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Ancestry evaluation from subtrochanteric shape of femur using Tallman and Winburn's Adjusted Platymeric Index: A validation study in the Northern Thai population

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ABSTRACT

Background: Ancestry estimation of unidentified human skeletons using metric parameters of bones other than the skull, such as the subtrochanteric shape of the femur, is a challenging method in cases with limited information from cranial examination. The results of multiple studies show that the subtrochanteric shape can differentiate Asian and non-Asian individuals. However, the cut-point of the platymeric index for subtrochanteric shape might need adjustment for each region or country for higher accuracy, due to interpopulation and intrapopulation variation.

Objectives: This study aims to validate the cut-point adjusted for the Thai population suggested by Tallman and Winburn and observes the differences between each sex within the same population.

Materials and methods: The researchers conduct the study by collecting and calculating multiple parameters (such as femoral subtrochanteric diameters and shape, and platymeric index) from 130 northern Thai individuals collected from the Chiang Mai University bone collection, then making comparisons with the traditional cut-point, and comparing these parameters between different populations and sex.

Results: The results show that the accuracy of ancestry estimation is improved from 46.38% to 57.49%, using an adjusted cut-point. This study also notes that the platymeric index of the northern Thai samples is significantly higher (p<0.05) than the north-eastern samples recorded by Tallman and Winburn. Moreover, the index of the male Thai samples is significantly higher (p<0.05) than the female samples from the same bone collection.

Conclusion: This study approves the use of the adjusted cut-point in the northern Thai region and indicates an intrapopulation variation and sexual dimorphism of subtrochanteric shape which might influence ancestry assessment.

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Introduction

In regular forensic work, understanding forensic anthropology is a crucial step in the personal identification of human remains. Forensic pathologists examine remains thoroughly to gain data on individual characteristics, called a biological profile. The police can compare this profile to missing person data.[1]

One crucial process in the biological profiling of human remains is ancestry assessment. Nowadays, forensic anthropologists use the morphological traits of the human skull (both metric and non-metric) as a significant aspect of the evaluation.[1-3] Meanwhile, the ancestry assessment of remains with incomplete or missing skulls might prove difficult. Thus, other bones such as femurs,[4-8] talus, humerus[1] and cervical spines[9] can provide the data to distinguish between ancestral origins.

Many studies indicate that subtrochanteric shape, intercondylar notch height and intercondylar shelf angle can differentiate between individuals of each descent.[4-6,8] These parameters are used by archaeologists and forensic anthropologists to distinguish between Native American remains and White and Black Americans.[8,10-12] The subtrochanteric aspects play a role in differentiating Asian remains from non-Asian remains.[6] Many researchers use the platymeric index as a representative of subtrochanteric shape. The index is calculated by dividing the antero-posterior subtrochanteric diameter by the medio-lateral subtrochanteric diameter and multiplying by 100.[13] Individuals with indices equal to or less than 84.9 are classified as platymeric (mediolaterally broad), those with indices between 85.0 and 99.9 are classified as eurymeric (round), and those with indices equal to or greater than 100.0 are classified as stenomeric (antero-posteriorly broad).[8] Many studies show that platymeric is the most common shape in the Asian population, while the non-Asian population usually exhibits a eurymeric shape.[4]

The study conducted by Tallman and Winburn shows that the platymeric index range of north-eastern Thai samples is significantly lower than the White American range. Moreover, applying the frequency distribution of the platymeric index to north-eastern Thai individuals is not accurate, using the traditional cut-point. An adjusted cut-point value for the Thai population is calculated and suggested, four units higher than the traditional value (platymeric with indices equal to or lesser than 88.9, eurymeric with indices between 89.0 and 103.9, and stenomeric with indices equal to or greater than 104.0).[4]

Within any population there is some difference in phenotype, called intrapopulation variation.[14,15] Therefore, the frequency distribution of the subtrochanteric shape in other Thai regions might differ from the north-eastern individuals and the adjusted cut-point from Tallman and Winburn's study might not be suitable for the Thai population in other areas.

Therefore, this study aims to validate the adjusted cut-point value using data from northern Thai individuals and observing the differences between each sex of the northern Thai population.

Materials and methods

Sample selection

This study uses the femurs of Thai skeletons donated for educational purposes to the Faculty of Medicine, Chiang Mai University (CMU). Before the femur examination, the researchers examined the general information on each case (ancestry, sex, age, underlying disease, evidence of trauma and orthopedic treatment). Any cases which matched the following exclusion criteria were rejected:

- Any femora that came from a deceased with a confirmed diagnosis of osteoporosis or diseases that affect bone quality (such as osteomalacia, Cushing's disease, Paget's disease or Marfan syndrome).[16]
- Any femora that had a moderate to severe degree of damage, such as fractures, deformities or post-mortem breaking.
- Any femora that had retained artificial implants or fixating material.

Of the 471 cases in the bone collection, 130 which came from the northern Thai population were randomly selected and included in the research as the northern Thai samples. The sample size was calculated using the formula:

$$n = (Z^2 \times P \times (1 - P))/ e^2$$

where Z = value from standard normal distribution corresponding to the desired confidence interval (CI) (Z=1.96 for 95% CI), P = expected true proportion (P=0.9), and e = desired precision (e=0.05).[17]

The sample contained 79 male and 51 female cases, with ages ranging from 26 to 94 years (average 60.42 years). For the north-eastern Thai sample and foreigner sample, the researchers used the data from Tallman and Winburn's study which is available in their study's full article.[4]

Femur examination and data collection

Metric dimensions of the subtrochanteric region (A-P and M-L diameter) of the left femur was measured using standard anthropometric sliding callipers (Figure 1A-1C), using the right femur if the left was missing or damaged (according to the measurement recommendation from standards for data collection from human skeletal remains).[18] Medio-lateral subtrochanteric diameter refers to the distance between the medial and lateral surfaces at the point of greatest expansion below the base of the lesser trochanter. Antero-posterior subtrochanteric diameter was defined as the distance between anterior and posterior surfaces perpendicular to the medio-lateral diameter (Figure 2).[18] Each parameter was measured three times and the platymeric index (PI) was calculated using an average of the measured values. Meanwhile, the anthropology expert measured and revised 30 samples for inter-observer bias calculation. Next, the subtrochanteric shape of each femur was classified by its calculated platymeric index compared to the traditional cut-point and adjusted cut-point from Tallman and Windburn's study (shifting the cut-point values by four units higher from the traditional cut-point).[4] The ancestry was estimated from the subtrochanteric shape and compared to the recorded ancestry of each case for validation. Difference in frequency distribution between the traditional and adjusted methods, between each sex, and between other population results were compared to other studies.

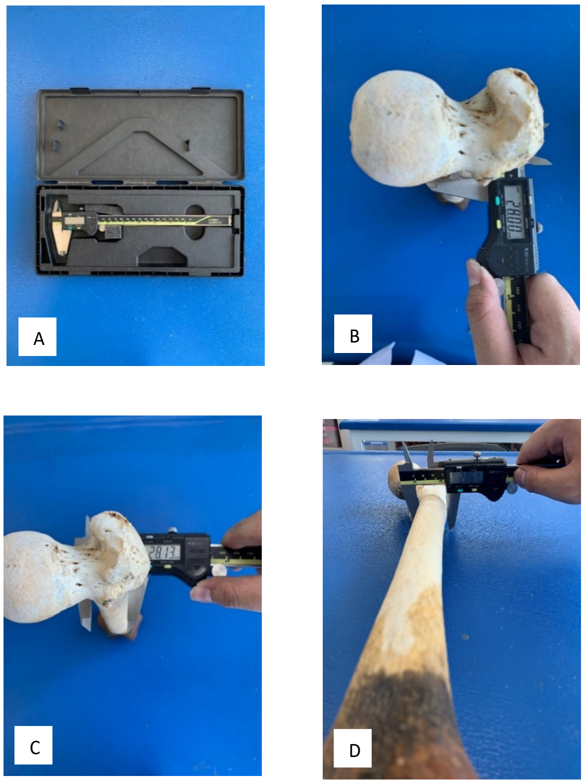

Figure 1. *Measurement of metric dimensions of subtrochanteric region (A-P and M-L diameter). (A): standard anthropometric sliding calipers being used in this study, (B): process of antero-posterior diameter, (C, D): medio-lateral diameter measurement from the selected femur.*

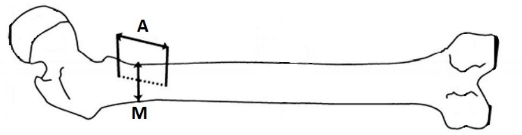

Figure 2. *Landmarks for antero-posterior (labelled as "A") and medio-lateral diameter (labelled as "M") measurement in human femur (modified from Figure 54. Measurements of the left femur, posterior view from Buikstra and Ubelaker's Standards for data collection from human skeletal remains, 1997).*[18]

Statistical assessment

The intraclass correlation coefficient (ICC) was used to calculate intra-rater and inter-rater bias during the data collection process. The researchers used Cohen's kappa coefficient to measure reliability between the adjusted cut-point evaluation and recorded ancestry data, for adjusted cut-point validation. For comparison between the two groups, the independent t-test and Pearson's chi-squared test were used to compare the platymeric index and frequency distribution of subtrochanteric shape, respectively.

Results

Platymeric index

Platymeric index of 130 samples from the northern Thai population samples from CMU had an average of 87.03 with SD of 6.53 (range 69.99-106.67). The platymeric index had a normal distribution, shown by the Kolmogorov-Smirnov test (p=0.20) (Figure 3). The demographic data, average A-P and M-L diameter, and platymeric index of each sex are shown in Table 1. There was excellent reliability of the rater according to the intra-rater and inter-rater ICC values (Table 2).

Table 1 Summation of demographic data and femoral metric data of northern Thai population samples from CMU.

	Cases	Age		A-P diameter	M-L diameter	Platymeric index	
	N (%)	Mean (SD)	Range	Mean (SD)	Mean (SD)	Mean (SD)	Range
Male	79 (60.8)	59.92 (12.87)	29-91	27.09 (2.11)	30.81 (2.14)	88.08 (5.93)	69.99-100.60
Female	51 (39.2)	61.18 (15.32)	26-94	24.17 (2.28)	28.34 (1.98)	85.42 (7.13)	70.77-106.67
All samples	130	60.42 (13.84)	26-94	25.95 (2.60)	29.84 (2.40)	87.03 (6.53)	69.99-106.67

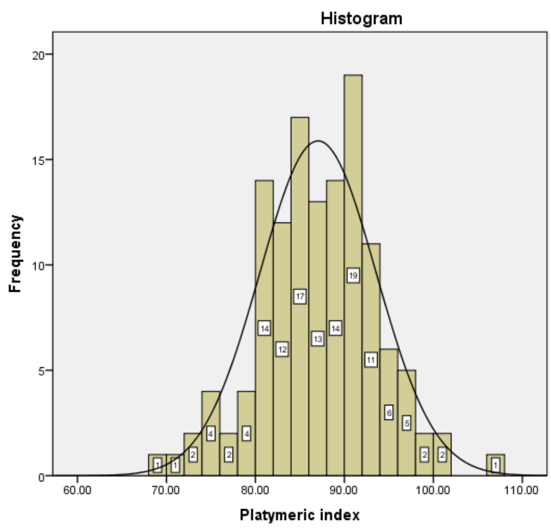

Figure 3. *Platymeric index distribution curve calculated from northern Thai population samples from CMU.*

Table 2 Intraclass correlation coefficient value for intra-rater and inter-rater bias of each parameter.

	A-P diameter	M-L diameter
Intra-rater bias	0.992	0.990
Inter-rater bias	0.957	0.910

Subtrochanteric shape and frequency distribution

Using the traditional cut-point, the most common type of subtrochanteric shape of northern Thai population samples from CMU is eurymeric (80 cases; 61.5%), while only 47 cases (36.2%) have platymeric shape. After re-classification of the subtrochanteric shape using the adjusted cut-point from Tallman and Windburn's study, the number of cases with platymeric shape increased by 32 (24.6%), while cases with eurymeric and stenomeric shape decreased by 30 and 2, respectively (Table 3).

The researchers used raw data on White American males from Tallman and Windburn's study as non-Asian representatives for the validation process. Assuming that a platymeric shape is interpreted as Asian and other shapes are interpreted as non-Asian (Table 4), there is slight agreement between the recorded ancestry and estimated ancestry using the adjusted cut-point of Tallman and Winburn (κ=0.123, *p*=0.075). Comparing the traditional and adjusted cut-point accuracy, the adjusted cut-point accuracy (57.49%) is higher than the traditional (46.38%).

Table 3 Subtrochanteric shape of northern Thai population samples from CMU, evaluated by traditional and adjusted cut-point from Tallman and Windburn's study.[4]

		Platymeric	Eurymeric	Stenomeric
		N (%)	N (%)	N (%)
Traditional cut-point[a]	Male	21	56	2
	Female	26	24	1
	Total	47 (36.2)	80 (61.5)	3 (2.3)
Adjusted cut-point[b]	Male	42	37	0
	Female	37	13	1
	Total	79 (60.8)	50 (38.5)	1 (0.8)

[a]*Platymeric (PI≤84.9), Eurymeric (85.0≤PI≤99.9), Stenomeric (PI≥100.0)*
[b]*Platymeric (PI≤88.9), Eurymeric (89.0≤PI≤103.9), Stenomeric (PI≥104.0)*

Table 4 Number of cases for each estimated ancestry by subtrochanteric shape, compared to recorded ancestry.

			Recorded ancestry	
			Asian	Non-Asian
Estimated ancestry	Traditional	Asian	47	28
		Non-Asian	83	49
	Adjusted	Asian	79	37
		Non-Asian	51	40

Subgroup comparison

Comparing male and female Thai samples from the CMU collection, as shown in Table 1, the platymeric indexes of the female skeletons are statistically significantly lower than the male skeletons (*p*=0.023). Also, the female skeletons' AP diameters and ML diameters are statistically significantly lower than the males (*p*<0.05). There is a statistically significant difference in the frequency distribution of subtrochanteric shape between the sexes, using the traditional cut-point (*p*=0.018) and adjusted cut-point (*p*=0.028).

Platymeric index and subtrochanteric shape of male Thai samples from the CMU collection was compared to male samples from the Khon Kaen University (KKU) collection and the American White males from Tallman and Winburn's study.[4] The results show that the platymeric indexes of the male skeletons from CMU (88.08±SE of 0.67) are statistically significantly higher than the male skeletons from KKU (83.85±SE of 0.65) (p<0.05) but statistically significantly lower than the American male skeletons (91.36±SE of 1.14) (*p*=0.014). Moreover, there is a statistically significant difference in the subtrochanteric shape distribution between the Thai males from the CMU collection and the KKU collection and American White males from the Tallman and Windburn study, using the traditional cut-point (*p*<0.05). The frequency distribution percentage comparison of the male Asian subpopulation (data from multiple studies) and White males from Tallman and Winburn's study is presented in Table 5.

Table 5 Number of cases for each estimated ancestry by subtrochanteric shape, compared to recorded ancestry.

	Northern Thai	Northeastern Thai[4]	Singapore Chinese[19]	Malaysia Chinese[20]	American white[4]
Platymeric	36.2	57.8	51.2	55.8	36.4
Eurymeric	61.5	39.1	48.8	30.0	37.7
Stenomeric	2.3	3.1	0.0	14.2	26.0

Discussion

Postcranial methods of ancestry estimation (the ancestry estimation using the other bones rather than the skull) have a major role in the skeleton with a damaged or missing skull.[1] But currently, the studies about postcranial methods are still not many. One of the most common bones that are being used for ancestry studies is the subtrochanteric region of the femur. Many researchers state that humans of different ancestry have different subtrochanteric shapes due to the type of terrain and subsistence method.[8] The subtrochanteric shape is different between Asian and non-Asian populations and between each region within populations.[4] Therefore, this study aims to validate Tallman and Winburn's adjusted cut-point of platymeric index using a sub-population different from the original research.

According to the results for the northern Thai population, the accuracy of the ancestry estimation using the platymeric index along with Tallman and Winburn's adjusted cut-point is higher than the traditional cut-point (57.49% and 46.38%, respectively), and the number of Asian cases correctly classified increases by 24.6% (32 cases). The results are similar to Tallman and Windburn's original study based on the KKU collection.[4] It can be assumed that the population-specific platymeric index cut-point should be used to estimate ancestry more accurately. However, we suggest that the platymeric index should not be used solely for estimation, based on the value of Cohen's kappa coefficient (κ=0.123). Evaluation using combined data from various femoral parameters (such as intercondylar notch height and intercondylar shelf) would be more proper and effective, and give more appropriate results.

Based on the frequency distribution of subtrochanteric shape in the northern Thai sample, the most frequent type is eurymeric (61.5%), while the platymeric shape is found in only 36.2%. These numbers contrast with the north-eastern Thai sample and other subpopulations from the Asian continent, where the most common type is platymeric, and eurymeric is less common. The average value of the platymeric index calculated from the CMU collection is higher than the KKU collection (88.08 and 83.85, respectively). These differences might be caused by intrapopulation variation of the femur due to multiple factors that affect the mechanical stress on the lower limbs and nutrition status, including the terrain of the northern province and the livelihoods of the population compared to other regions.[8,14,15,21]

Because of the difference between the northern and north-eastern Thai populations, the researchers suggest that the data from this study might not be sufficient to calculate a new platymeric index cut-point, and additional data collection from other Thai provinces is recommended.

This study finds that the average A-P diameter, M-L diameter and platymeric index of the male sample is significantly higher than the female. The frequency distribution of subtrochanteric shapes for each sex is significantly different. One reason for these findings is sexual dimorphism, which is the difference in phenotype between males and females of the same ancestry. The morphological variance of the femur between males and females is explained by the principle that the axial skeleton weight of males is relatively heavier than females, and one of the major bones that are impacted by the weight transmission is the femur. Another theory suggests that the female pelvis morphology is modified for reproduction and pregnancy, leading to different stresses and strains affecting the femur.[21,22] The researchers suggest that sexual dimorphism should be considered when estimating ancestry. In routine biological profile assessment, ancestry is the first aspect to be determined, before sex, so sexual dimorphism might interfere with the ancestry interpretation.

Conclusion

Postcranial studies for ancestry estimation are essential in the forensic field, especially in cases with limited skull data. However, few studies or databases exist in Thailand or other Asian countries. The researchers aim to contribute Asian data to further research on subtrochanteric shape and ancestry assessment. Secondly, this study validates the platymeric index cut-point adjusted by Tallman and Winburn to determine the intrapopulation variation between provinces and approve its accuracy and adaptability for use in Thailand. Lastly, this study raises one significant factor that might affect ancestry interpretation, the sexual dimorphism of the human femur. The researchers hope for the discovery of a new proper cut-point or other method for more accurate ancestry estimation using subtrochanteric shape, whatever the sex of the individual.

Conflict of interest

The authors declare no conflict of interest.

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