Abstract

One of the greatest challenges faced by forensic anthropologists is to keep up with the changing demographic structure of the populations with which they are confronted. It is from this population that forensic cases are drawn. A fundamental goal in forensic anthropology is to provide a biological profile for an unknown individual or individuals found in a forensic context. The majority of reference collections used to build identification criteria for the biological profile (age, sex, ancestry, and stature) come from the Terry and Todd anatomical collections, comprised mainly of 19th and 20th century American Black and White individuals.

Currently, the largest minority group in the United States is Hispanic. Data comparing 1990 and 2000 census results for Hispanics show that the Southeast experienced the largest influx of Hispanics in absolute terms (Ramirez and de la Cruz 2002). It exceeds the Northeast by a factor of five, the Midwest by a factor of three, and the West by a factor just less than one and a half (Ramirez and de la Cruz 2002). Because of this population growth of individuals considered Hispanic in areas other than the West and Southwest, it is certain that forensic anthropologists will encounter these individuals in their caseloads.

Further, *no standard or accurate identification criteria* exist for the determination of sex and ancestry for this group. Additionally, there are no anatomical collections of Hispanic skeletons equivalent to the Terry and Todd collections of American Blacks and Whites. The purpose of the proposed research is to provide new criteria, within the field of forensic anthropology, for the determination of sex and ancestry for Hispanic individuals in the U.S., particularly focusing on individuals entering the U.S. via the U.S./Mexico border.

The U.S./Mexico border, particularly in Arizona, is chosen because of the large number of forensic anthropological cases generated each year from illegal immigration, and the high

positive identification rate of these individuals. This proposal requests **151,323.00** for *Project Identification,* for the purpose of establishing a database containing metric data on *positively identified* Hispanic individuals in order to develop criteria for accurate estimation of sex and ancestry.

Purpose: To facilitate accurate identification criteria regarding **sex** and **ethnic affiliation and cultural origins** within the field of Forensic Anthropology.

Goal: To derive and implement accurate estimation of sex and ethnic affiliation and cultural origins/ancestry identification standards for individuals considered Hispanic, currently the largest minority in the United States (Bernstein 2007).

Objectives:

1. Collect a broad suite of cranial and post-cranial metric data, using 3D data collection methods, on U.S. / Mexico border-crossing fatalities. This objective will be implemented by collaboration with Dr. Bruce Anderson, PhD, Forensic Anthropologist, from the Pima County Office of the Medical Examiner (PCOME) in Tucson, Arizona.

2. Derive new statistical formulae for estimation of sex and ethnic affiliation and cultural origins/ancestry identification standards for individuals considered Hispanic that enter the U.S. via the U.S. / Mexico border. This objective will be implemented by collaboration with Dr. Richard Jantz, PhD, Professor and Director of the Forensic Anthropology Center, The University of Tennessee, Knoxville.

Review of relevant literature

Background

The population group considered Hispanic is now the largest minority in the United States (Bernstein 2007). Currently, there are no standard criteria in forensic anthropology that

provide accurate sex and ethnic identification and cultural origins (ancestry identification) for this population group. The purpose of the proposed research is to provide new criteria, within the field of forensic anthropology, for the identification of sex and ancestry for individuals considered Hispanic in the United States. According to the U.S. Census Bureau, more than 1 in 8 people are of Hispanic origin (Ramirez and de la Cruz 2002). The majority of Hispanics in the United States originate from Mexico, followed by Central and South America, many of whom enter the U.S. via Mexico (Ramirez and de la Cruz 2002).

Hispanic skeletons are difficult to recognize, especially by those with little experience. Even if they are recognized, there are few metric criteria available which allow quantification of visual assessments for sex and ancestry. With no criteria for sex estimation of Hispanics, more often it is White or Native American criteria derived from post-cranial data that are applied to Hispanics. While post-cranial data provides sex estimation superior to cranial morphology, these non-population specific criteria provide poor estimates of sex for this group (Spradley et al. 2008).

Craniometric data have shown to estimate ancestry with a high degree of accuracy (Howells 1973; Jantz and Ousley 2005; Ousley and Jantz 1996). FORDISC 3.0 (Jantz and Ousley 2005), a personal computer discriminant function program used by forensic anthropologists to estimate ancestry, provides a Hispanic male reference sample that an unknown can be statistically compared against. However, this Hispanic male sample is comprised of individuals from varying geographic and cultural areas and data has been collected by multiple observers. Further, the cranial measurements used by FORDISC 3.0 include only 24 *standard* measurements (Moore-Jansen et al. 1994). Recent research has shown that these 24 measurements provide poor classification rates for Hispanic individuals when compared against

other U.S. reference groups, and that by using a subset of measurements provided in Howells (1973) not found in the 26 *standard* measurements, classification rates increase (Spradley and Algee-Hewit 2007).

If there are no criteria to accurately assess the sex and ancestry, two fundamental components of a biological profile, then individuals considered Hispanic will likely remain unidentified as they show up in forensic anthropological cases across the nation. This proposal seeks to obtain funding to collect data with a collaborative partner, Dr. Bruce Anderson, PhD, of the Pima County Office of the Medical Examiner in Tucson (PCOME). Dr. Anderson examines over 250 U.S. / Mexico border-crossing fatalities per year. Of these fatalities, 40 – 50% are skeletal and approximately 70% are identified (Anderson 2008).

This proposal seeks to collect a broad suite of cranial and postcranial data (more than the current standards) from border-crossing fatalities as they enter the PCOME. This data will be curated in a relational database. When Dr. Anderson makes a positive identification, the demographic records will be updated, including the age, sex, stature, and geographic origin (country, state, and city). The end result will be a database of positively identified individuals, with associated metric and demographic data from varying national origins, potentially representing (but not limited to) Mexico, Latin America, and Central and South America.

The subsequent sections of this literature review address reviewer comments and critiques. The first section, *Defining Hispanic*, addresses the problems associated with the characterization of individuals as Hispanic and addresses how this project will deal with this matter. The next section, *Current Status of Forensic Anthropological Reference Data*, concentrates on the current status of reference criteria in sex and ancestry identification for individuals considered Hispanic. The third section, *Primary Source of Data*, provides a

justification of the PCOME as the primary source of data for this project. The final section, *Project Summary*, outlines the major benefits and impact of **Project IDENTIFICATION**.

Defining Hispanic

The most problematic aspect of this proposal is characterization of individuals considered Hispanic. The U.S. Census Bureau defines Hispanic as an individual originating from Mexico, Puerto Rico, Cuba, South or Central America, or other Hispanic/Latino origins (Ramirez and de la Cruz 2002). In other words, Hispanic is a generic category, with no precise biological meaning. Further, on the U.S. Census, Hispanic is an ethnic category, not a race. An individual must choose their race on the census, and then has the choice of selecting Hispanic as an ethnicity. Therefore, the largest minority in the U.S. is an ethnicity, rather than a race.

An ethnicity can be comprised of individuals from various geographic, linguistic and cultural origins (Itzigsohn and Dore-Cabral 2000; Melville 1988; Stephan and Stephan 2000). Contrary to the U.S. Census Bureau definition of Hispanic, Melville writes that for individuals of Spanish-speaking origins, “the most common practice is for each national origin group to use the name of their country (Melville 1988:68).” Thus, the ethnic category of Hispanic encompasses individuals from multiple countries of origin that do not necessarily share the same population history or geographic proximity.

For example, Ross et al. (2004) suggest that Cubans make up Florida's largest Hispanic community and that the unique population history of Cubans makes them more similar to American Blacks. Additionally Ross et al. further suggest that the designation of Hispanic does not capture the unique and complex population structure of Cubans, in that Cubans are less likely to have genetic Native American ancestry. Whereas individuals originating from Mexico,

Central, and Latin America derive genes primarily from Spanish and Native American sources, and in coastal geographic regions African ancestry is prevalent (Lisker et al. 1986; Lisker et al. 1996; Lisker et al. 1990; Long et al. 1991; Martinez-Abadias et al. 2006).

While Cubans would be most likely to consider themselves Cubans and Mexicans likely to consider themselves Mexican rather than Hispanic, once inside the U.S., for political and policy purposes, they are considered Hispanic (Melville 1988; Ramirez and de la Cruz 2002). However, because of the many geographic localities individuals considered Hispanic originate from and their distinct population histories, the term Hispanic does not adequately capture any biological or genetic meaning. Birkby et al. (2008) recently suggested the term 'Southwest Hispanic' to refer to an individual with Native American and European admixture. Anderson (2008) defines 'Southwest Hispanic' as individuals with mixed European, indigenous Native American, and African ancestry. While these definitions differ slightly, Birkby and Anderson further suggest that the term 'Southwest Hispanic' applies to an individual who entered the U.S. via the shared border with Mexico as opposed to entering the U.S. via Florida or elsewhere in the Southeast. Based on geographic proximity, individuals entering the Southeast are more likely to be Cuban, Dominican, or Puerto Rican.

Most forensic anthropological criteria have been developed for American Black and American White population groups. American Black individuals are predominantly West African with varying degrees of European admixture (Parra et al. 2001; Parra et al. 1998) and American Whites are predominantly of European ancestry. These two recent American groups have separate continental origins, making them easier to differentiate. Because Cubans, Puerto Ricans, and Mexicans, and individuals from Latin and Central America have varying degrees of

European, Native American, and African ancestry. It is no wonder that ancestry estimation of individuals considered Hispanic is problematic.

According to the U.S. Census Bureau, individuals considered Hispanic currently living in the United States come from Mexico (66.9%), followed by Central and South America (14.3%), Puerto Rico (8.6%), and Cuba (3.7%) (Ramirez and de la Cruz 2002). The remaining 6.5% is listed as "other Hispanic." The data accumulated from border-crossing fatalities at the PCOME in Tucson, Arizona is reflective of the national origins of individuals considered Hispanic currently living in the United States (Figures 1 and 2). During a 5 year period, from 2001 – 2006, of all of the U.S. / Mexico border-crossing fatalities handled by the PCOME, 92% were from Mexico with the next highest percentage from Central and South America (Anderson 2008).

This proposal does not seek to provide sex and ancestry identification criteria for all individuals considered Hispanic by the U.S., rather this proposal seeks to create new identification criteria for individuals who enter the U.S. via the shared border with Mexico. While the term 'Southwest Hispanic' may be appropriate terminology to describe these individuals, it is not a sound research design to include all individuals from the PCOME into one reference sample. Therefore, rather than grouping all individuals who cross the U.S. / Mexico border into one reference sample, country of origin will be used the grouping variable. For example, based PCOME data from 2001 -2006, 92% of positively identified border- crossing fatalities are from Mexico with only a few individuals from Latin or Central America. (Figure 1). sex and ancestry criteria will be created using only individuals from Mexico because projected sample sizes for the other countries that cross the U.S. / Mexico border will likely be too small.

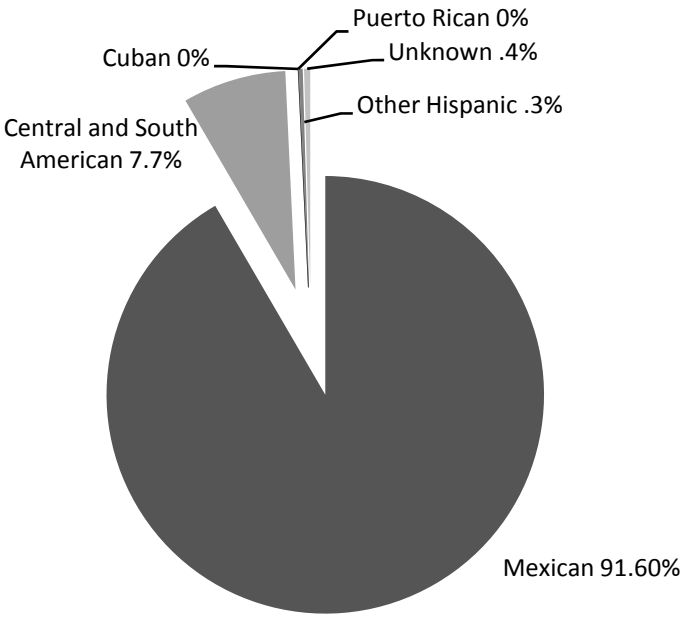

Figure 1: Countries of Origin for Border-crossing Fatalities at the PCOME from 2001 – 2006. Original data published in Anderson (2008).

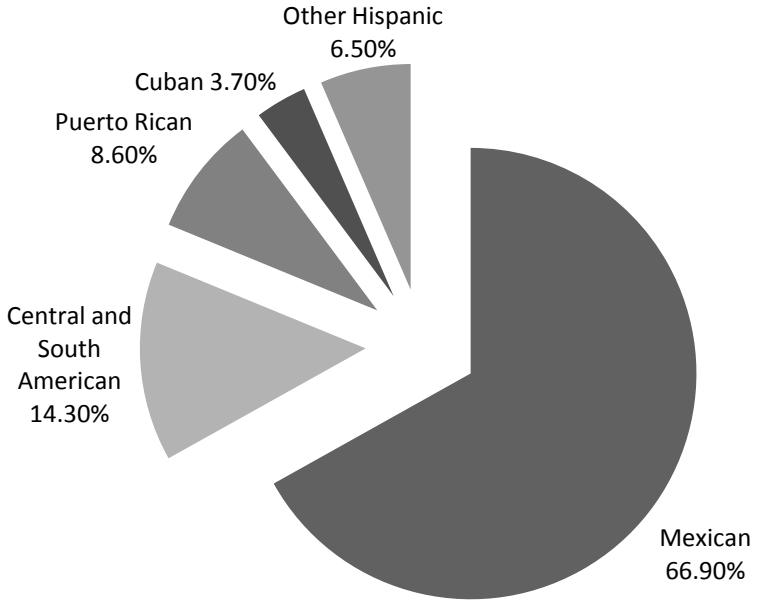

Figure 2: Countries of origin from U.S. Census Bureau records for individuals considered Hispanic. Original data published in Ramirez (2002).

Because Mexican individuals are considered Hispanic, this proposal will refer to creating new sex and ancestry criteria for individuals considered Hispanic. However, only individuals from Mexico will be used as a reference sample. Further, in the dissemination process, the use of a Mexican reference sample will be clearly defined.

Current Status of Forensic Anthropological Reference Data

Data from national origin groups considered Hispanic have not accumulated at a rate proportional to their representation in the U. S. population, now ranking as the largest minority population in the U.S. (Bernstein 2007). Additionally, there are no collections of Hispanic skeletons equivalent to the Terry and Todd collections for American Blacks and Whites. The Forensic Anthropology Data Bank (FDB) was started in 1986 from a grant from the NIJ for the purpose of providing up to date criteria for use in forensic anthropology (Jantz and Moore-Jansen 1988). The FDB relies on data submission by forensic anthropologists world-wide to provide the most up to date identification criteria. Once data is submitted to the FDB and subjected to error checks, metric data is then submitted to and used as a reference groups in the program FORDISC 3.0. These reference groups are based on self-reported ancestry or information from legal documents such as driver's licenses (Jantz and Ousley 2005). FORDISC 3.0 is a helpful tool, used by practicing forensic anthropologists around the country. However, FORDISC 3.0 is only as good as the reference samples it contains.

Currently there are 65 positively identified individuals considered Hispanic in the FDB. Of those, only 21 are associated with known national origin. Further, only 13 of those individuals were submitted to the FDB by practicing forensic anthropologists. Dr. Richard Jantz is responsible for obtaining the remaining 52 individuals by travelling to various academic

institutions and medical examiner's offices to collect data. During the past 19 years, the FDB has accumulated data on **65** positively identified individuals considered Hispanic, in comparison to **413** Black and **931** White positively identified individuals. The FDB, and therefore FORDISC 3.0, contain the largest reference collection of metric and demographic data derived from positively identified individuals considered Hispanic for use in sex and ancestry estimation.

Currently, in the entire field of forensic anthropology, data is only available for 21 individuals considered Hispanic from known countries of origin. The remaining 43 individuals are from unknown countries of origin. Because data has not accumulated at a rate proportional to American Black and White individuals, it is imperative that more data is collected in order to provide criteria for the purposes of identification.

Primary Source of Proposed Data

Of the 2,000 miles of shared border between the U.S. and Mexico, 281 miles are located in what the United States Border Patrol (USBP) refers to as the Tucson Sector (Anderson 2008). It is from the Tucson Sector that the PCOME receives border-crossing fatalities. The USBP reported in 2004 that 43% of all illegal border crossers were apprehended in the Tucson Sector (Anderson 2008). Thus, the high number of border-crossing fatalities brought to the PCOME can be viewed as a reflection of the high volume of border-crossings in Tucson Sector. While California also shares a border with Mexico, Hinkes et al. (2008) reports that medical examiner caseloads from U.S. / Mexico border-crossing fatalities from the California border are decreasing in numbers. Hinkes et al. cite this decrease in the California caseload as a result of Operation Gatekeeper pushing border crossers further east into Arizona.

The PCOME receives approximately 250 border-crossing fatalities per year with approximately 40 – 50% comprising skeletal remains. Because the PCOME has a 70% identification rate, the projected sample size for this project is approximately 175 positively identified individuals over a two year period. This would quadruple the number of positively identified individuals accumulated in the FDB. Consequently, the partnering with the PCOME allows for a large reference collection to be built in a short time period. This proposal requests equipment necessary for data collection, currently not owned by the PCOME, for continued use after the culmination of Project IDENTIFICATION.

Because of the high number of forensic cases that enter the PCOME each year, Dr. Anderson does not have the time or resources to collect data on each case (see APPENDIX: Letters of support). Since 2005, craniometric data have been collected on over 60 crania from the PCOME by the PI, Dr. Nicholas Herrmann, and Mr. Francisco Baires, with the support of Dr. Richard Jantz. These previously collected data representing positively identified individuals from Mexico were entered in the FDB and provided to FORDISC 3.0. These positive identifications will also be included into the reference sample to increase sample sizes.

When a positive identification is made by the PCOME, as much information as possible is obtained about the decedent, including their country of origin. By focusing on U.S. / Mexico Border-crossing fatalities from the PCOME – specifically fatalities that are subsequently identified with known countries of origin – sex and ancestry criteria can be developed. These criteria can be applied to the entire U.S. in order to identify the geographic origins of individuals who entered the U.S. via the shared border with Mexico.

Discussion

Data comparing 1990 and 2000 census results for Hispanics show that the Southeast experienced the largest influx of Hispanics in absolute terms (Ramirez and de la Cruz 2002). It exceeds the Northeast by a factor of five, the Midwest by a factor of three, and the West by a factor just less than one and a half (Ramirez and de la Cruz 2002). Because of this population growth of individuals considered Hispanic in areas other than the West and Southwest, it is certain that forensic anthropologists will encounter these individuals in their caseloads.

Forensic anthropologists in the West and Southwest that have border-crossing fatalities as part of their caseload are largely able to identify individuals based on geographic context (i.e. individual is found near the U.S. / Mexico border in the desert), cultural items, and artifacts on the person such as foreign currency (Anderson 2008; Anderson and Parks 2008; Birkby et al. 2008; Hinkes 2008). Forensic anthropologists outside the West and Southwest do not have the geographic context and are less likely to have cultural items and artifacts associated with individuals who are trying to assimilate in the U.S. Further, without any criteria for sex estimation, and with such small reference samples, most from unknown geographic origins, it is likely that individuals entering the U.S. via the shared border with Mexico will continue to remain unidentified as they show up in forensic cases across the country.

The end result of Project IDENTIFICATION will result in a database of positively identified individuals, with associated metric and demographic data from known countries of origin, primarily from Mexico. This proposal seeks funding in the amount of **151,323.00** to provide new sex and ancestry identification criteria for individuals entering the U.S. via the shared border with Mexico.

Research Methods and Design

Data Collection

The goal of data collection for this project is to create a data base of cranial and post-cranial data that will provide accurate sex and ancestry criteria. Further, data will be archived and made publically available for subsequent use by anthropologists for additional research. Craniometric data will be collected using a Microscribe® G2X digitizer in conjunction with the program Threeskull (Ousley 2004). The Microscribe® G2X digitizer collects landmark or coordinate data and 3Skull allows for the archival of the data. The end result is a database containing inter-landmark distances (or traditional craniometric data) and the landmark data. The traditional craniometric data archived includes all the standard craniometric data and additional craniometric data defined by Howells (1973).

Most forensic anthropologists utilize traditional, standard craniometric data (Buikstra and Ubelaker 1994; Moore-Jansen et al. 1994). The most popular application of traditional craniometric data by forensic anthropologists is FORDISC 3.0, used for estimation of sex, ancestry, and stature from unknown forensic cases. Although the cranial data that will be collected is coordinate data, the traditional craniometric data is automatically computed by 3Skull and will be archived in both formats. Therefore, all traditional craniometric will be input into FORDISC 3.0 for use by forensic anthropologists all over the country.

Standard postcranial metric data will also be collected (Buikstra and Ubelaker 1994; Moore-Jansen et al. 1994), however additional postcranial metric data will be collected following the measurements outlined in Zobeck (1983). These additional postcranial measurements have shown to differentiate population groups better than the standard measurements (Zobeck 1983). The standard postcranial measurements will be used to develop sex estimation criteria, thus

providing familiar methods easily used by all forensic anthropologists. However, the additional Zobeck measurements will be archived and used in subsequent research to determine if these measurements provide better estimates of sex. If additional measurements do provide more accurate criteria, results and measurement definitions will be published.

Because inter-observer variation can be an important source of error in multivariate analysis of metric data (Jamison and Zegura 1974), one person, experienced in data collection will collect all craniometric data. Mr. Francisco Baires, a graduate student in the Department of Anthropology at the University of Arizona, will collect cranial and postcranial data (cost **5,493.00** per year). Mr. Baires has extensive training in craniometric data collection (see APPENDIX: Resume of key personnel). The PI of this proposal personally trained Mr. Baires during the Spring and Summer of 2005. Mr. Biares repeatedly digitized (using the Microscribe® digitizer) crania from the William M. Bass skeletal collection at the University of Tennessee. Mr. Biares' measurements were compared against the PI of this proposal and Dr. Richard Jantz for accuracy. Further, intra-observer variation was rigorously tested by digitizing the same set of crania at least three times in order to detect any significant deviations.

Craniometric data will be collected at the PCOME in Tucson, Arizona using a three-dimensional Microscribe® digitizer (cost **3,995.00**) and laptop (cost **1,200.00**). Postcranial data will be collected using standard anthropometric equipment including sliding and spreading calipers and an osteometric board (available at the PCOME). All data collected will then be submitted to the Forensic Anthropology Data Bank (FDB) and to FORDISC 3.0 for widespread use by forensic anthropologists.

Data Management

All data collected will be sent to the PI via post or electronic mail. Data will be maintained in a relational database by the PI. Further, at the termination of this project, data will be made available to the public through a website maintained by the PI. Additionally, by submitting the data to the FDB, it also becomes available to the public on the Inter-university Consortium for Political and Social Research (ICPSR), found at http://www.icpsr.umich.edu/.

A Graduate Research Assistant (GRA) at the University of West Florida, Department of Anthropology, will be paid to enter the cranial and postcranial data into the relational database. The GRA will also assist with general duties regarding maintenance of database including, checking for outliers, communication with Dr. Bruce Anderson regarding updates on positive identifications of individuals and updating the database accordingly. (**11,875.00** per year)

Data Analysis

Sex estimation

When performing a forensic anthropological analysis, sex estimation is one of the first and most important steps. A visual analysis of the pelvis is the preferred indicator of sex. However, not all forensic cases provide the luxury of a complete skeleton. If an individual is left exposed in an outdoor context, such as border-crossing fatalities, taphonomic processes may impede the recovery of all elements. Sex estimation will be based on post-cranial remains, because post-cranial remains provide superior estimates of sex compared to the cranium (France 1998; Robling and Ubelaker 1997; Spradley and Jantz 2003)

Both univariate and multivariate methods will be used to develop sex estimation criteria. Previous studies have shown high classification rates using univariate data (France 1998;

Spradley and Jantz 2003). Univariate methods will include taking all of the 44 standard postcranial measurements (Buikstra and Ubelaker 1994; Moore-Jansen et al. 1994) from the left side, substituting the right side only when measurements from the left side are missing. Mahalanobis distances, sectioning points, and expected classification results will be produced, using SAS 9.1 (SAS 2002-2003). Sectioning points and associated classification results, especially for standard measurements, are easy to use and interpret and will published for each individual measurement. The same statistical procedures will be used on the additional Zobeck measurements (described in ***Data Collection***) in order to ascertain if any other measurements provide higher classification rates for sex estimation. If any Zobeck measurements provide better results, they will also be published along with the measurement definitions.

Multivariate analysis of sex estimation will be assessed via Discriminant Function Analysis (DFA). First, a stepwise DFA will be performed in SAS 9.1 in order to find the best subset of variables for discrimination of sex. A stepwise DFA will be run per bone, and then again for all possible combinations of measurements from all bones. The most significant subset of variables, respectively, will then be run using a DFA in SAS 9.1 in order to arrive at the best combination of variables for that discriminate sex.

Ancestry estimation

Ancestry estimation criteria will be assessed using traditional morphometric and geometric morphometric methods. DFAs using traditional craniometric data are widely used and more familiar to the majority of practicing forensic anthropologists (Barrio et al. 2006; Case and Ross 2007; Karaman 2006; Kim et al. 2006; Spradley et al. 2008; Wescott 2006). However, geometric morphometric methods are gaining popularity in forensic anthropology (Christensen

2005; Franklin and Cardini 2007; Franklin et al. 2007; Kimmerle et al. 2008; Ross et al. 1998; Ross et al. 2004). In a geometric morphometric analysis, landmark data, or coordinate data, is "pre-processed," for example, by a General Procrustes Analysis (GPA) or a Thin Plate Spline (TPS) that provides principal component scores or partial warp scores. These scores are then used in a traditional multivariate analysis (i.e. DFA) for group discrimination.

The added advantage of using landmark data is that the geometric properties of shape are preserved and the ultimately shape differences are visually observed (Figure 3). In addition to its ability to discriminate via traditional multivariate methods, the visualization process is what makes geometric morphometrics a useful tool in forensic anthropology. For forensic anthropologists in areas other than the West and Southwest, the visualization of differences in cranial morphology between individuals considered Hispanic and other population groups will provide a heuristic device.

Most forensic anthropologists are familiar with 24 standard cranial measurements (Buikstra and Ubelaker 1994; Jantz and Ousley 2005; Moore-Jansen et al. 1994). Therefore, these measurements will be used to assess the degree of ancestry estimation between the proposed reference sample and other reference groups. Reference groups used in all analyses for ancestry estimation will include indigenous Guatemalans, American Blacks, and American Whites. These reference groups, obtained from the FDB, contain large sample sizes and represent recent forensic cases. A stepwise DFA will be used to determine which linear combination of measurements best differentiate between the proposed reference sample and other population groups.

A multi-variate analysis of variance (MANOVA) will also be included to test for significant differences between group means. Mahalanobis distances will be used to explore

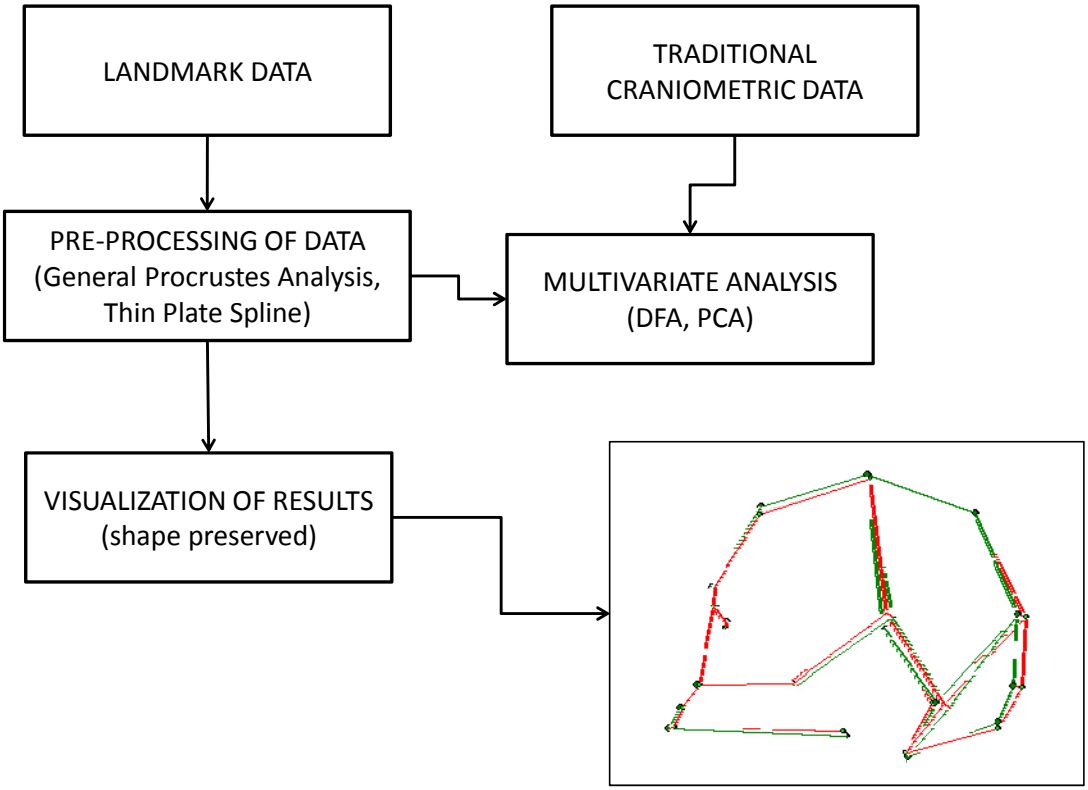

Figure 3: Groups visualized in this figure represent Guatemalan Mayans and individuals considered Hispanic from the FDB.

relationships between groups. Cross-validation classification rates will be used to assess the overall classification accuracy. Depending on the size of the proposed reference sample, presumably Mexican, a subset of this sample will be left out of the DFA to be used as a test sample in order to test the accuracy of the DFA. Further, data collected from individuals that originate from countries other than Mexico will also be compared to the reference sample using DFA and Mahalanobis distances to assess how they relate to the reference sample.

Previous research indicates that these 24 measurements provide poor classification rates, (**45%**, cross-validated) for individuals considered Hispanic (Spradley and Algee-Hewit 2007; Spradley et al. 2008), and that classification rates increase (**87.5%**, cross-validated) using measurements published in Howells (1973). Therefore, these additional measurements will also be subjected to the same multivariate tests described above to determine if they provide better classification results for ancestry.

Geometric morphometric analysis will include using landmark data to test for mean shape differences in groups, pre-processing landmark data for use multivariate analyses, and visualization of the shape differences between references groups. First, a General Procrustes analysis in Morpheus et al. (Slice 1998) will scale, rotate and translate all the landmark data into the same shape space so that mean shape differences can be tested for significance differences. Next, a General Procrustes Analysis will be performed in Morphologika 2.5 (O'Higgins and Jones 2006), followed by a Principle Components Analysis (PCA). The principle coordinates will then be subjected to the same multivariate methods (DFA) as the traditional craniometric methods in SAS 9.1. The purpose of repeating the same analysis with the PC scores from the landmark data is that geometric morphometric methods have been shown to discriminate better

among closely related groups (Adams et al. 2004). Shape differences will be produced for visualization and described.

By providing the traditional craniometric data to FORDISC 3.0, forensic anthropologists will be provided with a large positively identified sample and be able to select the measurements found to improve ancestry classification. Howells measurements can also be used in FORDISC 3.0, therefore, if some of Howells measurements are found to classify individuals considered Hispanic better than standard ones, forensic anthropologists will be able to utilize them as well. Providing results of the geometric morphometric analyses will provide a useful visual tool for forensic anthropologists that do not live near the U.S. / Mexico border that are not use to seeing individuals considered Hispanic in their forensic cases.

Implications for criminal justice policy and practice

Individuals considered Hispanic in the United States are now the largest minority population group. There are no population specific and reliable criteria for sex and ancestry determination. The formulae used by forensic anthropologists are only as good as the data that are used to derive them. The new formulae, for sex and ancestry estimation, derived from the data collected by this project will aid forensic anthropologists, especially in areas outside of the West and Southwest, in recognizing individuals, primarily of Mexican origin. For a forensic anthropologist, recognizing sex and ancestry of an individual is crucial in trying to positively identify an unknown individual. Being able to recognize that individual is of Mexican origin, or that the individual may have entered the country via the shared border with Mexico, will undoubtedly lead to more positive identifications. Additionally, by providing equipment to the

PCOME, data will be continually collected, research will be maintained, and data will be continually curated in the Forensic Anthropology Data Bank.

Management plan and organization

This proposed research project will last 2 years and can be divided into four phases (I, II, III, and IV) each one comprised of a six month period.

***Principal Investigator*:** M. Katherine Spradley, PhD, Assistant Professor, Department of Anthropology, University of West Florida, Pensacola (**40,939.00** – 3 months per year, 6 months total)

***Collaborator*:** Bruce Anderson, PhD, Forensic Anthropologist, D.A.B.F.A., Pima County Office of the Medical Examiner, Department of Anthropology, University of Arizona (**2,000.00 per year**)

***Statistical Consultant*:** Richard L. Jantz, PhD, Director, Forensic Anthropology Center, Professor, Department of Anthropology, University of Tennessee (**2,000.00 per year**)

Staff: Francisco Baires, Graduate Student at University of Arizona – data collection (**5,493.00** per year- 10.00 per hour @ 10 hours per week, 50 weeks per year, 100 weeks total)

Staff: Graduate Research Assistant (GRA) at University of West Florida – data entry and maintenance (**11,875.00** per year - 11.75 per hour @ 20 hours per week, 46 weeks, and 1,065 per

year fringe, for 92 weeks total, and in state tuition **9,536.00** for 18 semester hours per year, 36 hours total)

Phase I

- Purchase the PCOME a digitizer **(3,995.00)** and laptop (**1,200.00**) and establish protocol for data collection of three-dimensional cranial landmark and postcranial data.
- Start-up meeting in Tucson, Arizona at PCOME with Principle Investigator, University of West Florida GRA, Dr. Bruce Anderson, and Mr. Francisco Baires (**4,000.00** – travel for Principle Investigator and Graduate Research Assistant)

Phase II

- Data collection at PCOME and data entry at University of West Florida.
- Initial statistical analyses will begin by Principle Investigator.
- Data will be obtained from Dr. Richard L. Jantz for appropriate reference samples from recent forensic anthropological cases consisting of positively identified American Black and White individuals and indigenous Guatemalans. Dr. Jantz will also serve as a statistical consultant.

Phase III

- Meeting in Tucson, Arizona at PCOME to check status and progress of project with Principle Investigator, GRA, Dr. Bruce Anderson, and Mr. Francisco Baires (**4,000.00** – for travel for Principle Investigator and Graduate Research Assistant)
- Comprehensive Statistical analyses will begin by the Principle Investigator.

- Data collection will continue at PCOME and data entry will continue at the University of West Florida.

Phase IV

- Data collection and entry will continue until the end of this phase marking the two-year end-date.
- Final statistical analyses will begin of all data collected and the dissemination process will begin.
- Data will be sent to the Forensic Anthropology Data Bank for curation and submitted for inclusion into FORDISC 3.0.
- New formulae for sex and ancestry will be derived. Results will be published and presented to the forensic anthropological and forensic science community.

Dissemination strategy

The dissemination plan for the results from the proposed project include, but are not limited to, presentation of the findings at the American Academy of Forensic Sciences and publication of new sex and ancestry estimation formulae in the Journal of Forensic Sciences. As previously stated, all data will be made available to the FDB (available for download at http://www.icpsr.umich.edu/) and maintained on a website by the PI. Additionally, all data will be provided to FORDISC 3.0 for immediate use by forensic anthropologists around the country. Making the data publicly available will facilitate more research on individuals considered Hispanic that enter the U.S. via the shared border with Mexico.

Budget Justification

Project IDENTIFICATION requests **55,270.00** for direct costs and **22,312.00** indirect costs for Phase I and II (first year) for data collection, maintenance and initial analysis, and **51,134.00** for direct costs and **22,608.00** for indirect costs for Phase III and IV (second year) for creation of sex and ancestry identification criteria and dissemination of results. The total proposed cost for Project IDENTIFICATION: Developing accurate identification criteria for Hispanic individuals is **151,323.00**.

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