ordinally scored following Buikstra and Ubelaker (1994) and Walker (2008). Trait-by-trait frequencies, probabilities, and female/male sectioning points were established for each trait in each group. Chi-square analyses and binary logistic regression equations determined which traits differ and perform the best. Walker's (2008) and Garvin *et al.*'s (2014) Black, White, and Native American binary logistic regression equations were applied to the Japanese and Thai. Lastly, Spearman's rank order correlation coefficients examined age, while Cohen's kappa statistic examined intraobserver error.

Results

Table 1. Cranial correct classification rates, sectioning points, and probabilities for each group.

Trait/Correct Classified	Group	Sectioning Points and Probabilities (p)				
		1	2	3	4	5
Nuchal crest (59.8%)	Japanese (f=204; m=517)	Female (p=0.52-0.73)			Male (p=0.67-0.94)	
	Thai (f=190; m=401)	Female (p=0.62-0.74)		Male (p=0.61-0.90)		
Mastoid process (78.0%)	Japanese (f=209; m=513)	Female (p=0.74-0.88)		Ind. (p=0.50)	Male (p=0.65-0.66)	
	Thai (f=191; m=375)	Female (p=0.61-0.88)			Male (p=0.70-0.73)	
Supraorbital margin (69.0%)	Japanese (f=205; m=515)	Female (p=0.68-0.86)		Male (p=0.84-0.96)		
	Thai (f=191; m=402)	Female (0.63-0.81)		Male (0.65-0.87)		
Glabella (77.9%)	Japanese (f=205; m=515)	Female (p=0.76)	Male (p=0.86-1.0)			
	Thai (f=192; m=402)	Female (p=0.77)	Male (p=0.86-1.0)			
Mental eminence (64%)	Japanese (f=194; m=507)	Female (p=0.59-0.77)		Male (p=0.66-1.0)		
	Thai (f=183; m=388)	Female (p=0.65-0.81)		Male (p=0.59-1.0)		

Table 2. Walker (2008) and Garvin *et al.*'s (2014) logistic regression equations applied to the Asian sample.

Logistic Regression Equation	Pooled Japanese and Thai % Correctly Classified	Sex Bias*
Walker's American/English	76.8-86.8%	-5.1-71.1%
Walker's Native American	69.5-82.9%	-59.9-54.6%
Garvin *et al.*'s pooled U.S. White	30.6-97.9%	-67.3- -66.0%
Garvin *et al.*'s pooled U.S. Black	65.3-93.3%	-27.9-18.7%
Garvin *et al.*'s Arikara	74.9-88.4%	9.9-13.5%

*Negative sex bias = females better classified; positive sex bias = males better classified

Table 3. Cranial binary logistic regression equations for the pooled Japanese and Thai sample*.

Group	Coefficients						% Correctly Classified			% SB
	NC	MP	SOM	GLA	ME	CON	F	M	T	
Pooled sample[1]	--	-1.002	--	-2.052	--	5.406	80.0	85.7	84.0	5.7
	--	-0.929	-0.516	01.771	-0.579	7.541	75.9	89.7	85.3	14.8
	--	--	--	-2.435	--	2.703	91.7	72.0	77.9	-19.7
	-0.452	-0.893	-0.435	-1.697	-0.599	8.371	75.1	90.8	86.1	15.7
	-0.513	-0.921	--	-1.868	-0.639	7.847	73.5	91.0	85.8	17.5
	--	-0.970	--	-1.986	-0.0632	6.771	67.8	91.7	84.6	23.9

*While statistically significant chi-square differences ($p<0.05$) were found with NC, MP, GLA, and ME (females) and NC, SOM, and ME (males), population did not contribute to the models and therefore the Japanese and Thai are pooled. Likewise, while age is correlated with ME (females) and NC (males), age did not contribute to the models.
[1] Models used 1239 individuals (88.7%) to build equations
NC=nuchal crest; MP=mastoid process; SOM=supraorbital margin; GLA=glabella; ME=mental eminence; CON=constant; F=female; M=male; T=total; SB=sex bias

Intraobserver error: After rescoring 126 individuals (9%), all cranial and pelvic traits exhibit moderate to substantial agreement following Landis and Koch (1977), with the mental eminence performing the worst (Cohen's kappa=0.445) and the ischiopubic ramus performing the best (Cohen's kappa=0.973).
Secular change: Chi-square analyses were conducted between the modern (Jikei) and historic (Chiba) Japanese individuals. Based on significance values below 0.05, two traits show differences between the modern and historic samples for the females (nuchal crest and preauricular sulcus), and seven traits show differences in the males (all cranial traits, ventral arc, and sciatic notch). In general, the modern Japanese individuals are more gracile than historic individuals.

Table 4. Pelvic correct classification rates, sectioning points, and probabilities for each group.

Trait/Correct Classified	Group	Sectioning Points and Probabilities (p)					
		0	1	2	3	4	5
Ventral arc (87.2%)	Japanese (f=101; m=334)	--	Female (p=0.89)	Male (p=0.59-0.87)		--	--
	Thai (f=192; m=405)	--	Female (p=0.78-0.95)		Male (p=0.81)	--	--
Subpubic concavity (95.1%)	Japanese (f=115; m=338)	--	Female (p=0.56-0.98)		Male (p=0.92)	--	--
	Thai (f=191; m=405)	--	Female (p=0.87-0.96)		Male (p=0.95)	--	--
Ischiopubic ramus ridge (93.9%)	Japanese (f=113; m=330)	--	Female (p=0.80-0.96)		Male (p=0.90)	--	--
	Thai (f=193; m=406)	--	Female (p=0.83-0.96)		Male (p=0.94)	--	--
Sciatic notch (86.2%)	Japanese (f=116; m=339)	--	Female (p=0.93-0.98)		Male (p=0.60-0.83)		
	Thai (f=196; m=409)	--	Female (p-0.94-0.98)			Male (p=0.89-1.0)	
Preauricular sulcus (90.0%)	Japanese (f=116; m=339)	Male (p=0.86)	Female (p=0.80-0.99)				--
	Thai (f=196; m=409)	Male (p=0.83)	Female (0.81-0.98)				--

Table 5. Pelvic binary logistic regression equations for the pooled Japanese and Thai sample*.

Group	Coefficients						% Correctly Classified			% SB
	VA	SPC	IPR	SN	PAS	CON	F	M	T	
Pooled sample[1]	3.088	--	--	--	--	-5.748	89.0	97.3	94.9	8.3
	2.567	--	--	0.738	--	-6.983	91.8	97.3	95.7	5.5
	0.653	2.196	--	0.767	--	-7.730	91.8	97.3	95.7	5.5
	0.662	2.025	--	0.669	-0.349	-6.708	92.8	97.3	96.0	4.5
	0.599	2.737	--	--	--	-6.307	91.1	96.9	95.2	5.8
	1.776	--	--	--	-0.818	-2.201	78.5	88.5	85.6	10.0
	.588	1.931	.969	--	--	-6.666	91.8	97.0	95.3	5.2
	--	3.089	--	--	--	-5.750	89.0	97.3	94.9	8.3
	--	2.227	1.008	--	--	-6.083	91.9	97.0	95.5	5.1

*While statistically significant chi-square differences ($p<0.05$) were found with VA (females) and SN (males), population did not contribute to the models and therefore the Japanese and Thai are pooled. Likewise, while age is correlated with IPR (Thai males) and SN (males), age did not contribute to the models.
[1] Models used 1022 individuals (73.2%) to build equations
VA=ventral arc; SPC=subpubic concavity; IPR=ischiopubic concavity; SN=sciatic notch; PAS=preauricular sulcus; CON=constant; F=female; M=male; T=total; SB=sex bias

Discussion and Conclusions

The Japanese and Thai exhibit reduced sexual dimorphism compared to non-Asian groups. Males are more variable than females, and significant overlap exists in the expression of many traits; however, most traits show no truly intermediate scores. Further, cranial and pelvic sexually dimorphic differences between the Japanese and Thai are minimal. The population-specific univariate probabilities and multivariate logistic regression equations perform better in classifying Japanese and Thai individuals than those developed on non-Asian populations. This may be due to differences in nutritional intake, which can impact the development of secondary sex characteristics. Epidemiologically, North America is considered an obesogenic environment due to overnutrition, which accelerates growth during puberty (Chopra *et al.* 2002). This epidemic started in the early 20th century, when many of the collections used for method development were established (Komlos and Brabeck 2010). While age did not contribute to statistical models, the nuchal crest, ischiopubic ramus, and sciatic notch become more "male-like" from 17 to ~60 years of age, especially in males. The increasing constriction of sciatic notch morphology with advancing age in Asian males is consistent with Walker's (2005) finding that younger Americans of African and European ancestry and English-born individuals under 50 years exhibit wider sciatic notches than older individuals. It is possible that sciatic notch constriction is a product of the biomechanical stresses associated with bipedal locomotion. As such, age, population, intraobserver error, and secular change varyingly impact nonmetric trait expression.

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