

Development and Assessment of Postcranial Sex Estimation Methods for a Guatemalan Population*

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ABSTRACT: This study tests whether postcranial sex estimation methods generated from Hispanic, and mainly Mexican samples, can be successfully applied to other increasingly common migrant populations from Central America. We use a sample of postcranial data from a modern (1980s) Guatemalan Maya sample (n = 219). Results indicate a decrease in classification accuracies for previously established univariate methods when applied to the Guatemalan study sample, specifically for males whose accuracies ranged from 30-84%. This bias towards inaccuracies for Guatemalan males is associated with the smaller skeletal sizes for the Guatemalan sample as compared to the samples used in the tested sex estimation methods. In contrast, the tested multivariate discriminant function classification yielded less sex bias and improved classification accuracies ranging from 82-89%. Our results highlight which of the tested univariate and multivariate methods reach acceptable levels for accuracy for sex estimation of cases where the region of origin may include Guatemala.

KEYWORDS: forensic science, forensic anthropology, Hispanic, sex estimation, postcranial measurements, migrant

While Mexico remains a primary sending country for undocumented border crossers (UBC) at the U.S-Mexico border (1), recent years demonstrate an influx in migrants from Central and South American countries (2) as well as an increase in unaccompanied minors from the Northern Triangle countries of Guatemala, El Salvador and Honduras (3-6). In the last decade (2000-2013) in the U.S., the Central American population has increased by 56%, with Guatemalans being one of the lead sending countries from this region (7). These statistics are concomitantly reflected in the trends of those who die while attempting to cross. According to Martinez and colleagues' (8), analysis of over twenty years of death investigation cases of deceased UBCs from the Pima County Medical Examiner's Office (PCOME) in Tucson, Arizona, nearly 83% of those identified cases are Mexican nationals, with the next most prevalent country of origin being Guatemala (7%). There are a number of reasons as to why the rate of Central and South American UBCs is increasing, including the incumbent social, political and economic conditions in the sending countries (3,5,6).

In the context of the medico-legal death investigations of UBC cases, the cultural and biological diversity of the migrating demographic can make the identification process difficult in unique ways, yet is not necessarily explicitly reflected in forensic anthropology methods. For example, a basic concern is how the changing population diversity of migrants comprising the UBC demographic impacts the accuracy of the methods being applied to estimate the biological profile, such as sex, age and stature estimations.

The present study examines how reference sampling impacts the accuracy of methods which can be used in UBC casework, and whether they can be applied to the changing UBC demographic of Central Americans. Because UBC sending regions have markedly expanded in

recent decades, we propose that a concurrent expansion of skeletal diversity of the UBC demographic has also occurred. Specifically, the present study explores whether diversity in body size is captured in established postcranial sex estimation methods applicable to the current UBC demographic (9,10).

Previous studies (9-11) were led by researchers who identified a similar issue of a changing forensic anthropology UBC casework demographic, recognizing that the available methods at that time were drawn from a Latino demographic that did not adequately encompass the skeletal diversity of those who were crossing the border (B.E. Anderson pers. comm.). Specifically, Tise (11) and colleagues (9) addressed the shift from larger-bodied migrants from northern Mexican states to the expanded sending regions across Mexico, reflecting an increased variation in body size in their postcranial sectioning points for sex estimation. More recently, Spradley and colleagues (10) expanded on previous sampling efforts and produced subsequent sex estimation methods based on the inclusion of a southern Mexico sample. The expansion of sampling to a location where Mayan indigenous ancestry is prevalent effectively increased the representation of smaller-bodied individuals in the sample and methods. These sampling and method adjustments are reflective of the trends witnessed in the UBC demographic over the past 15 years, which indicate a marked increase in the number southern and central Mexico origins of Mexican migrants (8,12,13). The present study builds on these previous works by considering the most recent shifts in the UBC demographic, the Guatemalan migrant.

Migrants from Guatemala have consistently increased in recent years, (7), with a particular influx from poverty-stricken areas (6,14), which generally overlaps with those departments with the largest rural and indigenous Maya populations. Average body size of indigenous Guatemalans living in Guatemala has been demonstrated to differ significantly when

compared to indigenous Guatemalans who experience less social, economic and environmental stress, such as descendants of Maya refugees in the U.S. (15). Thus, Guatemalan migrants who are crossing into the U.S. potentially represent a UBC demographic whose smaller body size may not necessarily be reflected in the current reference samples and postcranial sex estimation methods.

The aims of the present study are 1) to assess whether established accuracies for UBC postcranial sex estimation methods are upheld when applied to an indigenous Guatemalan sample, and 2) based on the results of the study's first aim, make recommendations regarding which methods (e.g. univariate or multivariate methods; particular measurements) are most appropriate for the expanding UBC demographic.

Common Reference Sampling Strategies for Methods Development

Because most border-crossing cases that require a forensic anthropologist are not identified at the time of analysis, the reference samples from which the anthropological methods derive require thoughtful consideration. Because the origin of the unidentified decedent is unknown, the individual may be from a sending region whose skeletal variation is poorly reflected in a given method's sample diversity. One approach to generating an appropriate sample from which to establish forensic anthropology methods has been to source actual UBC cases, which may or may not have been identified. While an intuitive first step, secular changes in the border crossing demographic, as previously highlighted, require that this sample be consistently updated. Using identified UBC cases intuitively is preferred, as researchers can confirm that the decedent is included in the demographic of interest for method sampling. However, Hughes and colleagues (16) have demonstrated an identification bias in border-crosser

casework from recent years, where those individuals who have been identified exhibit a greater amount of European ancestry, as compared to those UBCs not yet identified. Therefore, if methods are derived from a sample of identified border crosser cases only, then the demographic may not necessarily represent who is dying, but only who is dying *and* being identified. In this situation, sampling only identified UBC cases may yield a sample that is skewed towards greater European admixture than what is represented among all deceased UBCs, regardless of identification status.

There are several contextual factors in UBC casework that render sex estimation more challenging than other forensic anthropological casework demographics. Often, a comprehensive application of the array of available sex estimation methods for human skeletal remains is not always possible with UBC cases, as many cases constitute only a partially recovered skeleton (B.E. Anderson pers. comm.). Furthermore, those skeletal elements present in a given UBC case commonly exhibit extensive taphonomic processes (e.g. cortical erosion, carnivore gnawing) which further limit the application sex estimation methods. Because of the sometimes limited availability of skeletal material, methods that use a single measurement from a single skeletal element, such as univariate sectioning points, are ideal for UBC casework, and thus the present study follows the approach of previous studies (9-11) in developing univariate sectioning points for sex estimation.

Another challenge common in the UBC casework context is DNA availability. In other forensic contexts, the anthropological sex estimation may be confirmed with DNA analysis, thus resolving any inaccurate information generated. In contrast, a misclassification of sex from forensic anthropological methods may not be resolved from DNA in the UBC context, as the DNA may be more degraded (due to an extended post-mortem interval under hot and dry

conditions) to the point where genetically-derived information on sex is not available for comparison (pers. comm. with B.E. Anderson).

As the ultimate goal is to identify the decedents and return them to their families, it is imperative that forensic anthropologists develop and employ sex estimation methods that are well balanced in both accuracy and precision for the most current border crossing demographic.

Materials and Methods

Study Sample

The sample data in the present study was collected from Forensic Anthropology Foundation of Guatemala (FAFG) cases of victims from the Guatemalan civil war (1960-1996), including 51 females and 168 males. The individuals included in the sample are geographically diverse, including 59 different grave sites located across the Guatemala highlands, from over five departments; Quiche, Chimaltenango, Baja Verapaz, Alta Verapaz and Solola. Based on the documentation of the gravesites, the majority of the sampled individuals date to the early 1980s, at the height of the civil war's violence according to the United Nations-sponsored Historical Clarification Commission (CEH) report (17). Data collection was completed by author CEH intermittently from 2006-2009. The estimated sex of each individual was drawn from the FAFG forensic anthropology reports, which used a variety of methods (depending on element availability) to assess sex, including traditional nonmetric methods (pelvic and cranial gross morphology) and metric methods (18-20). In the sample 49% of males and 69% of females were identified. In the cases where the individual was not identified, only instances where the final sex estimation was calculated using several methods and inference of sex was strong were utilised in

this study. Estimations of sex that were probable or possible male or female were excluded from the sample. Additionally clothing in the Guatemalan Mayan community is traditionally sex-specific and is used as corroboration by the caseworker to confirm the anthropological sex estimation. The majority (83%) of the reported missing persons related to the civil war were indigenous (17), and thus the study sample used here reflects a largely indigenous sample. This demographic mainly represents the population from Guatemala that is making the journey north, who are from poorer rural areas in search of economic opportunities (14).

Data Collection

Twenty-three standard postcranial measurements (21,22) were collected by author CEH. Digital sliding calipers and an osteometric board were used to collect the measurements. When taphonomic processes (e.g. damage, erosion, partial recovery) and/or trauma were present, the collections of the affected measurements on all individuals were not completed. Therefore, measurement-specific samples sizes are included in appropriate tables throughout the paper. Of the 23 measurements collected, only those measurements with a sample size greater than or equal to 20 for each sex are reported here, yielding nine postcranial measurements for the following analyses (see Table 1 for the measurement descriptions).

Data Analysis: Guatemalan Sex Differences and Sectioning Points

For those nine postcranial measurements with samples sizes greater than or equal to 20, basic test statistics were generated for male and females, with subsequent ANOVA tests. ANOVA tests that yielded significant differences (with a Bonferroni-corrected $\alpha = 0.006$) were then used to develop sex estimation methods for the Guatemalan sample. Basic statistics and

sectioning points were generated for comparison with other studies' (9-11) established sectioning points, which have been applied in forensic anthropological casework.

Sectioning points were generated for each postcranial measurement by summing the male and female means and dividing by two. Because a sectioning point is typically represented as an integer, the researcher must define what the appropriate interval attached to this integer will be. When postcranial measurements are collected using digital calipers, a non-integer value (e.g. with decimals) is produced, and thus the researcher typically rounds these decimals to the nearest integer. Therefore, we define the interval representing a sectioning point as half the distance to the nearest integers above and below the sectioning point. For example, if the sectioning point for humeral head vertical diameter is established as 40mm, then the numeric interval considered as the sectioning point would be 39.5 to 40.5mm. Any sampled individual whose humeral head vertical diameter measures within this range would be considered indeterminate sex. To calculate classification rates of the sectioning points, the number of individuals who were indeterminate was subtracted from the original sample size to yield an adjusted sample of only classified (correctly or incorrectly) individuals. Classification rates for the Guatemalan sample were generated for males and females using the sectioning points generated presently.

Data Analysis: Test of Classification Accuracy for Guatemalan Samples in Previously Established Sex Estimation Methods

The 23 postcranial measurements for which adequate data are present in the Guatemalan sample were narrowed down to those measurements which have been previously used in studies that established sectioning points for sex estimation of Hispanics (9-11), as these studies are based on two relevant samples: border-crosser cases at the Pima County Office of the Medical

Examiner (9,11) and a combined sample of historic Mexicans (from Hidalgo and Yucatan) and PCOME cases identified as Mexican (10). Of the available Tise (11) sectioning points (referred to henceforth as TSP), thirteen matched those with data available for the male and female Guatemalan sample. Of the available Spradley et al. (10) sectioning points (referred to henceforth SSP), five matched those with data available for the male and female Guatemalan sample. Because the Guatemalan sample is being used as a test sample for gauging the classification accuracy of these two sectioning point methods for this newer border crossing demographic, there is no minimum or consistent sample size per postcranial measurement. Instead, all available data are used to test methods accuracy and sample sizes are reported per sex per sectioning point in tables below.

Furthermore, a test sample of nine females and thirty-four males from the Guatemalan sample was used to test the femur discriminant classification function for Mexican Hispanics reported in Spradley et al. (10). The sample size was constrained by the measurements available in the Guatemalan sample that could be tested.

Results

Guatemalan Sample: Sex Variation and Sectioning Points

Table 1 provides ANOVA results for comparing Guatemalan male and female postcranial measurements. Prior to performing the ANOVA analyses, tests for equal variances for males and females were performed for each postcranial measurement. None of these tests yielded significant differences in variance. ANOVA tests yielded significant differences (with a Bonferroni-corrected $\alpha = 0.006$) for all nine comparisons of male and female means, and were thus suitable variables for developing sex estimation methods. The adjusted R^2 values range from

0.26-0.50, indicating that sex differences account for a significant portion of the variation present in these measurements. Table 2 provides the Guatemalan male and female sectioning points, the adjusted sample sizes (only those classified as male or female, and thus excluding “indeterminate” cases as described in Methods), and their associated classification rates. For males, the lowest classification rate is 79.03% (anterior-posterior diameter at midshaft of the femur) and the greatest classification rate is 94.66% (maximum diameter of femoral head). For females the lowest classification rate is 77.27% (transverse diameter of the femur at midshaft) and the greatest classification rate is 96.00% (maximum diameter of humeral head). As a forensic anthropological sexing method, these sectioning points are useful in a limited context, such as the analysis of victims of the Guatemalan civil war. The main purpose for generating the sectioning points in the present study is for comparison with classification rates of existing sectioning points applicable to border crosser casework (9-11).

[Insert Tables 1 and 2 here]

Testing Classification Accuracies of SSP and TSP Methods

The Guatemalan study sample was treated as a test sample for classification accuracy of the TSP and SSP methods. Table 3 provides a comparison of the classifications rates for the two methods. SSP consistently classifies the Guatemalan test sample more accurately than the TSP for males, with accuracy ranging from 66.95-84.17% compared to the TSP sample, which ranges from 30.51-68.69%. The female sample is more consistent between the SSP and TSP samples with accuracies over 80% for both. These accuracies are consistent with what is known about the two samples used to generate these sectioning points, as the SSP reference sampling included some individuals within the Maya region of Mexico which likely exhibited smaller

measurements for both males and females, and thus more representative of the smaller Guatemalan measurements included in the sample here.

[Insert Table 3 here]

In general, when compared with the classification rates using the Guatemalan sectioning points (Table 2), the two alternative methods have sectioning points that are skewed toward larger body size (e.g. greater sectioning point values). This is indicated by the trends in classification rates between the male and female Guatemalans (Table 3), with females consistently exhibiting higher accuracies for all TSP and SSP sectioning points. Specifically, the male test sample experiences a 30-50% drop in classification accuracy when comparing the results of the five shared sectioning points between the Guatemalan (Table 2) and the TSP (Table 3) samples (including maximum diameter of the humeral head, maximum diameter of the femoral head, maximum length of the femur, maximum length of the tibia, and the transverse diameter of the femur at midshaft), whereas the SSP method exhibits a 10-26% drop in male classification accuracy when compared with two of the shared sectioning points with the Guatemalan sample (maximum diameter of the humeral head, maximum diameter of the femoral head). The SSP method therefore exhibits a considerable improvement over the TSP classification rates. Of the SSP's five sectioning points for which Guatemalan postcranial measurements were available, three of these generated high accuracy rates (greater than or equal to 80%) for Guatemalan males, while none of the TSP method's thirteen sectioning points included here reach this threshold for Guatemalan males (Table 3).

The Guatemalan male classification rate discrepancies between the TSP and SSP methods are likely a result of the larger body bias in the TSP sample. Table 4 highlights this trend by comparing the means for males across all comparable postcranial measurements for all

three study samples: the present study's Guatemalan sample, TSP, and SSP. The Guatemalan study sample consistently exhibits the smallest means, the TSP sample exhibits the greatest means, and the SSP sample exhibits intermediate means. Interestingly, several of the standard deviations are comparable (maximum radius, humerus and clavicle measurements) for the Guatemalan, SSP and TSP studies' samples, suggesting that the Guatemalan sample is as diverse as those studies drawing from a variety of source populations. This heterogeneity ultimately impacts the accuracy of the sectioning points as a method, and emphasizes the need for methods that capture the actual diversity of the border crosser demographic.

When tested with the Guatemalan sample, the discriminant function analysis (DFA) classifications using Spradley and colleagues' function (10) for the femur misclassified six out of the 34 males and one out of the nine females, with classification percentages of 82.35% and 88.89% respectively. The cross-validated classification rate for the femur reported in Spradley et al. (10) is 85.94% for males and 100% for females, which is slightly greater for males and significantly greater for females than the results for the Guatemalan sample. Regardless of the classification differences, the present study's classification percentages using the SSP DFA of femoral measurements indicates that the DFA has an acceptable classification percentage of over 80% for the Guatemalan males and females.

Discussion

The results of the present study indicate that current sex estimation methods potentially applied to UBC casework are biased towards a specific UBC demographic that does not fully encompass the most current migrant demographic trends. Explicitly, current methods misclassify Guatemalan males who are on the lower end of the spectrum for Hispanic male body size.

However, the bias is minimal for several of the postcranial measurements for the SSP method, including ulnar maximum length, biepicondylar breadth of the humerus, and maximum vertical diameter of the femoral head. These three sectioning points provide accurate classification rates of 80% or more for the Guatemalan samples, suggesting that these three sectioning points can be applied to UBC casework for a wide range of migrants, including indigenous Guatemalans.

Beyond explicit classification rates, patterns of classification accuracy for the Guatemalan sample were considered, based on the results in Table 3. When assessing classification accuracy of the TSP method, postcranial measurements on or near epiphyses tended to outperform maximum long bone length measurements of the lower extremity. Furthermore in both SSP and TSP methods, maximum lengths for bones of the lower extremity are less accurate for the Guatemalan sample than similar metrics for the upper extremity. We see general consistency in accuracies for specific measurements for the two methods, with the top-performing sectioning points being the same for both the TSP and SSP methods: ulnar maximum length, biepicondylar breadth of the humerus, and maximum vertical diameter of the femoral head. The results support that the SSP method for these three postcranial measurements are the most appropriate for estimating sex for UBC cases of unknown origin.

It is often purported that a multivariate approach (e.g. DFA) is preferable to a univariate approach, as more independent variables can potentially better approximate the dependent variable of interest. The present study's test of Spradley and colleagues' (10) femoral DFA found that the rate of misclassifications were similar to their best-performing univariate sectioning points for the Guatemalan test sample. In UBC casework, more often than not only incomplete skeletons are recovered, and often exhibit damage from taphonomic processes such as scavenging or erosion. Because the DFA requires all measurements in the function to be present,

this limitation reduces the likelihood that the method can be used on a range of cases. When all measurements are available, this method is appropriate to use, as the classification accuracies of were acceptable for Guatemalan males and females (82%-89%).

Sampling Strategies and Potential Identification Biases

The complex context of the border and the shifting trends in who is migrating require us to think more critically about approaches to sampling for methods development for UBC casework, and how this impacts not only method accuracy but ultimately the identification process itself. The results of the present study highlight this point in important ways. The study sample used here is comprised of the very families that suffered the most during the protracted violence in Guatemala, whose communities have continued to live in a time of poverty and violent crime, a legacy of the civil war. Consequently, these are the same individuals who are more susceptible to migration and yet have a greater risk of death while migrating, as they must travel across two borders (Reineke and Martinez 2014). The lasting, yet justified distrust of the state (whether their own or the U.S) makes it difficult to collect information about who is actually migrating and who has gone missing during their migration. Collecting DNA samples to identify the missing is also difficult in this context, even when the agency is not affiliated with the state, as some families are concerned about the security of their data and how it used; for example, there is concern it may be used to identify and deport their undocumented family members in the U.S. (Marco Perez, personal communication). Furthermore, many of the rural impoverished Guatemalans who migrate to the U.S. speak indigenous languages, making it challenging to access resources available to Spanish-speaking migrants, such as help hotlines, NGOs, or authorities. These vulnerabilities are, to an extent, experienced by all migrants, and

have a direct impact on the ability to successfully identify those who die in transit (16). However, certain migrants undergo heightened vulnerabilities that stratify the migrant demographic in gradations of marginalization.

Forensic anthropologists must ensure that our methods for generating a biological profile do not reify these marginalizations. For example, when sex estimation methods are developed that represent the traditional majority of migrants (e.g. Mexicans), yet fail to represent other common migrants (such as rural indigenous Guatemalans), the increased misclassifications of sex for this particular migrant demographic disproportionately reduces the chance of identification in a population that already has the most hurdles impeding their odds of being successfully identified.

The present study highlights the existing complexities of developing applicable methods to UBC casework, while simultaneously managing outcomes which could potentially prioritize the (mis)identification of one UBC demographic (i.e. larger bodied) over another. Several methodological approaches can assist in mitigating this issue. In particular, a comprehensive sample should be used to develop sex estimation methods, as the ancestry and national origin are not likely known for an unidentified border crosser. By combining samples that represent border crosser sending regions, accuracy will be balanced across the samples, instead of being biased towards a particular demographic. For example, the SSP method is based on a geographically and ancestrally diverse sample, and is thus more accurate for classification of Guatemalans than the TSP method. However, it is important to also note the lack of success for the SSP method, as two of the five sectioning points analysed here exhibit only moderate classification success (see Table 3: vertical diameter of humeral head: 66.95% for males; maximum length of clavicle: 70.83% for males). These under-performing sectioning points suggest that more comprehensive validation is required for sectioning points applicable to a diverse border crosser demographic.

The authors propose that as diverse a sample as possible be assembled from the various studies (present study included) to generate a more representative sample from which to generate methods.

Broader Implications for UBC Biological Profile Assessment

There are broader implications to be considered concerning the assessment of the biological profile for UBC cases. This study has demonstrated the inconsistent accuracies of current postcranial sexing methods when applied to the changing UBC demographic. It is intuitive that other components of the biological profile will also be impacted by the increasing diversity of who is crossing the U.S.-Mexico border. For example, stature estimates will also be impacted, as highlighted here with the smaller maximum long bone lengths for the indigenous Guatemalan sample. As traditional biological profile methods' applicability is assessed, and new methods are developed that are representative of UBC diversity, the potential for identification and repatriation of decedents from the U.S.-Mexico border will continue to improve.

Another worrying trend is the increase in migration of family units (defined as a group which includes a minor) and unaccompanied minors from the Central American Northern Triangle countries, which includes Guatemala, along with El Salvador and Honduras. These three countries are especially vulnerable to migration as many are escaping gang-related violence and poverty which are cited as the two main causes (5). The number of border apprehensions from these groups is increasing, compared to the number from Mexico (6), and as a general trend, reflects the changing demographic at the border. With the number of migrants from Honduras and El Salvador on the rise, additional studies will need to be performed to revisit the recommendations for specific methods endorsed in the present study; continual critical

assessment of our current methods for an ever-changing case demographic is a well-established best practice in forensic anthropology (16,23-25).

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TABLE 1—*Basic statistics and ANOVA test results for Guatemala study sample, unit in millimetres.*

Measurement	Sex	<i>n</i>	Mean	SD	Adjusted		
					R ²	<i>F</i> -ratio	<i>p</i>
Glenoid Cavity Breadth	F	32	22.69	2.17	0.36	97.58	<0.0001
	M	144	26.24	1.75			
Glenoid Cavity Height	F	36	31.47	1.70	0.47	165.28	<0.0001
	M	150	35.81	1.85			
Humerus Max Diam	F	27	37.19	1.69	0.46	141.61	<0.0001
	M	140	42.83	2.35			
Fem. Max. Vert. Head Diam.	F	32	38.13	2.07	0.50	175.28	<0.0001
	M	143	43.82	2.23			
Fem. Trans. Diam. Midshaft	F	28	21.93	1.75	0.39	63.51	<0.0001
	M	71	24.88	1.63			
Fem. AP Diam. Midshaft	F	29	23.63	2.25	0.26	36.37	<0.0001
	M	71	26.49	2.12			
Femur Max. Length	F	22	384.05	17.34	0.41	57.37	<0.0001
	M	60	419.45	19.23			
Fem. Bicondylar Length	F	21	382.19	17.01	0.41	54.86	<0.0001
	M	58	417.22	19.09			
Tibia Length	F	22	315.82	19.24	0.38	46.94	<0.0001
	M	55	348.76	18.99			

TABLE 2—*Guatemalan study sample sectioning points, sex-specific adjusted sample sizes, and their associated classification rates.*

Measurement	Sectioning Point mm	Adjusted Sample Size Female	Adjusted Sample Size Male	Correct Classification Female	Correct Classification Male	Overall Classification Rate
Hum. Head Max. Diameter	40	25	130	96.00%	93.08%	94.54%
Fem. Head Max. Vert. Diam.	41	32	131	90.63%	94.66%	92.65%
Glenoid Cavity Breadth	24	26	135	88.46%	94.07%	91.27%
Glenoid Cavity Height	34	34	134	94.12%	87.31%	90.72%
Fem. Bicondylar Length	400	21	58	95.24%	82.76%	89.00%
Femur Max. Length	402	21	60	95.24%	81.67%	88.46%
Tibia Length	332	21	54	85.71%	83.33%	84.52%
Fem. Trans. Diam Midshaft	23	22	61	77.27%	90.16%	83.72%
Fem. AP Diam. Midshaft	25	25	62	80.00%	79.03%	79.52%

TABLE 3—*Classification of male and female Guatemalan samples using two sectioning point methods.*

Measurement	Sample size (male, female)	TSP Method % Accuracies			SSP Method % Accuracies		
		Sectioning Point mm	Male	Female	Sectioning Point mm	Male	Female
Ulna Maximum Length	33, 6	248	66.67	100	240	80.00	100
Hum. Epicondylar Br.	99, 12	57	68.69	100	56	82.41	92.31
Fem. Max. Vert. Diam. Head	123, 31	43	65.85	100	42	84.17	96.67
Clavicle Max. Length	27, 10	147	51.85	100	143	70.83	81.82
Hum. Head Max. Diam.	115, 27	43	46.96	100	42	66.95	100
Epicondylar Br. Femur	37, 9	78	64.86	100			
Radius Max. Length	45, 11	232	53.33	100			
Humerus Max. Length	54, 17	300	48.15	100			
Tibia Max. Prox. Epiph. Br.	88, 11	73	52.27	100			
Fem. Trans. Diam Midshaft	54, 25	25	50.00	100			
Tibia Length	54, 22	354	44.44	90.91			
Circum. Tibia Midshaft	123, 18	88	65.85	94.44			
Femur Max. Length	59, 22	430	30.51	95.45			

TABLE 4—*Comparison of basic statistics for males across all comparable postcranial measurements in the three comparative samples, units in millimetres.*

Measurement	Sample*	N	Mean	Std Dev
Humerus Head Max. Diameter	Guatemalan	140	42.83	2.35
	SSP	63	45.29	3.02
	TSP	74	45.92	2.59
Humerus Epicondylar Br.	Guatemalan	120	58.00	2.72
	SSP	64	59.70	4.02
	TSP	73	61.05	3.88
Ulna Maximum Length	Guatemalan	35	249.94	14.53
	SSP	46	253.74	18.80
	TSP	57	261.75	14.98
Clavicle Max. Length	Guatemalan	27	149.33	9.59
	SSP	52	151.44	9.36
	TSP	48	154.63	7.93
Fem. Max. Vert. Diam. Head	Guatemalan	143	43.82	2.23
	SSP	78	44.64	2.89
	TSP	81	45.98	2.57
Humerus Max. Length	Guatemalan	56	299.16	15.49
	TSP	77	317.03	17.69
Radius Maximum Length	Guatemalan	47	232.19	13.24
	TSP	58	244.98	13.53
Epicondylar Breadth of Femur	Guatemalan	40	79.13	3.73
	TSP	76	83.08	4.73
Fem. Trans. Diam Midshaft	Guatemalan	71	24.88	1.63
	TSP	95	30.60	2.80
Femur Max. Length	Guatemalan	60	419.45	19.23
	TSP	87	446.34	24.93
Circumference of Tibia Midshaft	Guatemalan	130	89.75	5.58
	TSP	70	94.04	7.72
Tibia Max. Prox. Epiph. Br.	Guatemalan	102	73.32	3.37
	TSP	69	76.93	4.41
Tibia Length	Guatemalan	55	348.76	18.99
	TSP	22	369.72	24.75