Population Affinity from Subtrochanteric Shape: The Applicability of Osteometric Techniques on Contemporary Native American Populations

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INTRODUCTION

Analysis of the proximal femur has been considered relatively reliable in differentiating between very broad ancestral groups (i.e., Indigenous American vs. Black/white Americans), particularly the anterior-posterior (A-P) and medial-lateral (M-L) subtrochanteric diameters (Gilbert and Gill 1990; Gill and Rhine 1990). Additionally, **the platymeric index (PI; A-P/M-L x 100) is often used to estimate subtrochanteric shape** as platymeric (mediolaterally broad), eurymeric (round), or stenomeric (anteroposteriorly broad). Traditional PI thresholds, such as Wescott's (2005), have been relatively successful in differentiating between Indigenous Americans (generally platymeric; PI < 84.9) from pooled Black/white American samples (generally eurymeric; 85.0 < PI < 99.9).

Use of the proximal femur in ancestry estimation is complicated by several methodological issues and assumptions: (1) A-P and M-L subtrochanteric diameters often demonstrate high intra- and inter-observer error (Adams and Byrd 2002); (2) **Indigenous ancestry estimation methods were largely built on archaeological samples and likely do not reflect modern variation**; and (3) subtrochanteric methods often underestimate the effects of sex differences, assume temporal and geographic homogeneity, and attribute population differences to genetics rather than biomechanics (Wescott & Srikanta, 2008). Temporal change has been found to have a more significant impact than previously understood (Tallman 2015). Tallman and Winburn (2015) found that modern Thai individuals exhibit less platymeria than the Native American samples upon which many of these methods are based and proposed adjusted thresholds to better classify East Asian groups from white Americans.

The New Mexico Decedent Image Database (NMDID) has helped to mitigate the lack of modern Indigenous representation by providing a substantial dataset of CT scans. The current study tests the methods of Gill & Rhine (1990), Wescott (2005), and Tallman & Winburn (2015) on a modern sample of Indigenous individuals from the NMDID and data from modern Black/white individuals and archaeological Indigenous to evaluate the impact of secular change and biomechanical stress. **This study tests whether established PI thresholds derived from archaeological samples remain appropriate within forensic anthropological casework or if modern environmental influences have rendered traditional sectioning lines obsolete.**

MATERIALS & METHODS

All three samples—modern Indigenous American, modern Black/white American, and archaeological/historic Indigenous—consist of 400 individuals (f = 200; m = 200), resulting in a **total of 1,200 individuals**. The modern Indigenous sample is comprised of the CT images of 400 individuals aged 18 to 93 from the NMDID. Data for the modern Black/white American sample was provided by the Forensic Databank (FDB) housed at the University of Tennessee, Knoxville (UTK). The Black American sample (*n* = 166) had birth years ranging from 1892 to 1990 and ranged in age from 18 to 99 years. The white American sample (*n* = 234) had birth years ranging from 1934 to 1993 and ranged in age from 18 to 89 years. Data for the archaeological/historic Indigenous sample was generously provided by Daniel J. Wescott and originally acquired from the University of Tennessee/Smithsonian Institution (UT/SI) postcranial databases (Wescott 2001), first assembled by Zobeck (1983). The dates provided for the remains ranged from ~7500 years BP to 1865.

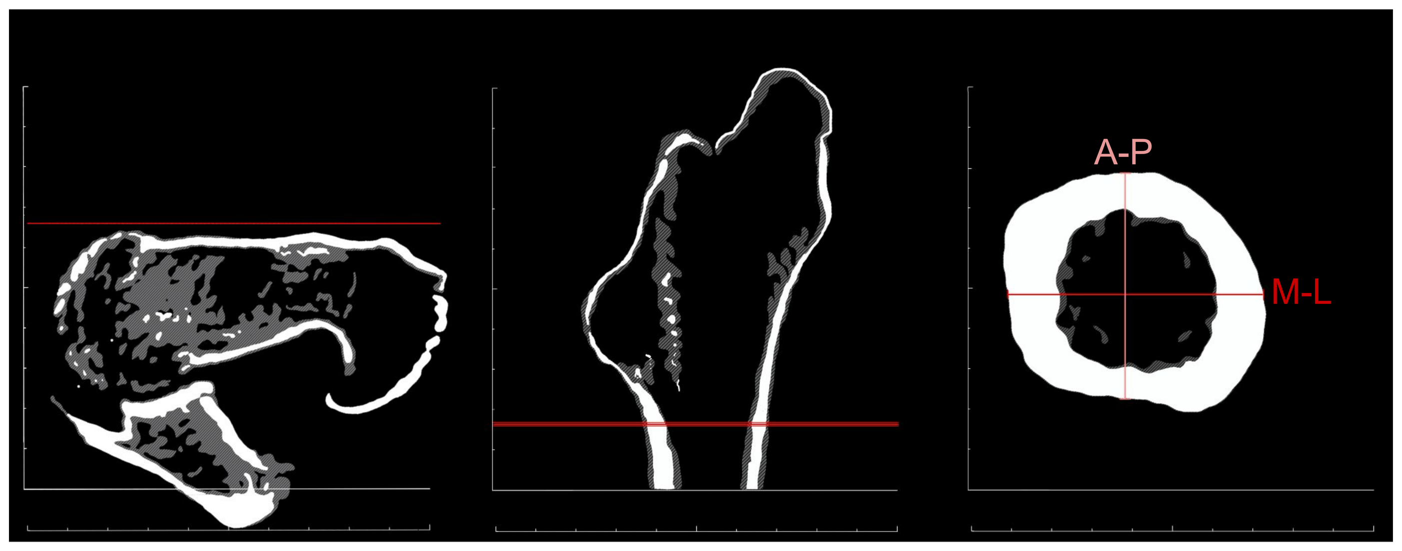

Figure 1. Illustration of orientation and measurements of proximal femur within *Horos™*.

(1) axial view of left proximal femur, anterior neck aligned parallel to guides & angle recorded; (2) coronal view of proximal femur locating subtrochanteric region; (3) axial slice of subtrochanteric femur with A-P and M-L diameter measurements.

The CT images were analyzed using freely available *Horos™* (version 4.0.1). Femoral measurements of the subtrochanteric A-P and M-L diameters were taken from two-dimensional slices of the CT images (Figure 1) and recorded to the nearest millimeter and used to calculate PI. To examine intraobserver error, 40 femora (10%) were re-measured. Intraclass correlation coefficients, descriptive statistics, discriminant functions, t-tests, and ANOVAs were calculated in the SPSS statistical software package.

RESULTS

Intraobserver error was minimal for measurements obtained from CT scans (Table 1).

Table 1. Intraclass correlation coefficients for 40 remeasured NMDID femora.

Test	A-P	M-L
Intra-observer Single Measures	0.985	0.986
Intra-observer Average Measures	0.993	0.987

Descriptive statistics by group and sex are provided in Table 2 and show that modern Indigenous and modern Black/white individuals are mostly eurymeric, archaeological/historic Indigenous individuals are strongly platymeric, and no group is markedly stenomeric.

Table 2. Descriptive statistics with traditional (T) & adjusted (A) PI definitions*

Sample	Sex	*N*	Mean PI	SD	PI Range	Platymeric	Eurymeric	Stenomeric
Modern Indigenous	F	200	89.19	5.75	72.22-106.90	T: 25.00%	T: 69.50%	T: 5.50%
						A: 47.50%	A: 52.00%	A: 0.50%
	M	200	90.77	6.03	75.00 - 106.45	T: 17.50%	T: 70.50%	T: 12.00%
						A: 42.50%	A: 56.50%	A: 1.00%
	C	400	89.98	5.94	72.22 - 106.90	T: 21.3%	T: 70.0%	T: 8.8%
						A: 45.0%	A: 54.3%	A: 0.8%
Modern Black/white	F	200	89.06	9.82	61.11 - 125	T: 34.50%	T: 49.00%	T: 16.50%
						A: 54.50%	A: 39.50%	A: 6.00%
	M	200	90.24	7.95	74.19 - 116.67	T: 28.00%	T: 59.50%	T: 12.50%
						A: 44.00%	A: 51.50%	A: 4.50%
	C	400	89.65	8.94	61.11 - 125.00	T: 31.3%	T: 54.3%	T: 14.5%
						A: 49.3%	A: 45.5%	A: 5.3%
Archaeological/historic Indigenous	F	200	77.40	8.85	58.97 - 120.83	T: 85.00%	T: 12.50%	T: 2.50%
						A: 91.50%	A: 7.50%	A: 1.00%
	M	200	80.81	10.90	56.10 - 125.93	T: 73.00%	T: 20.50%	T: 6.50%
						A: 86.00%	A: 10.00%	A: 4.00%
	C	400	79.11	10.06	56.10 - 125.93	T: 79.0%	T: 16.5%	T: 4.5%
						A: 88.8%	A: 8.8%	A: 2.5%

*T: Platymeric (PI ≤ 84.9), Eurymeric (85.0 ≤PI ≤ 99.9), Stenomeric (PI ≥ 100) (Wescott 2005); A: Platymeric (PI ≤ 88.9), Eurymeric (89.0 ≤PI ≤ 103.9), Stenomeric (PI ≥ 104) (Tallman & Winburn 2015)
- Modern Indigenous females differ from Modern Indigenous males (p = 0.004); Modern Black/white females differ from Modern Black/white males (p = 0.095); Archaeological/historic indigenous females differ from Archaeological/historical indigenous males (p < 0.001).
- F = female; M = male; C = combined

Table 3 demonstrates that discriminant functions using the PI correctly classified archaeological/historic Indigenous individuals more frequently than the modern individuals.

Table 3. Cross-validated discriminant function classification rates.

Group	Sex	*N*	Platymeric Index		A-P & M-L	
			Correct	Incorrect	Correct	Incorrect
Modern Indigenous	F	200	52.5%	47.5%	55.0%	45%
	M	200	51.5%	48.5%	51.0%	49.0%
	C	400	50.8%	49.2%	53.3%	46.7
Modern Black/white	F	200	27.5%	72.5%	48.5%	51.5%
	M	200	21.0%	79.0%	41.0%	59.0%
	C	400	24.5%	75.5%	40.8%	59.2%
Archaeological/historical Indigenous	F	200	**82.0%**	18.0%	**78.5%**	21.5%
	M	200	**75.0%**	25.0%	**71.5%**	28.5%
	C	400	**75.5%**	24.5%	**72.0%**	28.0%

One-way ANOVAs (Table 4) determined **negligible effects of age on PI** within all three groups (modern Indigenous: $F(8, 391) = 0.98$, p = 0.453; modern pooled Black/white: $F(8, 368) = 0.81$, p = 0.595; archaeological/historic Indigenous: $F(5, 394) = 0.64$, p = 0.670.) suggesting that the PI remains stable across age categories.

Table 4. ANOVA: Age effects on PI of 9 Modern Indigenous age groups, 9 Modern Black/white age groups, and 6 Archaeological/historical Indigenous age groups.

Test	Sample	Sum of Squares	df	Mean Square	*F*	Sig.
Between Groups	Modern Indigenous	276.199	8	34.525	.978	.453
	Modern Black/white	518.912	8	64.864	.809	.595
	Archaeological/historical Indigenous	324.484	5	64.897	.638	.670
Within Groups	Modern Indigenous	13801.551	391	35.298		
	Modern Black/white	29504.637	368	80.176		
	Archaeological/historical Indigenous	40046.238	394	101.640		
TOTAL	Modern Indigenous	14077.750	399			
	Modern Black/white	30023.549	376			
	Archaeological/historical Indigenous	40370.722	399			

A one-way ANOVA (Table 5) revealed a **significant effect of time period on PI ($F(2, 1197) = 212.12$, $p < .001$, $\eta2 = .26$)**. Post hoc comparisons using Tukey's HSD indicate that the archaeological/historic Indigenous sample is significantly different from both the modern Indigenous and the modern Black/white American samples ($p < .001$). However, **no significant difference was found between the two modern groups ($p = .847$)**. These findings suggest that while PI is a highly reliable indicator of time period ($\eta2 = .26$), it does not reliably distinguish between modern groups.

Table 5. ANOVA: Ancestry effects on PI.

Test	Sum of Squares	df	Mean Square	*F*	Sig.	$\eta2$ [95% CI]
Between Groups	30598.757	2	15299.379	212.120	<.001	.262 [.221, .300]
Within Groups	86334.960	1197	72.126			
TOTAL	116933.717	1199				

DISCUSSION & CONCLUSION

Overall, the results demonstrate that **subtrochanteric measurements and the PI should not be used in modern forensic contexts** to differentiate Indigenous individuals from Black/white Americans as the proximal femur does not vary along the ancestral lines historically—and problematically—used in forensic anthropology. The modern Indigenous and Black/white American samples exhibit no statistical difference in their subtrochanteric size and shape and are largely eurymeric, while the archaeological/historic Indigenous individuals are largely platymeric and are statistically different from the modern samples (Table 5). This further suggests that time period is a more significant factor in contributing to subtrochanteric morphology than ancestry. However, the PI could be used in very limited contexts where modern Indigenous remains need to be distinguished from archaeological remains. This further suggests that biomechanics play a more significant role in proximal femur morphology than genetics.

Early research considered that the flattening of long bones exhibited in "primitive" populations might be due to bone "deficiency" (Buxton 1938). Nearly a century later, however, anthropologists continue to consider subtrochanteric morphology as a genetic trait tied to ancestry, despite its ties to beliefs of racial superiority in its origination. Furthermore, research widely suggests a connection between PI and biomechanical and environmental stressors. In particular, generally platymeric populations tend to be those living on rougher terrains and/or upholding more consistent mobility patterns (Bleuze 2004; Wescott 2005; Wescott and Srikanta 2008; Wescott 2014). **The temporal increase of the circularity of long bones has been reported for many populations**, particularly coinciding with the shift toward agriculture and industrialism (Ruff, Larsen, and Hayes 1984; Brown 2006; Tallman and Winburn 2011; Tallman 2015; McIlvain and Schepartz 2015). Biomechanical research suggests that current changes in femoral morphology may be due to the **increasingly sedentary lifestyle** of modern humans (Wescott and Zephro 2016). Additionally, it is important to note that **all Indigenous groups are not a monolith and display a significant level of variation.** As such, the field of biological anthropology must move beyond its use of broad demographic groupings—as employed and critiqued within the present research—toward more population-specific studies.

Statistical analysis of the present study confirms that sex and time period significantly affect PI ($p < 0.001$), while age does not ($p = 0.453 - 0.670$). This suggests that subtrochanteric form is not entirely determined by ancestral groups nor genetics but rather is influenced by biomechanical stresses and secular change. This research demonstrates that **PI may be a cautiously useful indicator of Native American ancestry in archaeological contexts** ($\eta2 = 0.262$) **but is not suitable for use in modern forensic casework.** Further study on the femoral morphology of contemporary populations is required to discern whether adjusted PI thresholds and A-P and M-L sectioning lines may improve the utility of this method for modern populations.

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References: