University of Nevada, Reno

A Craniometric Analysis of Basque Skulls from the Cathedral of Santa Maria, Vitoria-Gasteiz: Biological Distance and Population History

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Anthropology

by

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THE GRADUATE SCHOOL

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Abstract

The origins and uniqueness of the Basque have long puzzled anthropologists and other scholars of human variation. Straddling the border between France and Spain, Basque country is home to a people genetically, linguistically and culturally distinct from neighboring populations. The craniometrics of a burial population from a Basque city were subjected to cluster analysis to identify the pattern of relationships between Spanish Basques and other populations of the Iberian Peninsula, Europe, and the world. Another method of affinity assessment -- discriminant function analysis – was employed to classify each individual cranium into one population from among a wide array of groups in a worldwide craniometric database.

In concert with genetic and linguistic studies, craniometric analyses find Basques are distinct among Iberian and European populations, with admixture increasing in the modern era. Basque populations from different provinces show marked heterogeneity, including variable sexual dimorphism. Population history and linguistic studies suggest this heterogeneity is reinforced as much by cultural and linguistic practices as by geographical isolation. Individual identification using discriminant function analysis found a suggestive relationship with North Africa for Iberian and Basque populations that began before the 800-year occupation of Iberia by North African Moors, Arabs and Berbers. While the ultimate origins of the Basque remain a mystery, their physical, genetic and linguistic characteristics suggest ancient western European roots for this population.

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Chapter 1: **Introduction**

The autonomous Basque country crosscuts the border of southern France and northern Spain centering on the Pyrenees Mountains. It is home to a people linguistically, genetically and physically unique among European populations. The Basque language has few recognizable ties to any modern European language and only ephemeral links to ancient tongues. Genetic studies have found that in comparison to contemporary Spanish and French populations Basques are outliers for many molecular traits, from a high frequency of Rh negative blood types (Chalmers et al., 1949, Van der Heide et al., 1951) to mitochondrial DNA haplogroups (Alfonso-Sánchez et al., 2008). Even their fingerprints show distinctive patterns and frequencies (Arrieta et al., 1987). The causes for this distinctiveness range from geographic isolation among the mountains, valleys and watersheds of northern Spain to isolating factors within Basque culture itself. Studies suggest that Basques are the most distinct and possibly the most ancient population of the Iberian Peninsula.

There are two primary models of Basque origins described by scholars of Iberian population history. In the first model, agriculture spread into the Iberian Peninsula from Europe from the north and east, mostly through France and less frequently along the Mediterranean coast, starting around 5600-5500BC (Zapata et al., 2004). This reflects the Neolithic demic-diffusion model described by Cavalli-Sforza et al. (1994) in *The History and Geography of Human Genes*. In his 1992 synthesis of Iberian archaeology, Straus notes that the Iberian Peninsula underwent one of the earliest Neolithic transitions in Europe, nearly concurrent with central and southeastern Europe. Groups that adopted farming integrated with and eventually replaced local populations of hunters and gatherers. The ancestors of modern Basques are thought to have developed at some point during this transition period.

The second origin model links Iberian and North African populations. There are closer genetic relationships between Iberian and North African populations than would be expected if the current Basque population had its ancient roots in mainland Europe and the Mediterranean as depicted in the Neolithic demic-diffusion model (Flores et al., 2000; Moral et al., 2000). North African influence in Spain is clear during the historical period, but DNA studies, including classical and restriction fragment length polymorphisms (RFLPs) and human leukocyte antigen polymorphisms, provide evidence of much earlier contact and significant north-south clines throughout the Iberian Peninsula (Calafell and Betranpetit, 1994a,b; Peréz-Miranda et al., 2003). North African migrants, traveling north through the Pyrenees, may have taken refuge in Cantabria and the Basque country.

Material culture in the Iberian Peninsula suggests habitation since the Upper Paleolithic (Calderon et al., 1998; Flores et al., 2000). Recent studies on the heterogeneity of mitochondrial DNA haplogroup frequencies among Basque populations suggest that the arrival of people in the Basque region was very early, predating the Neolithic transition. The fragmentation of populations during Pleistocene glaciations and subsequent re-expansions may have contributed to the differentiation of early Basque groups (Alfonso-Sánchez et al., 2008).

Studies of Basque language reveal tantalizing hints about Basque origins but nothing conclusive. *Euskera* is one of the few non-Indo-European languages of Europe and has no recognized living relative (Douglass and Zuilaika, 2007), nor any resemblance to ancient Iberian, another non-Indo-European language (Sampietro et al., 2005). This fact alone suggests great antiquity. There is no written record of Basque prior to the Roman period, so all studies compare recent Basque to other ancient and modern languages. Arnaíz-Villena and Alonso-García (2000) summarize a prevailing theory that Basque is related to *Aquitanian*, an ancient language of Western France. Along with Martínez-Laso et al. (2000), they argue there are recognizable elements in Basque inscriptions that link it to other ancient Mediterranean languages, such as Linear A or Minoan, Tartesian-Iberic, Etruscan, and even the Berber languages of North Africa. Ruhlen (2000), in the same volume, suggests Basque is neither Indo-European nor Eurasiatic and more likely belongs to a Dene-Caucasian language family that was distributed across Europe during the latter stages of the Upper Paleolithic prior to its disruption by a wedge of Indo-European farmers. Despite more than a century of research, the position of Basque among other European language families remains a mystery.

Basque skeletal morphology is distinct from that of other European populations as well, particularly cranial morphology. De Aranzadi (1922) devoted over twenty years of research identifying traits peculiar to the Basque in an effort to organize Basque crania into the standard racial classification of the time. In 1992, de la Rùa described the Basque skull as narrow in breadth with a flattened cranial vault and a deeply angled base. Bregma, the point at which the coronal and sagittal sutures meet, is pushed to a more posterior and inferior position than seen in other European populations.

Using craniometric traits to evaluate population relationships

Skeletal traits in general and cranial traits in particular provide excellent and accessible data that can be used to study the biological uniqueness of human populations. This is due to the manner in which bone changes over time in response to the pressures of both genes and the environment (Howells, 1973). Precise measurements and determinations of the angles between and among the landmarks on the bones of the skull provide suites of traits that can be used in population comparisons. Phenotypically, craniometric traits are continuous, meaning that the measurements fall within a spectrum of possible values that exhibit a normal distribution. Twin studies have shown these variables have relatively high heritability coefficients, indicating that genes contribute significantly to cranial size and shape (Nakata et al., 1974). Intentional or unintentional cranial deformation can introduce an environmental component into craniometric variables but lacking such deformation, these traits can be a good reflection of the population's underlying genetic makeup.

When comparing two or more populations for a set of biological traits, a basic assumption is that the more similar they are phenotypically, the closer the populations are genetically (Constandse-Westermann, 1972). Multivariate analysis is often employed in biology and anthropology to compare two or more populations using multiple traits. Through these comparisons, it is possible to estimate relative degrees of similarity among a series of groups. The difference or "distance" between populations is used to make inferences on affinity and phylogenetic descent. Biological distance is not an objectively defined quantity, but is instead a value that is dependent on the method of calculation chosen.

Though he was not the first researcher to apply multivariate statistics to cranial measurements, W.W. Howells’ (1973) *Cranial Variation in Man: A Study by Multivariate Analysis of Patterns of Difference Among Recent Human Populations* was a landmark in terms of thoroughness and breadth. Howells obtained 70 measurements from 17 distinct populations and subjected those variables to different types of multivariate analyses. His goal was to study the overall size and shape of the human skull and develop a taxonomy for a representative sample of world populations.

According to Howells (1973), differences in individuals can be extended to differences among groups. In craniometric studies using multivariate analysis, skulls become the unit, and populations are configurations or swarms of units. The ultimate goal is to identify how the variation in skull shape among individuals is related to the variation among populations. Success is limited by the number and exactness of the measurements, but is otherwise not affected by the researcher.

Statement of problem

The origin of Basques remains a mystery. Are they the descendants of late Upper Paleolithic hunting and gathering groups in Western Europe who used the Pyrenees as a refuge when Neolithic agriculturalists spread across Europe during the Holocene? Alternatively, did the peopling of the Basque region occur more recently, so that the traits unique to the Basque arose due to cultural, linguistic and geographical isolation? Either view sets the Basques apart, as though lost in space with only tenuous ties to surrounding Spanish and French populations.

My intention is to examine two hypotheses for the origins of the characteristics that set the Basque apart from Iberian and European populations. The first suggests that modern Basques represent an ancestral population that predated the Neolithic transition and subsequently experienced geographic and cultural isolation that conserved its unique genetic and physical characteristics. Regardless of recent admixture with other European and North African populations, a cluster analysis of craniometric variables should show the Basques are divergent from other European populations. The results of the discriminant function analysis would likely reflect an overall lack of similarity to populations present in the reference samples.

The second hypothesis addressed revolves around the potential links between Basques and North African populations. Lalueza-Fox et al. (1996) and Cruciani et al., (2004) find little craniometric or genetic evidence of admixture between Basques and North Africans prior to the modern era. Should this be the case, a cluster analysis of Basque crania would be expected to show a closer relationship between Basques and European populations than between Basques and African populations. The discriminant function analysis of individual Basque samples would support this close connection with Europe.

Using multivariate statistics, this project addresses the question of how Basques are related to other Iberian, European and North African populations of the past and present through a comparative analysis of cranial measurements. How do individual Basque skulls classify into known, non-Basque reference categories? Finally, what do biological distances between this population and other populations throughout the world suggest about Basque population history and their potential links with North African populations? To examine the cranial similarities between Basques and other populations, this project derives biological distances between Basques and an array of Iberian and world samples based on an evaluation of 17 craniometric traits.

Chapter 2: Materials and Methods

MATERIALS

Basque sample

The data for this project consist of cranial measurements performed on individuals buried in the Catedral de Santa María in Vitoria-Gasteiz, capital of the Autonomous Basque Community, Álava province, Northern Spain. The 14th century cathedral has been undergoing massive restoration since 1994 to stabilize the foundations and preserve its unique features (Fig.1). This necessitated the exhumation of all burials associated with the cathedral. Burials in the cathedral and surrounding grounds were allowed from its inception until the 19th century when the cathedral closed its doors due to safety concerns, but were most common during the Medieval and immediate post-Medieval periods (Azkarate, 2001). Those physical remains were made available for us to study in the summers of 2006 and 2008.

Two hundred twenty crania were evaluated for age and sex based on the methods summarized in Brothwell (1981). Only individuals determined to be 18 years old or older were included in the study, as the small size and proportions of juveniles would skew the results of both cluster analysis (Howells, 1973) and discriminant function analysis (Uberlaker et al., 2002). Of the 220 skulls measured, only 59 males and 52 females over the age of 18 were in a state of completeness sufficient to

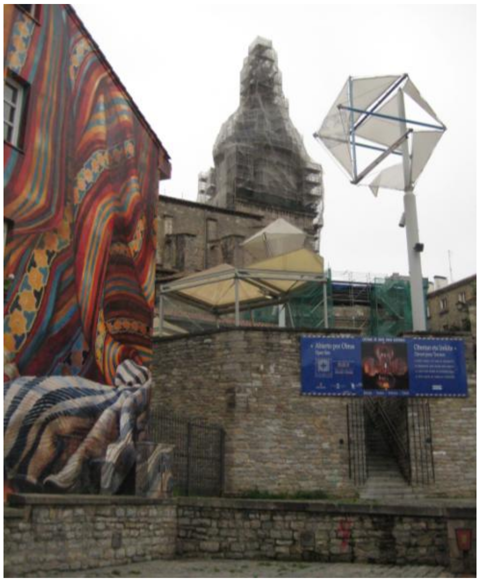

Fig. 1. Restoration of the Catedral de Santa Maria, Vitoria-Gasteiz.

measure 10 or more traits (Table 1). Individuals for which 14 or more measurements were recorded were selected for individual classification using FORDISC 2.0, amounting to a total of 71 specimens (Table 2). Of these, 37 were male and 34 were female.

TABLE 1. Age and sex of Vitoria Basque samples used in cluster analysis

Age Range (years)	Number of Individuals	
	Males	Females
19-22	--	2
23-35	20	20
36-55	27	18
56+	12	12
Total	59	52

TABLE 2. Age and sex of Vitoria Basque samples used in discriminant function analysis

Age Range (years)	Number of Individuals	
	Males	Females
19-22	--	2
23-35	14	12
36-55	17	15
56+	6	5
Total	37	34

Comparative samples

To put the Vitoria Basque into a broader geographic perspective, comparative data were drawn from an extensive literature on craniometric variation (Table 3). The first set of comparative data includes Iberian populations from numerous sources representing over 40 years of research in the area. These studies, summarized in Lalueza-Fox et al. (1996), represent four main areas: Catalonia, the Balearic Islands, Granada, and the Center-North peninsular region (Fig. 2). The 19th century Basque population was selected on the basis of documentation in the form of church registers ensuring their

TABLE 3. Samples from the Iberian Peninsula[a]

Population	Number of Individuals		Site/Region	Period	Dating	Reference
	Males	Females				
Basque	100	70	Basque Country, Varied Provinces	Recent	AD 19th cent	de la Rua 1985
Tarragona	103	62	Tarragona	Roman	AD 200-500	Pons 1949
Majorca 1	56		Son Real (Aluedia, Majorca)	Talayotic	5th century BC	Font 1977
Burgos 1	33		Palacios de La Sierra (Burgos)	Reconquest (Christian)	AD 900-1300	du Souich et al 1990
Muslim	47	47	La Torrecilla (Granada)	Medieval (Muslim)	AD 800-1400	du Souich 1979
Visigoth	88	88	North Meseta	Visigothic	AD 400-700	Varela 1974-1975
Cantabria	55	40	Santa Maria de Hito (Cantabria)	Medieval (Christian)	AD 500-1200	Galera and Garralda 1992
Catalonia 1	120	80	Central Catalonia	Bronze Age	2000-1000 BC	Turbon 1981
Burgos 2	26		Villanueva de Soportilla (Burgos)	Reconquest (Christian)	AD 800-1200	du Souich et al 1991
Jewish	37	18	Montjuich (Barcelona)	Medieval	AD 1000-1400	Prevosti and Prevosti 1951
Majorca 2	55	54	Illot des Porros (Majorca)	Talayotic	500-100 BC	Malgosa 1992
Catalonia 2	74	45	Central Catalonia	Reconquest (Christian)	AD 800-1100	Vives 1987
Granada	80	53	Upper Andalusia (mainly Granada)	Bronze Age	1800-1200 BC	Jiménez 1987

[a] All as reported in Lalueza-Fox et al. (1996).

Fig. 2. Geographic locations of Iberian samples, including Vitoria Basque.

Basque origin (de la Rúa, 1985). Tarragona, a site off the northeastern coast of Spain, represents the Roman occupation era (Pons, 1949). Majorca 1, from the island of Son Real (Majorca 1) (Font, 1977) and Marjoca 2 from the s'Illot des Porros (Malgosa, 1992) are Talayotic sites from the Balearic Islands, and represent two of the earliest Iberian samples in this comparison. The Burgos populations of Palacios de la Sierra (Burgos 1) (du Souich et al., 1990) and Villanueva de la Soportilla (Burgos 2) (du Souich et al., 1991) date from the Reconquest era, the period of Christian reconquest and repopulation of the Muslim Al-Andalus Province during the 13th-15th centuries. The sample from La Torrecilla are attributed to a Muslim population of that period (du Souich, 1979). A sample from central Spain was archaeologically determined to be Visigoth (Varela, 1974-1975). The Cantabrian population from northern Spain dates to the medieval period (Galera and Garralda, 1992). There are two Catalonian populations included in the analysis: Catalonia 1 dates to the Bronze Age (Turbón, 1981) and Catalonia 2 dates to the medieval period (Vives, 1987). Another Bronze Age population was selected from Granada (Jiménez, 1987). Finally, a burial population from an area outside Barcelona that was characterized by tombstones with Hebrew inscriptions represents a Medieval Jewish population (Prevosti and Prevosti, 1951).

Howells notes that the use of multivariate analysis in craniometrics ideally requires geographic and temporal definition, and he sought both in selecting the populations for his 1973 study. These populations represent the second set of comparative data and are summarized in Table 4. The Egyptian and Siberian Buriat populations meet this requirement. For the South African Bushman and the Tasmanian samples, so few crania exist that the temporal definition became secondary to ensuring the sample be regionally defined. The Berg of Carpathia, the Arikara of the Great Plains of North America, the Andaman Islanders and the South Australia samples could all be traced to specific, narrowly defined regions – specific villages, islands or river valleys. Similarly, Howells selected Medieval European samples from the Norse of Oslo and the Zalavár populations of Hungary as he felt that period in history would find the Europeans more geographically isolated, technologically comparable and pathologically similar (in terms of dental health, life expectancy and mortality) to the other populations selected. The Teita, Dogon and Zulu represent eastern, western and southern Africa, respectively. Along with the Australian and Tasmanian samples, the

TABLE 4. Samples from Howells, Cranial Variation in Man (1973)

Population	Number of Individuals		Site/Region
	Males	Females	
Norse	55	55	Oslo, Norway
Zalavar	54	56	Zalavár, Hungary
Berg	56	53	Berg, Carinthia, Austria
Egypt	58	53	Gizeh, Egypt
Teita	34	49	Kenya
Dogon	48	53	Dogon, Mali (Ex French Sudan)
Zulu	55	47	South Africa
Bushman	41	49	South Africa
Andaman	26	28	Andaman Islands
South Australia	52	49	Lake Alexandria Tribes, South Australia
Tasmania	44	42	Tasmania
Tolai	55	55	Melanesia, Toloai, New Britain
Mokapu	51	49	Polynesia, Mokapu, Oahu, Hawaii
Buriat	54	55	Siberia, Buriats
Eskimo	54	54	Greenland, Inugsuk Eskimo
Arikara	42	27	North America, Early Arikara
Peru	55	55	South America, Yauyos, Peru

Tolai sample from Melanesia and Polynesian sample from pre-contact Hawaii (Mokapu) round out the Pacific Southwest. Finally, there are two additional populations from the New World – the Yauyos from South America and a Greenland Eskimo sample. All of these were included in the cluster analysis in my project.

METHODS

Observational Methods

The crania were examined and measured over two two-week periods during the summers of 2006 (by G. Richard Scott) and 2008 (by Jennifer Janzen). In addition to making cranial measurements, the skulls and post-cranial skeletons (if available) were examined to evaluate the age and sex of each individual set of remains.

Determination of Sex and Age-at-Death

To determine sex, five features were scored using a scale of one (minimal expression) to five (maximum expression) from Buikstra and Ubelaker (1994). These features include: development of the nuchal crest at the base of the occipital bone; the size and volume of the mastoid process, a bony protuberance where several muscles involved in moving the head attach below the ear canal; the development of the brow ridges (or suprorbital margins); the protuberance of the frontal bone (the prominence of glabella); and the mental eminence, a projection along the front of the chin. Other cranial features scored on a comparable five-point scale include the development of the malars, or the zygomatic bones that form the cheeks, and a rounded eminence of the parietal bones, termed parietal bossing. These factors were considered along with the overall robusticity and rugosity of the entire cranium, as well as the lower jaw (mandible).

Cranial features were supplemented by an examination of the pelvic bones, or os coxae, if this portion of the skeleton was present. Sex differences were scored on the face of the pubic symphysis and angle of the pubic bone at the front of the pelvic girdle. Special attention was paid to the width of the sciatic notch (where the sciatic nerve exits the spinal column to the legs) and to variations in the width and depth of the pre-auricular sulcus, along the medial edge of the sciatic notch below the point where the pelvic bones join the sacrum. These features were all scored following the standards described in Buikstra and Ubelaker (1994).

The age at death of individuals was assessed using several criteria described in Brothwell (1981). First the degree of tooth wear was scored against a scale developed by Brothwell to classify age in a Medieval British population. Next the extent of cranial suture fusion was assessed on a scale of zero (no evidence of closure) to three (total obliteration of the suture according to the standards provided by Buikstra and Ubelaker (1994). While the overall state of suture closure was observed, only the coronal, sagittal and lambdoidal sutures were recorded. Changes on the face of the pubic symphysis and auricular surface of the ilium were also used to evaluate age. The combined scores of cranial and innominate characteristics were considered together to determine whether individuals were young, middle or old adults. For craniometric analysis, however, the only critical determination is of adult status because skull measurements do not change after the age of 21 years.

Craniometric Measurements

Craniometric measurements were restricted to those that can be taken with either sliding or spreading calipers (Fig. 3). The same types of calipers, skull restraints and reference materials were utilized by each researcher when taking the measurements. Table 5 describes the 17 craniometric variables measured for the Vitoria Basque sample, taken from Brothwell (1981) and Howells (1973, 1989). Figure 4 provides an orientation to the landmarks utilized, from Buikstra and Ubelaker (1994) and Moore-Jansen et al. (1994). The abbreviations for each variable were adapted from Moore-Jansen et al. (1994) and correspond to the terms used in FORDISC 2.0.

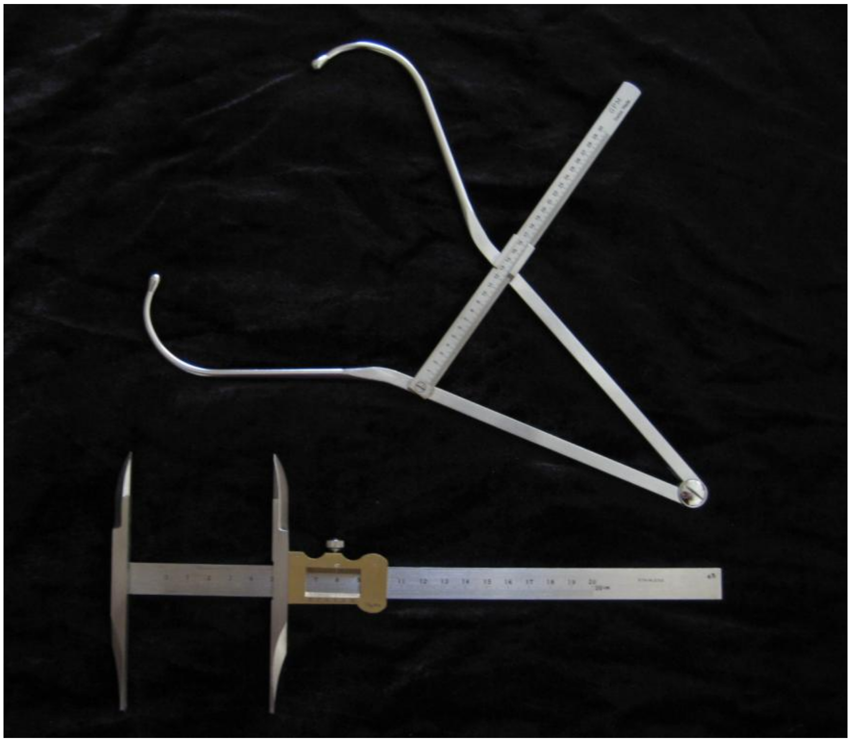

Fig. 3. Spreading calipers (above) and sliding calipers (below) used in taking cranial measurements.

TABLE 5. Alphabetical list of craniometric measurements[a]

Abbreviation	Measurement	Description
BBH	Basion-Bregma Height	Distance from bregma to basion
BNL	Basion-Nasion Length	Direct length between nasion and basion
BPL	Basion-Prosthion Length	The facial length from prosthion to basion
DKB	Interorbital Breadth	The breadth across the nasal space from dacryon to dacryon
EKB	Biorbital Breadth	The breadth across the orbits from ectoconchion to ectoconchion
FRC	Nasion-Bregma Chord (Frontal Chord)	The frontal chord, or direct distance from nasion to bregma, taken in the midplane and at the external surface
GOL	Glabello-Occipital Length	Greatest length from the glabellar region in the medial sagittal plane
NLB	Nasal Breadth	The distance between the anterior edges of the nasal apeture at its widest extent
NLH	Nasal Height	The average height from nasion to the lowest point on the border of the nasal aperture on either side
OBB	Orbit Breadth (Left[b])	Breadth from ectoconchion to dacryon, as defined, approximating the longitudinal axis which bisects the orbit into equal upper and lower parts
OBH	Orbit Height (Left[b])	The height between the upper and lower boders of the left orbit, perpendicular to the long axis of the orbit and bisecting it
OCC	Lambda-opisthion chord (Occipital Chord)	The external occipital chord, or direct distance from lambda to opisthion, taken in the midplane and at the external surface
PAC	Bregma-Lambda Chord (Parietal Chord)	The external chord, or direct distance from bregma to lambda, taken in the midplane and at the external surface
UFHT	Nasion-Prosthion Height (Upper Facial Height)	Upper facial height from nasion to prosthion (NPH in Howells 1973)
WFB	Minimum Frontal Breadth (Bifrontal Breadth)	Smallest diameter between the temporal crests on the frontal bone (FMB in Howells 1973)
XCB	Maximum Cranial Breadth	The maximum cranial breadth perpendicular to the median sagittal plane (above the supramastoid crests)
ZYB	Bizygomatic Breadth	The maximum breadth across the zygomatic arches, wherever found, perpendicular to the median plane

[a] From Howells 1973 and FORDISC 2.0

[b] Left was measured if present - if not, the measurement of the right feature was taken.

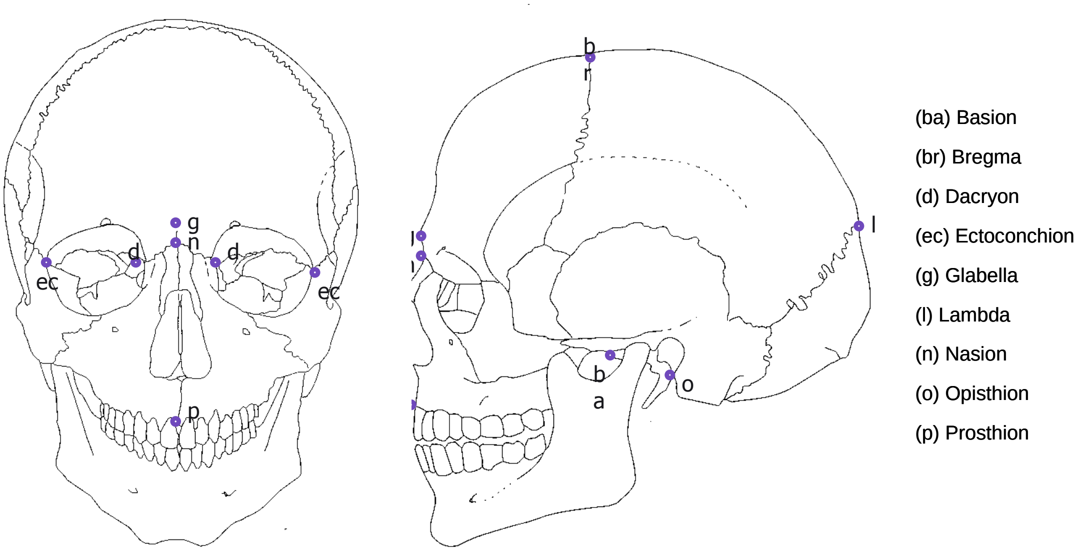

Fig. 4. Anatomical landmarks of the skull (after Moore-Jansen et al. 1994).

Basion-Bregma Height (BBH), Basion-Nasion Length, and Basion-Prosthion Length all describe distances between basion, the most anterior (front facing) point on the margin of the foramen magnum (where the spinal cord exits the skull), and other key landmarks on the face and skull. Basion-Bregma Height describes the distance from basion to bregma, the point near the top of the skull where the coronal suture and the sagittal suture meet, providing the ultimate vertical height of the skull. The Basion-Nasion Length measures the span between basion and nasion, the point between the eyes where the fine nasal bones meet the frontal bone, which makes up the forehead and anterior portion of the skull. This provides both the vertical distance between these points and an indication, in reference to other measurements, of the extent to which that portion of the face protrudes. Prosthion, also known as alveolare, describes the most anterior point of the maxillary alveolar process (upper jaw) that extends just between the two front teeth, so that Basion-Prosthion Length is the distance between those two points. In conjunction with other measurements and angles, this measurement provides information about the height of the lower part of the face and mandible as well as the protrusion of the upper jaw.

Three chords (direct lines measured between points along the curve of the skull) are included in this study. The Frontal Chord (FRC) is measured from nasion to bregma. The Occipital Chord (OCC) describes the distance between lambda, the point at which the sagittal and lambdoidal sutures meet at the back of the skull, and opisthion, a point on the foramen magnum opposite basion. Finally, the Parietal Chord (PAC) stretches between bregma and lambda. Along with the Glabello-Occipital Length (GOL), which measures the greatest length from the front of the skull (glabellar region of the frontal bone) to the back of the skull (on the midpoint of the occipital bone), these chords help describe the length of the skull.

The width of the face is examined using two measurements. The first is the Minimum Frontal Breadth, or Bifrontal Breadth (WFB). This is the smallest distance across the frontal bone between the two crests that define the temples. The Bizygomatic Breadth (ZYB) is the maximum breadth across the zygomatic arches, or cheek bones. Finally, the Maximum Cranial Breadth (XCB) measures the breadth of the skull. This measurement is not between two specific landmarks, but instead represents the maximum width of the skull on a horizontal plane.

The Interorbital Breadth (DKB) and the Biorbital Breadth (EKB), along with the Orbit Breadth (OBB) and Orbit Height (OBH) provide information about the shape and size of the eye sockets. The Interorbital Breadth describes the distance between the eyes, measured from the most medial (mid-facing) points on the interior of the orbital rim.

These points are referred to as dacryon. The Biorbital Breadth is measured from the outermost point on the orbital rim, called ectoconchion, of both eyes. Orbit Breadth measures the distance between ectoconchion to dacryon, describing the width of the eye socket. Orbit Height is the distance between the upper and lower rims of the orbit at its midpoint. Although it does not describe the orbits themselves, the Nasion-Prosthion Height describes the vertical distance between nasion and prosthion and is also known as Upper Facial Height (UFHT).

Finally, two nasal measurements were included. Nasal height refers to the average height from nasion to the lowest point on the border of the nasal cavity. Nasal breadth is the measurements between the anterior edges of the nasal aperture at its widest extent. Together, these measurements provide the nasal index, a major discriminator among certain populations.

Sources of Error and Sample Sizes

According to Howells (1973), measurement error is a significant problem in multivariate analyses. Errors made during measurement or recording will permeate an entire analysis by changing the “shape” of a specimen or group of specimens, ultimately distorting the results. When measuring skulls, possible sources of error include:

(1) Mistakes made identifying cranial landmarks and positioning the calipers

(2) Flaws in the equipment

(3) Recording errors (writing down wrong numbers by mistake, or looking at wrong mark on calipers).

(4) Intraobserver error (the degree to which an individual deviates in measuring the same variable on two or more occasions)

(5) Interobserver error (the degree to which measurements differ between two workers taking the same measurements on the same or different skulls)

To control for the first three errors, the record of measurements was double-checked while the skull was still available to measure again in hopes of identifying and rectifying unusual readings. Reading and recording errors discovered once the skull was no longer available resulted in the disqualification of the specimen from analysis.

Because this project utilizes data from two researchers, and because the use of means is the only way to compare the data with the literature, the measurements were subjected to Student's T-tests and Fisher tests. The former evaluates the effect of intraobserver error, error or variations committed by a single researcher. The latter examines the extent of interobserver error, which occurs due to differences in practice between researchers. These tests revealed a few instances of deviation beyond what was expected in the population. In those cases, the outlying measurement was discarded, even when this resulted in the disqualification of the individual specimen from subsequent analyses. With the outliers discarded, it can be said that variation within the populations or between the Vitoria population and comparative populations can be considered to be the result of factors other than method or recording error.

In many instances, the remains were incomplete and the skulls broken. Breakage of skulls leads to incomplete set of measurements for some individuals. In cluster analysis and discriminant function analysis of cranial traits, all measurements are important, so in order to maximize sample sizes incomplete remains were used when necessary. Measurements from damaged or fragmentary specimens were taken when the damage did not appear to affect the measurement by obliterating landmarks or changing the shape of the skull .

Analytical methods

Biological Distance

Multivariate analysis is used in both biology and anthropology to examine biological variation and descent, specifically the difference or “distance” between species or populations (Constandse-Westermann, 1972). This distance is not an objectively definable quantity, but instead a value that is dependent on the method of calculation chosen. The measure of the size of this distance is termed the distance coefficient. Distance coefficients can be determined for populations being characterized by both quantitative (metric traits) and qualitative (non-metric) traits. Because cranial measurements are quantitative, the current discussion is limited to distance coefficients of that category.

Karl Pearson, often credited as the founder of modern statistics, is best known in anthropology for developing a distance coefficient termed “the coefficient of racial likeness” (CRL), published in 1926. The CRL is a measure of the probability that two groups being compared are random samples from the same population. To develop the CRL, means and differences are expressed as standard deviations, and “standardized” standard deviations are determined for each trait.

Howells (1973) notes three drawbacks to Pearson’s CRL. First, he found the computations required in order to compare more than one population using one trait at a time inadequate. Second, comparing the standard deviations only allows comparison of the traits examined and does not extend trends of similarity or difference to the reference populations. Finally, and more importantly, the CRL does not address traits which are highly correlated or distinguish between size and shape. Other researchers, notably Penrose (1954), attempted to modify the CRL to distinguish size and shape. Penrose's size and shape distance coefficient remains one of the preferred coefficients in use today. Another approach developed from the CRL uses distance coefficients expressed as squared differences, where the differences are either in terms of standard deviations or some other units to which they are related (Constandse-Westermann, 1972). This is called the Generalized Distance and is useful for comparing two populations expressing correlated traits. In the 1930's, Ronald Fisher attempted to develop a method of associating individuals or populations with existing groups for which the means and standard deviations had already been determined. In so doing, Fisher defined a discriminant function analysis useful for comparing two populations. Mahalanobis (1936) devised a more specialized distance coefficient during the same time period that could be applied to two or more populations. This distance coefficient D^2 provided a discriminant score or weight by which to multiply the original measures. This had the effect of maximizing the between-group variance (distance of the measures from the mean) relative to the within-group variance. Mahalanobis (1936) was more concerned with biological distance than Pearson or Fisher, and according to Howells, provided a correct measure of distance.

Mahalanobis' D^2 is based on adding the squared differences between populations for all available characters (Constandse-Westermann, 1972). These differences are transformed in order to break the correlative effect and then geometrically calculated as a vector. The length of this vector is the distance between vectors representing the populations within a dispersion matrix made up of the pooled values of variances and covariances (or measures of how much variables change together). The space in which these vectors exist is multidimensional, so that all distances are valid regardless of their direction. All the differences are expressed in terms of the pooled standard deviation of the character in question.

In his cluster analysis, Howells (1973) utilized a simplified computation of Mahalanobis' D^2 as his distance coefficient. This two-step procedure corrects for correlation by transforming the measurements into new, uncorrelated values with the same unit variance. This keeps size differences among the samples from becoming too influential in the analysis, so that an unusually large or small measurement does not skew the results. Next, the discriminant function coefficients are found as the differences of the means of the two populations in uncorrelated variables, with D^2 being the sum of the squared difference. In keeping with Howell's example, the current study also employs the modified D^2 as the distance coefficient.

Cluster Analysis

NTSYSpc software for multivariate statistics and data analysis (Rohlf, 2007) was used for the cluster analysis. Computations were performed to provide a distance matrix using the Mahalanobis' D^2 distance coefficient. The data matrix was then standardized using a linear transformation, as in Howells (1989). This is to ensure that relatively small linear measurements such as nasal breadth, which naturally show less absolute intergroup variation than larger measurements (such as bizygomatic breadth), will still be accorded the same importance in determining the distance coefficient (Costandse-Westermann, 1972).

Cluster analyses were performed using the unweighted pair group method with arithmetic mean (UPGMA) algorithm, a hierarchical method used for the creation of dendograms (Sokal and Michener, 1958). These trees are used to infer evolutionary relationships among the groups based upon similarities or differences in their physical and genetic make up. UPGMA was chosen as it assumes constant mutation rates among the populations or lineages examined. The branches can be attributed to population evolution or migration, although the trees do not distinguish between these sources of variation.

Discriminant Function Analysis

FORDISC 2.0 is an interactive computer program that allows researchers to apply custom discriminant functions for up to 21 cranial measurements. It has the added benefit of providing sex and race classifications even for incomplete remains from which a limited number of measurements can be obtained. The reference samples used in FORDISC 2.0 are based on two sources of data. The Forensic Data Bank (Jantz and Moore-Jansen, 1988; Moore-Jansen et al., 1994) provides information garnered from modern individuals, primarily 20th century Americans of both sexes of White, Black, Native American, Chinese, Japanese, Vietnamese or Hispanic ancestry. The Hispanic, Vietnamese and Chinese reference samples in the Forensic Data Bank consist only of males. The program also utilizes the data collected by Howells (1973, 1989) for cranial measurements taken on museum collections of remains from around the world. The discriminant functions derived from these two databases offer different, complementary approaches to ancestry classification.

The combination of modern and archaeological samples makes FORDISC 2.0 a flexible choice when examining collections with no known temporal provenience. However, discriminant function classification assumes that the unknown originates from one of the reference samples within the database. This limits individual classification when the ancestry of the unknown material is not represented among the reference samples (Birkby, 1966; Ousley and Jantz, 1996). However, while the program was not designed for this purpose, this limitation is less of a problem when the goal is to identify the overall similarity of a *group* of individuals to the reference samples, as is the goal of the current study.

Chapter 3: Results

Summary Statistics

Due to the fragmentary condition of the Vitoria Basque skulls examined in 2006 and 2008, many individuals are represented by only a few measurements. The number of individual measurements per trait for Vitoria Basque males and females are summarized in Table 6, along with the mean, standard deviation, standard error and range for each trait. Standard deviation is a measurement of variability, or divergence, from the mean or expected value, whereas the standard error of the mean is the standard deviation of those sample means over all possible samples included in the population. Finally, the range indicates the minimum and maximum values for each trait.

Because of lack of completeness, analysis was confined to the traits measured in 2006. Moreover, no additional angles as described by Howells (1973) were computed for multivariate analysis. However, in the discriminant function analysis using FORDISC 2.0, the program computed additional angles for individuals with sufficient measurements. Only individuals for which 14 or more measurements were recorded were selected for individual classification using FORDISC 2.0.

Biorbital breadth (EKB) was not measured in 2006 for the Vitoria Basque, and so was not included in analysis by clustering for either comparisons with Iberian populations or those examined by Howells, although it is included in subsequent individual identification using FORDISC 2.0. Interorbital breadth (DKB) and bizygomatic breadth (ZYB) were not reported for Iberian data from the literature, so these measurements were not included in comparisons with those populations.

TABLE 6. Summary statistics for Vitoria Basque males and females

	Males					Females				
	Number	Means	Standard Deviation	Standard Error	Range	Number	Means	Standard Deviation	Standard Error	Range
BBH	44	132.18	5.186	0.782	121-143	43	126.79	4.585	0.699	117-136
BNL	46	103.57	103.565	0.788	88-112	43	98.28	5.333	0.813	85-118
BPL	37	92.14	5.355	0.88	83-100	34	88.65	6.129	1.051	72-104
DKB	67	26.03	2.38	0.291	20-31	68	24.85	2.672	0.324	18-30
FRC	96	114.49	5.156	0.526	101-129	90	109.07	3.951	0.417	101-119
GOL	75	187.75	6.556	0.757	169-203	75	178.76	6.311	0.729	165-195
NLB	68	24.18	2.292	0.278	20-32	71	23.23	1.921	0.228	19-28
NLH	70	52.59	3.681	0.44	45-63	65	49.22	3.489	0.433	41-58
OBB	69	38.45	1.827	0.22	34-44	69	36.9	2.143	0.258	32-41
OBH	69	34.81	2.777	0.334	27-40	70	34.83	2.502	0.299	28-42
OCC	62	98.65	6.087	0.773	85-113	55	95.29	6.151	0.829	83-111
PAC	86	115.52	6.968	0.751	97-134	84	110.46	7.038	0.768	89-128
UFHT	60	71.63	5.237	0.676	59-84	62	66.94	5.001	0.635	52-77
WFB	96	96.31	3.988	0.407	88-108	99	93.61	4.06	0.408	84-103
XCB	74	141.16	5.572	0.648	131-158	72	136.79	5.273	0.621	127-151
ZYB	48	126.88	5.655	0.816	114-138	42	119.12	4.589	0.717	107-131

Table 7 provides the means of the craniometric variables for the comparative Iberian populations gathered from the literature. The number of individuals examined from each population and the means of the cranial measurements are the only information available for this data set, because individual measurements were not ordinarily reported in the original publications. Because of this, the standard deviations, standard errors, and the range of values are unavailable, and all information about variation within the populations is lost. Because of consistent sex dimorphism in skull size, males and females are tabulated separately. Only males were examined from the Talayotic populations from Son Real (Majorca 1), the Medieval Christian population from Palacios de La Sierra (Burgos 1) and the Medieval Christian population from Villaneuva de Soportilla (Burgos 2). The number of female samples available from these populations is insufficient for inclusion in this study (less than 30 individuals).

Consistent with the data available for the Iberian populations, Table 8 provides the number of individual crania measured and the means of the relevant cranial measurements for the samples measured by Howells (1973). Standard deviations are available in the original publication but are not included here. Sex determination was accepted as published because this data set provides a standard for sex identification using FORDISC 2.0.

TABLE 7: Mean values of the craniometric variables of the Iberian samples

	Number	BBH	BNL	BPL	FRC	GOL	NLB	NLH	OBB	OBH	OCC	PAC	UFHT	WFB	XCB
Male sample															
Basque	100	130.61	100.02	92.27	113.73	188.39	22.74	54.28	41.67	35.09	98.62	115.15	73.41	97.29	143.53
Tarragona	103	133.72	102.47	95.56	112.01	186.93	24.93	52.94	40.81	33.68	98.03	117.24	71.97	97.18	142.07
Majorca 1	56	137.58	104.52	95.72	113.89	188.56	23.50	51.37	40.83	32.11	98.69	116.00	69.20	97.31	140.29
Burgos 1	33	133.63	100.31	92.95	114.06	187.90	24.95	53.31	40.96	32.84	97.26	117.92	72.38	95.28	140.02
Muslim	47	135.31	101.46	97.34	111.69	184.74	24.86	51.69	41.97	33.38	96.63	117.61	69.86	96.30	135.69
Visigoth	88	137.00	102.90	97.70	114.05	190.87	25.49	52.38	41.15	32.87	100.31	117.61	72.44	97.42	140.20
Cantabria	55	136.68	101.40	94.00	114.44	192.68	24.40	53.52	40.30	33.91	100.09	118.32	75.12	97.82	142.12
Catalonia 1	120	135.07	100.97	95.57	112.89	188.07	23.70	51.24	41.42	31.87	100.28	115.90	68.05	95.74	141.04
Burgos 2	26	137.71	101.76	96.87	111.84	186.68	22.39	51.89	40.46	32.10	100.03	117.13	70.09	94.63	140.65
Jewish	37	132.50	103.00	95.57	111.90	187.88	24.17	52.82	44.00	35.78	96.76	120.03	71.06	98.87	139.60
Majorca 2	55	134.96	101.22	98.32	113.07	186.82	23.60	51.04	39.92	30.95	98.57	115.00	70.46	97.61	139.59
Catalonia 2	74	135.43	102.47	94.26	113.62	189.28	23.96	52.40	38.10	33.59	100.14	115.54	69.63	96.54	139.52
Granada	80	133.56	100.29	95.69	112.44	186.45	24.26	50.04	40.89	32.09	100.38	116.54	70.72	95.14	140.07
Female sample															
Basque	70	125.21	95.03	88.44	109.58	179.75	22.57	50.73	38.48	33.92	95.86	109.96	68.55	94.97	138.85
Tarragona	62	128.96	96.62	90.55	108.34	179.72	23.99	49.97	39.36	33.42	95.83	113.98	67.59	95.41	137.68
Muslim	47	128.85	96.16	91.64	107.37	176.26	23.49	49.02	41.11	32.31	94.14	111.58	65.16	92.88	132.83
Visigoth	88	132.34	99.00	93.33	110.22	181.51	24.03	49.61	39.13	32.82	94.97	113.29	68.00	97.42	135.63
Cantabria	40	131.84	98.43	91.05	110.40	185.11	23.13	50.08	38.71	33.10	96.92	114.93	69.36	94.43	138.17
Catalonia 1	80	129.54	94.77	91.12	108.04	179.65	23.00	48.40	40.13	31.23	97.24	112.47	63.97	94.01	136.35
Majorca 2	18	128.93	97.00	93.59	109.13	179.82	22.59	47.86	38.32	31.05	95.98	111.98	64.91	95.23	126.38
Jewish	54	127.17	96.83	92.11	108.41	177.94	23.36	50.27	42.18	34.36	95.07	113.82	66.70	94.17	133.64
Catalonia 2	45	131.17	97.19	90.00	108.71	181.44	22.93	48.93	37.47	32.94	97.07	119.91	66.76	94.00	136.40
Granada	53	129.94	94.06	94.78	108.51	179.71	23.04	48.25	39.00	30.46	96.21	112.79	67.50	92.72	137.17

TABLE 8: Mean values of the craniometric variables of the samples measured by Howells (1973)

	Number	BBH	BNL	BPL	DKB	FRC	GOL	NLB	NLH	OBB	OBH	OCC	PAC	UFHT	WFB	XCB	ZYB
Male sample																	
Norse	55	131.73	101.80	96.96	22.34	113.13	188.47	25.42	51.96	40.38	33.74	97.25	114.44	68.93	99.02	141.87	134.44
Zalavar	54	134.96	101.26	97.04	21.39	122.74	185.22	25.37	51.41	39.98	32.65	96.28	115.48	68.50	98.13	141.39	133.06
Berg	56	130.25	98.59	93.75	22.88	111.05	180.32	25.46	51.71	40.14	33.75	94.00	110.09	67.89	99.59	147.61	135.55
Egypt	58	133.74	101.50	96.52	20.86	111.91	185.62	24.83	51.74	39.50	32.95	97.48	115.72	68.43	96.05	139.22	128.83
Teita	34	129.03	102.23	102.41	24.38	108.71	183.88	27.91	50.09	39.65	33.29	93.53	114.03	66.00	100.06	129.85	131.00
Dogon	48	132.19	98.60	99.94	23.50	110.00	177.85	28.35	47.83	39.71	33.79	94.52	112.15	64.85	99.54	137.29	129.56
Zulu	55	133.67	102.00	102.38	23.53	111.69	185.13	28.65	50.00	40.44	33.76	96.53	115.31	67.33	101.98	134.11	129.94
Bushman	41	122.54	94.76	93.66	21.73	109.17	178.37	27.17	43.76	39.27	30.83	88.56	109.49	57.51	97.27	133.58	123.56
Andaman	26	128.23	93.08	92.35	20.85	105.77	167.81	24.50	46.54	37.54	32.58	90.81	107.58	60.69	92.04	135.38	123.69
South Australia	52	129.61	101.98	105.50	21.69	111.90	190.31	27.88	49.69	41.86	33.46	92.11	116.63	64.77	102.42	131.94	136.77
Tasmania	44	131.93	99.64	103.25	22.36	110.20	185.29	28.86	48.70	40.70	31.04	93.11	115.73	62.41	101.73	138.18	135.73
Tolai	55	134.94	101.45	107.11	22.04	107.73	183.53	27.82	48.44	41.18	32.24	95.56	116.51	66.07	101.67	130.36	136.00
Mokapu	51	144.04	107.00	104.35	21.65	117.71	186.31	27.39	53.31	40.69	35.06	102.45	112.69	68.61	100.37	143.72	138.82
Buriat	54	132.56	101.94	99.06	21.76	113.50	181.83	28.48	56.89	41.52	35.87	94.56	109.68	74.50	101.56	154.96	144.43
Eskimo	54	139.06	106.54	103.17	18.59	112.87	188.30	23.68	54.11	41.96	36.18	98.20	114.96	71.70	98.91	133.94	139.59
Arikara	42	133.36	102.83	98.59	21.12	109.29	179.48	27.09	54.45	40.55	34.95	95.14	108.93	71.69	99.05	141.55	140.88
Peru	55	130.53	96.00	94.27	21.13	109.73	177.96	25.24	50.34	38.25	34.27	98.11	108.98	67.78	96.13	137.94	134.93
Female sample																	
Norse	55	125.96	97.31	94.02	20.64	107.98	179.98	24.18	49.25	39.20	33.22	95.33	109.53	64.25	94.60	136.29	124.40
Zalavar	45	128.76	96.51	92.13	20.67	107.47	176.44	24.67	48.49	38.67	32.09	94.20	110.64	63.18	94.78	136.89	125.44
Berg	53	124.47	92.92	89.13	22.07	106.23	170.53	24.89	48.23	38.38	32.75	91.43	105.21	63.49	95.04	140.36	126.38
Egypt	53	127.41	95.89	91.24	20.04	108.13	175.58	24.02	48.96	37.87	32.83	94.57	110.49	64.06	91.70	135.57	120.06
Teita	49	125.06	96.29	96.18	23.88	105.75	174.61	27.18	46.43	37.75	32.18	89.94	109.75	60.98	95.43	126.37	124.14
Dogon	53	127.98	94.83	96.07	22.26	105.66	169.83	27.70	46.09	38.07	32.75	94.15	107.68	61.43	94.34	132.21	121.09
Zulu	47	128.77	97.36	98.79	22.34	109.49	179.38	27.98	47.34	39.25	32.91	95.25	112.38	63.40	97.89	131.91	122.89
Bushman	49	119.51	91.67	90.61	21.73	105.10	171.71	25.92	42.86	37.67	30.96	88.47	105.29	56.12	93.90	128.37	116.53
Andaman	28	124.36	89.61	90.25	21.04	101.68	160.61	24.07	43.79	36.61	32.39	89.93	102.93	56.68	89.93	131.61	118.18
South Australia	49	123.53	96.16	100.45	20.90	105.86	181.10	26.24	46.51	39.96	33.10	91.41	110.26	61.14	97.65	127.51	125.78
Tasmania	42	126.59	94.88	98.21	20.57	105.93	177.90	27.64	45.36	39.59	30.74	92.12	111.48	58.36	96.74	133.02	125.62
Tolai	55	127.27	95.74	101.56	21.22	103.02	174.74	26.67	46.65	39.07	32.29	93.42	112.54	62.80	96.33	128.11	126.40
Mokapu	49	136.57	101.45	100.20	19.94	111.29	175.39	26.02	49.39	39.43	34.12	99.92	105.61	63.75	95.16	138.67	126.88
Buriat	55	127.25	96.71	94.49	19.89	109.98	171.82	26.82	53.42	39.78	34.91	94.71	102.80	69.45	95.67	148.42	134.45
Eskimo	54	132.74	100.09	99.30	17.24	109.48	180.81	23.31	50.39	40.46	35.13	96.04	111.46	67.05	94.98	131.02	130.17
Arikara	27	126.81	97.52	95.15	20.15	105.63	171.11	25.81	50.52	39.22	34.63	91.04	104.07	67.63	94.78	136.48	130.67
Peru	55	124.91	90.58	88.87	19.44	105.07	169.00	23.96	47.65	36.82	34.14	95.53	104.07	63.65	91.11	134.98	125.60

According to Howells (1973, 1989), analyzing only the means of the measurements is a poor option in cluster analysis, as a large skull could skew the data. Since the Vitoria project was in a way a salvage operation on material that under current conditions may not be available for future examination, and since much data in the literature on Basque and Spanish literature are reported as means without including the original measurements, analysis of means was the only option. It is useful to remember that means are a characteristic of the trait being examined, rather than of the population manifesting the measures that contribute to it. The population is best described by the information provided by all the attributes and traits considered together. This is the purpose of multivariate analysis.

Distance Matrices

Distance matrices were computed using the Mahalanobis D^2 distance coefficient. Matrices were computed for male and female samples for the three different comparisons that were performed – Vitoria Basques with Spanish samples, Vitoria Basques with Howells' samples and Vitoria Basques with both Spanish and Howells' samples – for a total of six matrices.

Table 9 is the distance matrix for male and female samples from Vitoria along with comparative Iberian populations. For the male sample, the biggest difference appears between the Basque population studied by de la Rúa (1985) and the Muslim population. The distance between the male sample from Vitoria and the Muslim sample is not as great, but the Vitoria sample still shows the greatest difference from that population of all the populations included in the study. The male sample from Vitoria shows the least distance from the Reconquest-Era Catalonia population (Catalonia 2). For the female distance matrix in Table 9, the greatest distance lies between the Muslim sample and Cantabria. The female Vitoria sample are least like the Talayotic Majorca population (Majorca 2), and most similar to the Basque population studied by de la Rúa (1985). For both males and females, the Basque sample of de la Rúa (1985) is more similar to the Vitoria Basque than to any other Iberian group.

Table 10 contains the distance matrixes for male and female Vitoria Basques compared to male and female samples from Howells (1973). Male Vitoria Basques show the greatest distance from Bushman and Andaman Islanders. The smallest distance values are with Norse, Egypt, Zalavar and Berg, i.e., the three European populations, and Egyptians. For females, the greatest distances are once again associated with Bushmen and Andaman Islanders. As with the males, the females show the greatest similarity, or smallest distances, to Egypt, Norse, Zalavar, and Berg. It is reassuring that comparable patterns of distances are obtained from both the male and female samples. The Vitoria Basques are craniometrically most similar to the three European samples in Howells' dataset along with Egyptians.

The distance matrices for the male and female samples from Vitoria compared with Iberian samples and Howells (1973) samples are shown in Table 11. For the male sample from Vitoria, the greatest similarities are to Catalonia (0.270), Tarragona (0.586), Norse (0.586), Egypt (0.648), Burgos (0.788), Cantabria (0.790), and Basque (0.878). For Vitoria Basque females, the greatest similarities are to Basque (0.559), Egypt (0.703), Tarragona (0.727), Norse (0.817), and Catalonia 2 (0.919). Although the order of distance values is not identical, the smallest pairwise comparisons between the Vitoria

Basques and other groups include the same set of samples. That is, the Vitoria Basques show the least difference from certain Iberian populations along with Egyptians and the Norse. For de la Rúa’s Basque sample, the smallest distances are between the same set of groups, including Tarragona, Vitoria Basques, Cantabria, Norse, and Egyptian.

TABLE 9. *Distance matrices for samples from Vitoria with samples from Iberia (Mahalanobis D^2 distances)*

Male sample

	Basque	Tarragona	Majorca 1	Burgos 1	Muslim	Visigoth	Cantabria	Catalonia 1	Burgos 2	Jewish	Majorca 2	Catalonia 2	Granada	Vitoria
Basque	0.000													
Tarragona	1.768	0.000												
Majorca 1	3.342	1.434	0.000											
Burgos 1	1.752	0.980	2.188	0.000										
Muslim	4.448	1.509	2.202	1.857	0.000									
Visigoth	3.382	1.211	1.168	1.717	2.509	0.000								
Cantabria	2.069	1.749	2.366	1.648	4.375	0.938	0.000							
Catalonia 1	2.607	1.358	0.967	1.639	1.969	1.626	2.708	0.000						
Burgos 2	3.334	1.699	1.328	2.242	2.061	2.248	3.132	0.712	0.000					
Jewish	2.947	1.267	2.729	2.347	1.865	2.526	3.022	3.134	3.525	0.000				
Majorca 2	3.081	1.379	0.950	2.059	1.607	1.651	3.001	0.780	1.241	3.263	0.000			
Catalonia 2	2.356	1.280	0.856	1.536	2.456	1.264	1.739	0.908	1.413	3.296	1.186	0.000		
Granada	2.995	1.394	1.774	1.540	1.647	1.932	3.067	0.446	0.995	3.321	0.935	1.379	0.000	
Vitoria	1.567	1.223	1.575	1.314	3.202	2.082	1.983	1.958	2.660	3.054	2.206	0.697	2.146	0.000

Female sample

	Basque	Tarragona	Muslim	Visigoth	Cantabria	Catalonia 1	Majorca 2	Jewish	Catalonia 2	Granada	Vitoria
Basque	0.000										
Tarragona	1.397	0.000									
Muslim	2.781	1.407	0.000								
Visigoth	3.031	1.105	2.997	0.000							
Cantabria	2.101	1.466	3.960	1.343	0.000						
Catalonia 1	2.335	1.442	1.353	3.072	2.677	0.000					
Majorca 2	3.128	2.423	1.925	2.514	3.028	1.326	0.000				
Jewish	1.666	0.768	0.772	2.080	2.521	1.727	2.254	0.000			
Catalonia 2	2.458	1.274	2.753	2.307	1.135	1.427	2.102	2.191	0.000		
Granada	2.569	1.707	1.577	2.838	2.420	0.832	1.553	2.043	1.747	0.000	
Vitoria	1.011	1.052	1.802	2.328	2.084	2.124	2.349	1.476	1.782	2.462	0.000

TABLE 10. Distance matrices for samples from Vitoria with samples from Howells (1973) (Mahalanobis D^2 distances)

Male sample

	Vitoria	Norse	Zalavar	Berg	Egypt	Teita	Dogon	Zulu	Bushman	Andaman	S. Australia	Tasmania	Tolai	Mokapu	Buriat	Eskimo	Arikara	Peru
Vitoria	0.000																	
Norse	0.865	0.000																
Zalavar	1.383	0.533	0.000															
Berg	1.419	0.507	1.165	0.000														
Egypt	0.988	0.309	0.611	0.897	0.000													
Teita	1.680	0.892	1.736	1.197	1.164	0.000												
Dogon	1.827	0.924	1.506	0.727	1.077	0.388	0.000											
Zulu	1.651	0.635	1.233	1.218	1.019	0.305	0.441	0.000										
Bushman	4.306	3.074	3.463	2.261	2.742	2.044	1.543	2.890	0.000									
Andaman	4.274	3.771	4.173	2.526	2.808	3.248	2.234	4.257	1.181	0.000								
S. Australia	3.004	1.019	1.655	1.773	1.598	0.726	1.202	0.571	3.033	5.156	0.000							
Tasmania	2.941	1.085	1.572	1.366	1.413	0.642	0.694	0.560	2.028	3.896	0.489	0.000						
Tolai	2.957	1.143	1.842	1.798	1.372	0.597	0.851	0.428	3.998	4.399	0.434	0.380	0.000					
Mokapu	2.460	1.256	1.373	2.233	1.744	2.501	2.285	1.443	6.486	6.903	2.238	2.437	1.982	0.000				
Buriat	3.093	1.483	2.228	1.218	2.502	2.733	2.332	2.135	5.816	6.282	2.474	2.672	2.866	1.718	0.000			
Eskimo	2.932	1.283	1.782	2.454	1.484	2.721	2.950	2.060	6.372	6.419	1.903	2.979	2.005	1.166	2.260	0.000		
Arikara	2.157	0.771	1.600	0.608	1.191	1.367	1.140	1.238	3.746	3.699	1.666	1.731	1.561	1.429	0.642	1.372	0.000	
Peru	1.724	1.032	1.614	0.662	0.852	1.552	0.944	1.765	2.185	1.477	2.655	2.138	2.206	2.730	2.503	2.673	0.998	0.000

Female sample

	Vitoria	Norse	Zalavar	Berg	Egypt	Teita	Dogon	Zulu	Bushman	Andaman	S. Australia	Tasmania	Tolai	Mokapu	Buriat	Eskimo	Arikara	Peru
Vitoria	0.000																	
Norse	1.014	0.000																
Zalavar	1.202	0.185	0.000															
Berg	1.511	0.839	0.615	0.000														
Egypt	0.908	0.382	0.324	0.897	0.000													
Teita	1.933	1.326	1.046	1.150	1.472	0.000												
Dogon	1.809	1.043	0.754	0.845	0.962	0.475	0.000											
Zulu	1.949	0.856	0.842	1.806	1.520	0.942	0.851	0.000										
Bushman	3.472	2.622	2.217	1.563	2.165	1.192	1.359	3.024	0.000									
Andaman	4.001	3.588	3.001	1.915	2.449	2.528	1.917	4.957	1.085	0.000								
S. Australia	2.694	0.912	1.048	1.606	1.754	0.749	1.102	0.678	2.096	3.995	0.000							
Tasmania	3.230	1.206	0.859	1.491	1.685	0.771	0.806	0.739	1.686	3.451	0.503	0.000						
Tolai	2.679	1.075	0.893	1.568	1.546	0.628	0.661	0.748	2.253	3.329	0.417	0.477	0.000					
Mokapu	2.654	1.354	1.482	2.756	1.945	3.185	2.063	1.473	5.669	6.144	2.618	2.668	2.441	0.000				
Buriat	3.087	1.704	1.934	1.735	2.503	3.697	2.787	2.634	5.819	6.124	3.128	3.457	3.279	1.724	0.000			
Eskimo	2.926	1.106	1.497	3.068	1.843	3.455	2.969	1.948	5.967	6.651	2.002	2.839	2.188	1.146	2.227	0.000		
Arikara	2.107	0.891	0.981	0.791	1.353	1.650	1.289	1.769	3.263	3.448	1.452	1.988	1.438	1.808	0.822	1.622	0.000	
Peru	1.979	1.465	1.349	0.848	0.901	2.254	1.376	3.154	2.160	1.316	2.814	2.825	2.409	3.252	2.724	3.297	1.460	0.000

TABLE 11. Distance matrices for samples from Vitoria with samples from Iberia and Howells (1973) (Mahalanobis D2 distances)

Male sample

	Basque	Tarragona	Majorca 1	Burgos 1	Muslim	Visigoth	Cantabria	Catalonia 1	Burgos 2	Jewish	Majorca 2	Catalonia 2	Granada	Norse	Zalavar	Berg	Egypt	Teita	Dogon	Zulu	Bushman	Buriat	Vitoria
Basque	0.000																						
Tarragona	0.617	0.000																					
Majorca 1	1.437	0.469	0.000																				
Burgos 1	0.626	0.316	0.794	0.000																			
Muslim	1.197	0.357	0.670	0.533	0.000																		
Visigoth	1.266	0.343	0.346	0.635	0.610	0.000																	
Cantabria	0.764	0.469	0.790	0.537	1.140	0.362	0.000																
Catalonia 1	1.057	0.473	0.378	0.459	0.502	0.505	0.890	0.000															
Burgos 2	1.407	0.576	0.415	0.658	0.604	0.616	0.945	0.243	0.000														
Jewish	1.046	0.858	1.567	1.349	0.866	1.256	1.421	1.612	1.975	0.000													
Majorca 2	1.580	0.627	0.443	0.821	0.711	0.615	1.104	0.357	0.432	2.269	0.000												
Catalonia 2	1.229	0.585	0.622	0.773	1.180	0.754	0.638	0.762	0.682	2.367	0.729	0.000											
Granada	1.071	0.455	0.638	0.387	0.477	0.619	0.938	0.131	0.309	1.753	0.382	0.766	0.000										
Norse	0.837	0.297	0.688	0.749	0.675	0.612	0.857	0.680	1.095	1.238	0.600	0.687	0.740	0.000									
Zalavar	2.057	1.469	1.290	1.396	1.655	1.366	1.674	1.470	1.871	2.799	1.235	1.472	1.575	1.480	0.000								
Berg	1.649	1.594	2.484	1.947	1.975	2.805	2.817	2.014	2.616	2.922	1.850	2.206	1.929	1.080	2.402	0.000							
Egypt	1.157	0.295	0.556	0.489	0.413	0.683	1.002	0.402	0.453	1.762	0.356	0.389	0.329	0.363	1.317	1.377	0.000						
Teita	3.769	2.172	2.741	3.026	1.745	2.688	3.782	2.790	3.185	3.135	2.027	2.791	2.580	1.470	3.267	2.368	1.603	0.000					
Dogon	3.598	2.369	3.107	2.988	1.914	3.158	4.039	2.670	3.181	3.678	2.149	2.952	2.351	0.363	2.864	1.206	1.627	0.868	0.000				
Zulu	3.210	1.656	2.045	2.591	1.421	1.682	2.673	2.271	2.744	2.353	1.656	2.354	2.216	1.022	2.268	2.334	1.501	0.521	0.978	0.000			
Bushman	7.314	6.672	7.383	6.331	5.826	8.263	9.041	6.022	7.221	8.506	5.625	6.942	5.554	5.393	6.623	3.460	4.986	3.877	2.651	5.509	0.000		
Buriat	2.753	2.525	3.820	3.571	3.442	3.319	3.468	4.028	4.550	3.239	3.742	3.951	4.117	2.115	3.428	1.836	3.272	3.974	3.314	2.945	9.085	0.000	
Vitoria	0.878	0.586	0.979	0.788	1.390	1.127	0.790	1.204	1.215	2.033	1.315	0.270	1.102	0.758	1.591	2.011	0.648	3.086	3.238	2.771	7.101	3.417	0.000

Female sample

	Basque	Tarragona	Muslim	Visigoth	Cantabria	Catalonia 1	Majorca 2	Jewish	Catalonia 2	Granada	Norse	Zalavar	Berg	Egypt	Teita	Dogon	Zulu	Bushman	Buriat	Vitoria
Basque	0.000																			
Tarragona	0.462	0.000																		
Muslim	1.328	0.710	0.000																	
Visigoth	1.472	0.599	1.681	0.000																
Cantabria	1.030	0.514	1.564	0.555	0.000															
Catalonia 1	1.111	0.601	0.449	1.455	1.176	0.000														
Majorca 2	1.546	0.982	1.028	1.008	1.251	0.728	0.000													
Jewish	1.140	0.592	0.471	1.436	1.378	1.029	1.626	0.000												
Catalonia 2	1.186	0.558	1.450	1.111	0.469	0.978	1.097	1.634	0.000											
Granada	1.549	1.073	0.828	1.805	1.354	0.392	0.864	1.701	1.185	0.000										
Norse	0.788	0.422	0.623	1.023	1.108	0.706	0.803	0.732	1.215	1.045	0.000									
Zalavar	1.059	0.485	0.518	1.103	1.360	0.502	0.720	1.144	1.077	0.832	0.299	0.000								
Berg	1.668	1.902	1.676	3.451	3.870	1.933	2.695	2.531	3.275	2.379	1.570	1.031	0.000							
Egypt	1.004	0.899	0.622	2.090	1.566	0.825	1.150	1.372	1.122	0.867	0.613	0.455	1.289	0.000						
Teita	3.460	2.615	2.075	3.123	4.268	2.697	1.903	3.038	3.520	2.802	1.618	1.254	1.751	1.904	0.000					
Dogon	3.102	2.289	1.727	3.207	3.998	2.093	2.111	2.763	3.206	2.201	1.476	0.982	1.288	1.392	0.652	0.000				
Zulu	2.843	1.644	2.299	1.132	2.368	2.177	1.512	2.199	2.589	2.430	1.231	1.361	3.343	2.608	1.644	1.729	0.000			
Bushman	5.430	5.541	4.089	7.337	8.104	4.490	4.501	5.910	6.634	4.847	4.161	3.340	1.923	3.504	1.758	2.249	5.442	0.000		
Buriat	1.944	2.011	2.011	2.531	2.981	3.283	4.041	2.365	3.968	3.503	1.904	2.277	2.535	2.665	4.423	3.305	2.953	7.727	0.000	
Vitoria	0.559	0.727	1.551	1.542	1.006	1.664	1.573	1.567	0.919	2.034	0.817	1.033	2.115	0.703	2.985	2.726	2.857	5.454	2.451	0.000

Cluster Analysis

Cluster analyses produced six separate dendrograms that graphically depict relationships between the Vitoria Basque and other populations. Male and female samples were analyzed independently. The first cluster analysis compares the Vitoria Basque with other Basque and Spanish samples. Next, Vitoria Basques are compared against Howells' world samples. Finally, Vitoria Basques are compared with Iberian samples from the literature and Howells' European and African populations. Figures 5-7 show the dendrograms for male groups, while female dendrograms are presented in Figures 8-10.

In the UPGMA clustering analysis comparing Vitoria Basque males with the Iberian populations (Fig. 5), the Jewish and Muslim populations represent the first split in the tree. The second split separates the Basque sample from the rest of the Iberian populations, including the Vitoria Basque. The third branch contains the Visigoth and Medieval Cantabrian populations. The remaining groups cluster loosely. The next branch has one subsequent fork containing the Roman population from Tarragona, clustered with the Christian Burgos 1 population from the Reconquest era. The other fork contains the Vitoria Basque, which unexpectedly clustered not with the other Basque population, but with the Medieval Catalonian population. The final branch contains the two Talayoticpopulations (Majorca 1 and 2, clustered together), Burgos 2 which splits off by itself, and then the two Bronze Age populations, Granada and central Catalonia.

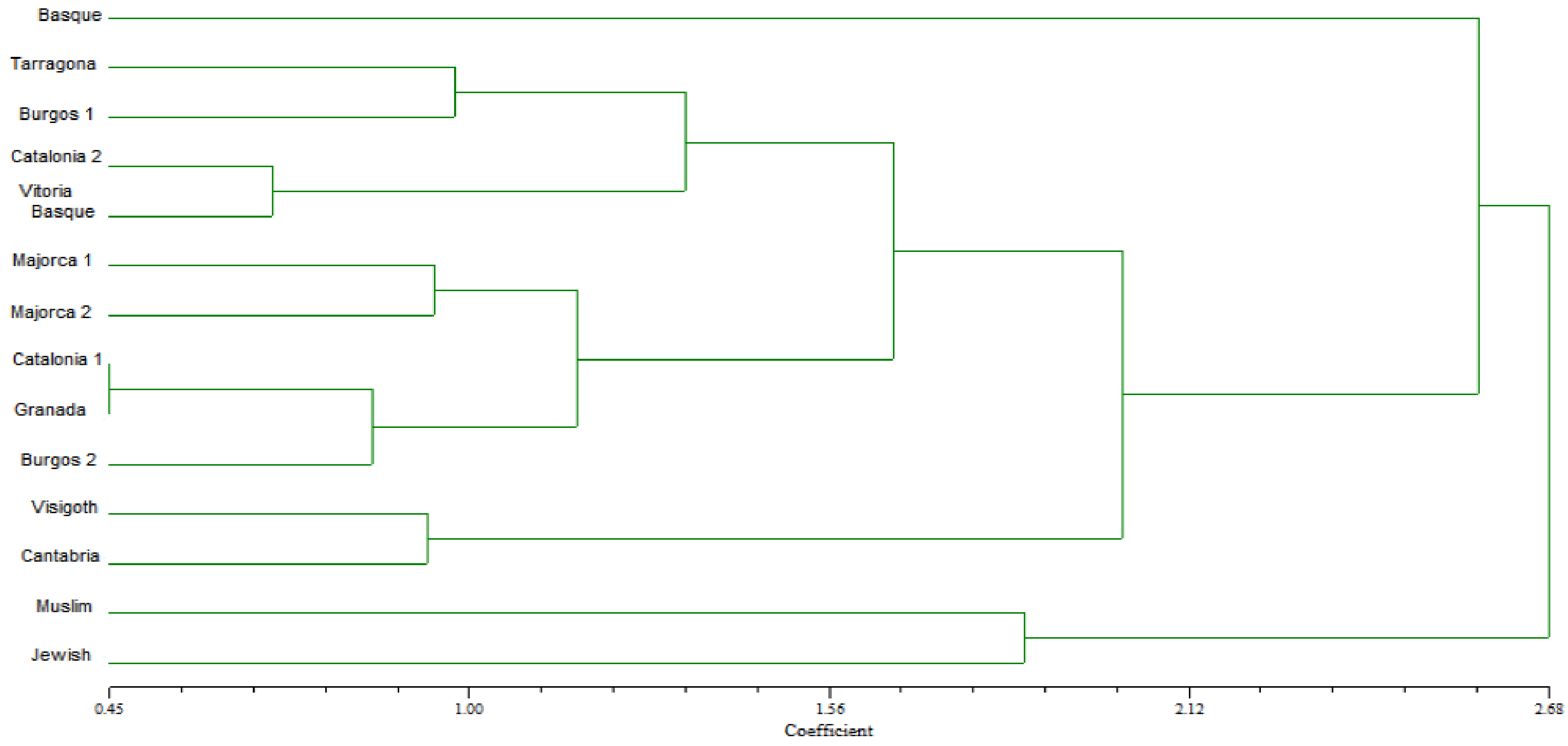

Fig. 5. Average linkage phenogram (UPGMA) using D^2 distance coefficient for male Vitoria Basque samples compared with male samples from Iberian populations.

When Vitoria Basque males are compared with samples from Howells populations (Fig. 6), Bushman and Andaman Islanders branch off together first. The next branch contains Buriat of Siberia, which split off alone, and a branch containing the Mokapu of Hawaii and the Eskimo. Next, the Vitoria Basque branch off separately. The subsequent branches house a cluster that includes the remaining European populations (and Egypt), which are associated with the New World populations, and another cluster containing the remaining African populations in close association with the populations from Southeastern Australia, Tasmania and Malaysia. Why Vitoria Basques do not cluster more closely with Europeans or Egyptians reflects one of the strange results from a cluster analysis that includes highly variable samples.

Figure 7, the tree comparing male Vitoria Basques with Iberian and Old World populations, displays a more logical pattern of relationships than Figure 6. The Bushman are the most highly differentiated group in this sample matrix. The following groups to branch off are, somewhat surprisingly, Berg and Buriat, and then more predictably three African samples. The remaining Iberian and European groups are all very similar. The most divergent group is Zalavar (Hungary). Basques cluster with the Spanish Jewish sample while Vitoria Basques cluster once again with Medieval Catalonia. However, the distances are all relatively small so subtle differences in branching patterns should not be over-interpreted. Interestingly though, Egyptian clusters most closely with Tarragona and Norse.

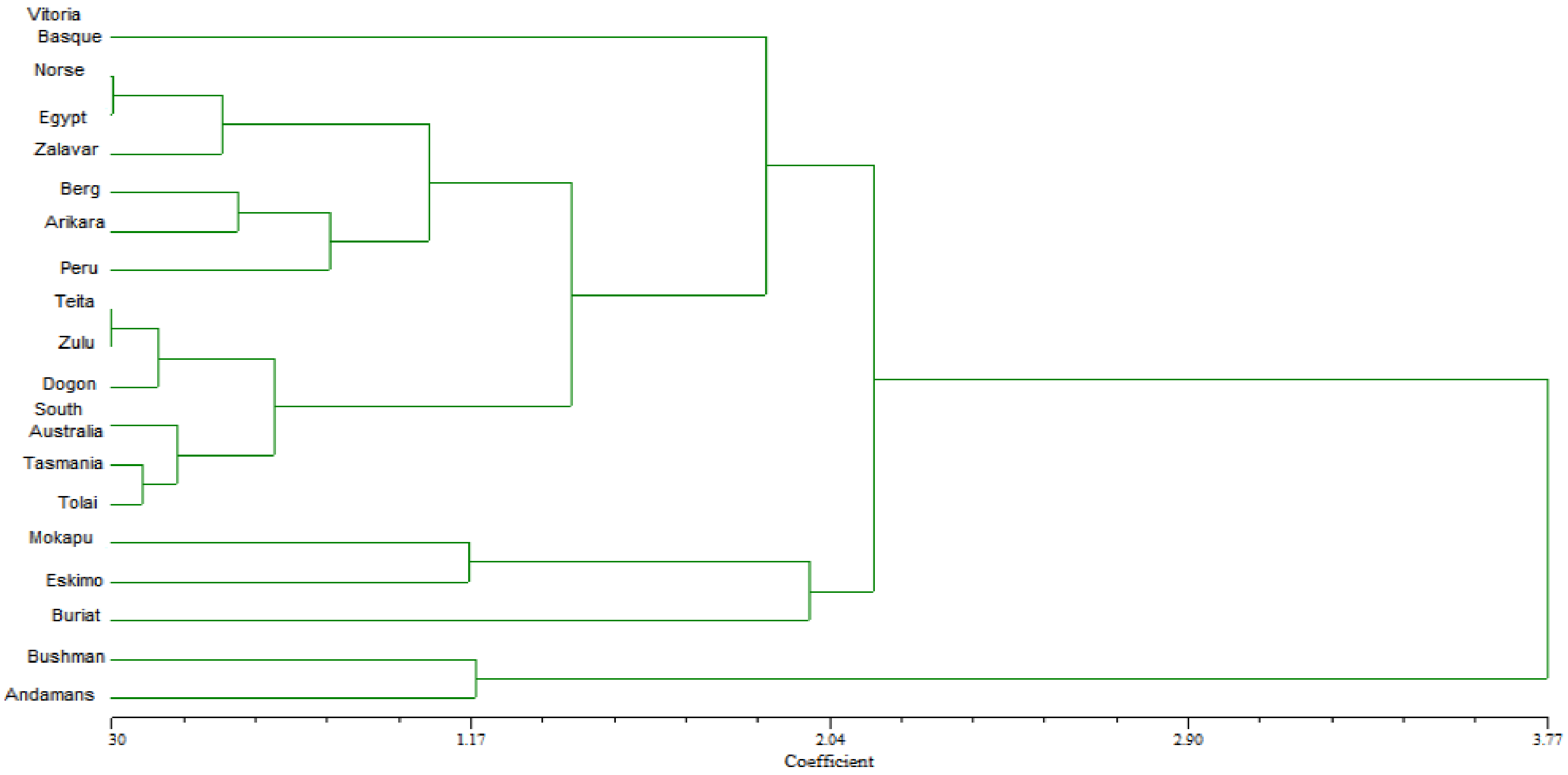

Fig. 6. Average linkage phenogram (UPGMA) using D^2 distance coefficient for male Vitoria Basque samples compared with male samples from Howells (1973) populations.

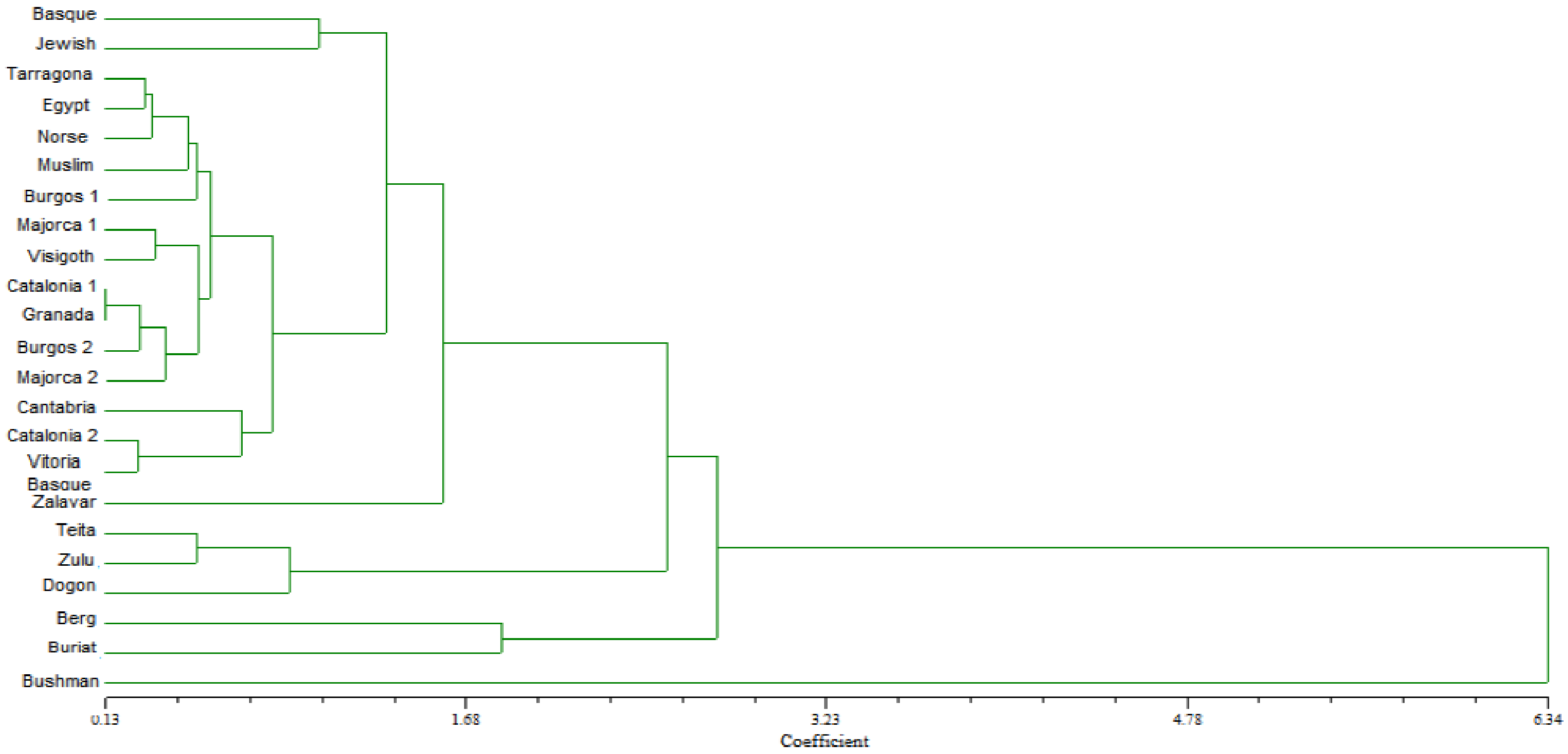

Fig. 7. Average linkage phenogram (UPGMA) using D2 distance coefficient for male Vitoria Basque samples compared with male samples from Iberian populations and samples from Howells (1973) populations.

Figure 8 displays the dendrogram for female Vitoria Basques and other Iberian populations. These groups show little overall divergence from each other. The first groups to branch off in this sample array are the Visigoths, along with Cantabrians and Medieval Catalonians. The branch containing the remaining populations splits into two subsequent branches. The first contains a branch linking Vitoria Basques and the Basque sample of de la Rúa (1985). A separate branch contains the Roman Tarragona population along with Jewish and Muslim samples. The final branch contains the Talayoticpopulations from Majorca and the two Bronze Age populations from Granada and Central Catalonia.

In Figure 9, Vitoria Basque females are compared to Howells' (1973) samples. Comparable to the tree comparing male populations, the first group to branch off is Bushman, this time accompanied by Andaman Islanders. The next branch includes the Buriat of Siberia, the Mokapu of Hawaii, and two Native American groups, Arikara and Eskimo. The next cluster groups African, Australian and Pacific populations. Finally, Vitoria Basques are found in a cluster with groups that are primarily European, but which also includes Egyptians.

Figure 10 compares Vitoria Basque females with Iberian and Old World populations. The first split is a branch containing African populations (Bushman, Dogon, Teita), along with Berg. Buriat and Zulu also branch off at a relatively high level. The Vitoria Basque sample clusters with de la Rúa's (1985) Basques, linking at a slightly higher level with Visigoths, Cantabrians and Medieval Catalonians. The remaining populations, including Howell's Egyptian population and the Jewish and Muslim

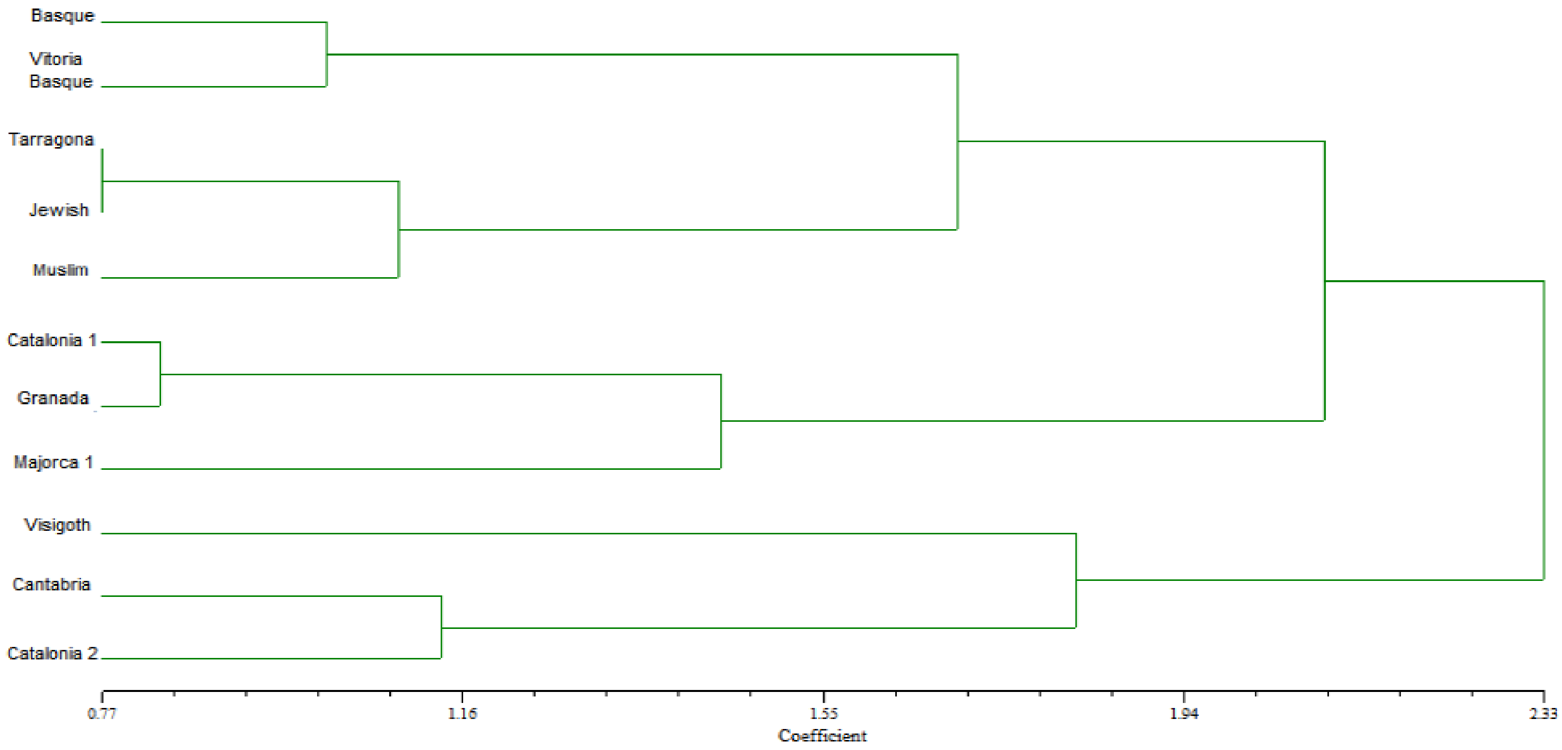

Fig. 8. Average linkage phenogram (UPGMA) using D2 distance coefficient for female Vitoria Basque samples compared with female samples from Iberian populations.

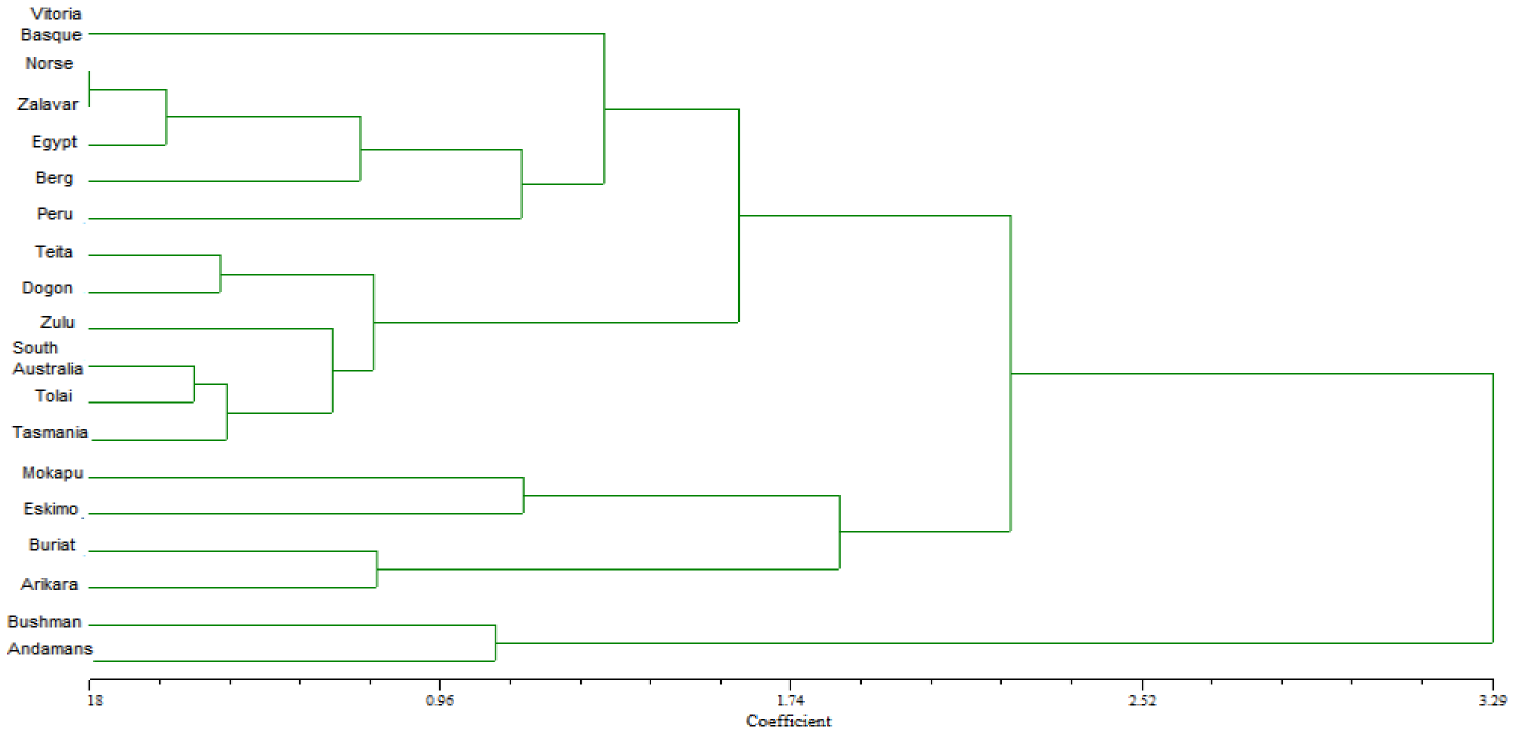

Fig. 9. Average linkage phenogram (UPGMA) using D2 distance coefficient for female Vitoria Basque samples compared with female samples from Howells (1973) populations.

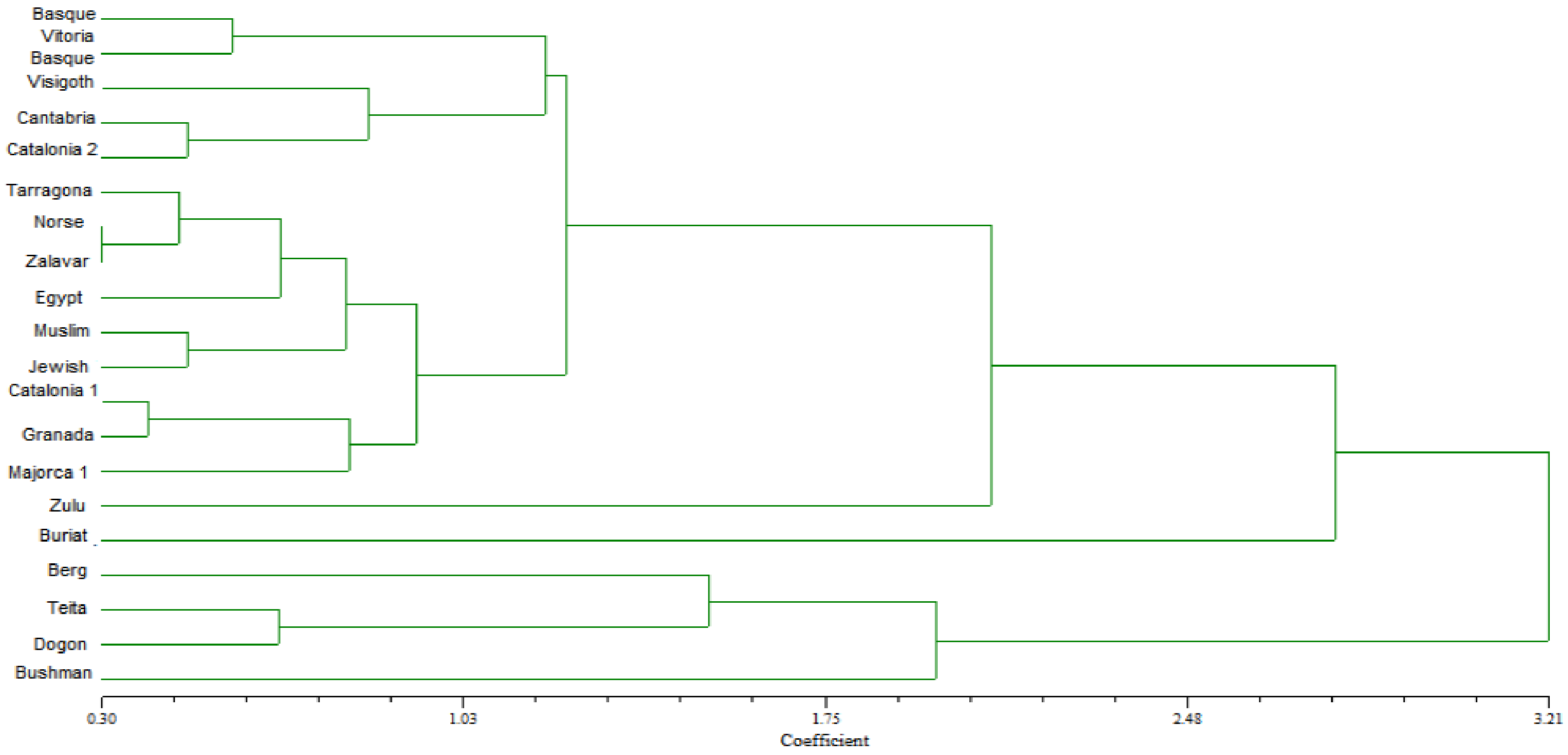

Fig. 10. Average linkage phenogram (UPGMA) using D2 distance coefficient for female Vitoria Basque samples compared with female samples from Iberian populations and Howells (1973) populations.

populations from Spain, cluster shallowly with European populations. There is distinctly less overall divergence between the two female Basque populations and other female Iberian and European samples than seen among the male populations. Despite the occasional strange linkages in the cluster diagrams, there is an overall consistency comparable to the raw distance values linking the Vitoria Basque with the other Basque sample, along with Tarragona, Cantabria, Catalonia, the Norse, and Egypt.

Discriminant Function Analysis using FORDISC 2.0

The measurements for each Basque cranium were entered into FORDISC 2.0 and analyzed using both the Forensic Databank option for comparison and the Howells Database. These analyses were conducted twice, following the example in Ubelaker et al. (2002). The first analysis used reference groups of both sexes, while the second used reference groups of the sex determined through morphological assessment. Comparisons of the results provide additional information about the individual classifications.

When the results of the individual classifications are analyzed, the Vitoria Basque sample shows some heterogeneity using both databases. Table 12 shows the results of the group classification of the Vitoria Basque with 14-17 available measurements analyzed using the Forensic Data Bank option. When the sample was run with no sex assigned, 66% (47/71) of the individuals analyzed were classified as White, 17% classified as Black, 8% as Hispanic, 1% as Chinese, 1% as Japanese, 1% as Amerindian and 3% as Vietnamese. When the same sample was run again using the sex assigned by the researchers, the results were only slightly different: 59% classified as White, 18% as

Black, 8% as Hispanic, 3% as Chinese, 1 % as Japanese, 4% Amerindian (up from 1%), and 3% Vietnamese.

TABLE 12. Group Classification of the Vitoria Basque Using the Forensic Data Bank

Group	Sex Unknown		Sex Known	
	No. classified into	%	No. classified into	%
White	47	66%	42	59%
Black	12	17%	13	18%
Hispanic	6	8%	6	8%
Chinese	1	1%	2	3%
Japanese	1	1%	1	1%
Amerindian	1	1%	3	4%
Vietnamese	3	4%	2	3%
DIS	0	0%	2	3%

Table 13 shows the group classification of the individual Vitoria Basques using the Howells database. Again, the first analysis was run with no sex assigned while the second analysis had sex assigned. For the Sex Unknown option, the Vitoria Basque classified into 13 different groups (unclassified individuals are not included). A slight majority, 51%, classified as Egyptian. The second most common classification is Medieval Norse (18%), followed by Berg (8%). About 79% of the samples were classified as European or Egyptian. When the data were run using the Sex Known option, the percentages changed very little: 50% classified as Egyptian, 18% as Medieval Norse, and 7% as Berg. About 76% of the individuals in the total sample classified as either Egyptian or European.

Following the example provided by Ubelaker et al. (2002), Table 13 also displays the typicality probabilities for the group classifications of the Basque sample. This statistic provides information about the likelihood that a particular skull belongs to the reference sample, so that values less than 0.05 are considered atypical and those greater than 0.05 are typical. Crania classified into the Egyptian groups were considered typical in 51% of instances using sex unknown and 53% using sex known. For groups classified as Norse, typicalities were lower; 18% were considered typical using the sex unknown option, and 42% were considered typical for the sex known option. Of the 39 crania considered typical for the sex unknown option, 74% classified as European or Egyptian and the remaining 26% classified as others. Of the 34 crania considered typical for the sex known option, almost 80% classified into European or Egyptian groups – 8% classified as Berg, 18% Norse, 1% Zalavár and 51% Egyptian.

TABLE 13. Group Classification of the Vitoria Basque Using the Howells Database

Group	Sex Unknown				Sex Known			
	Total		Typical		Total		Typical	
	No.	% of total sample	No.	% of total group	No.	% of total sample	No.	% of total group
Ainu	1	1%	1	100%	1	1%	1	100%
Andaman Islands	1	1%	1	100%	2	3%	2	100%
Berg	6	8%	1	17%	5	7%	1	20%
Dogon	1	1%	0	0%	2	3%	0	0%
Easter Island	3	4%	2	67%	1	1%	0	0%
Egypt	36	51%	22	61%	34	50%	18	53%
Moriori	1	1%	0	0%	0	0%	0	0%
North Japan	3	4%	2	67%	4	6%	3	75%
Medieval Norse	13	18%	5	38%	12	18%	5	42%
Yauyos District, Peru	2	3%	2	100%	2	3%	2	100%
Santa Cruz	1	1%	1	100%	1	1%	1	100%
Teita (Kenya)	2	3%	1	50%	3	4%	1	33%
Medieval Hungary, Zalavar	1	1%	1	100%	1	1%	0	0%

Individuals too dissimilar for classification are not included.

Chapter 4: Discussion

While the Basque have long aroused the curiosity of scholars interested in human variation, it has only been within the last hundred years that the tools to statistically characterize the relationships between Basques and other groups have become available. For example, in 1929, G.M. Morant re-examined Basque crania from the Spanish portion of the cranial collection of Paul Broca. He used Pearson's Coefficient of Racial Likeness (CRL) to compare standard deviations of Basque samples from different regions with each other and with the standard deviations of other European samples. Morant noted some divergence from neighboring populations, but nothing statistically significant. However, comparing the standard deviations using the CRL only allows comparison of the traits under study and fails to distinguish between size and shape. Morant's analysis was therefore limited to characterizing the means of the traits under study, rather than addressing the relationships of the populations manifesting them.

The last 30 years have seen an increase in the number of statistical tools available to describe groups based on physical and genetic traits and to examine the relationships among them. De la Rùa (1992) conducted factor analysis and principal components analysis of craniometric variables in order to statistically rather than descriptively define distinctively "Basque" cranial characteristics. De la Rùa's sample dates from the late 19th through the early 20th centuries and contains only individuals whose ancestry could be confirmed through birth and burial records. Most hailed from the central and coastal regions of Basque country, predominately Guipúzcoa and Vizcaya, with a few from Àlava and Navarre. De la Rùa compared the Basque sample to a known population also included in the present study, a Roman population from Tarragona in Catalonia, Eastern

Spain. Her results identified several features that distinguish Basques from the Tarragona population. These features include the height of the skull, the anterior (front) and posterior (back) breadths, the angle of the skull on its axis, and the location of bregma. De la Rúa concluded that while these traits do not represent enough difference to qualify the Basque as a separate group in terms of “traditional anthropological classifications,” they separate Basques from other Iberian populations. Likewise, a cranio-facial study by Brace et al. (2006) found Basques to be European, albeit with some distinguishing features.

Lalueza-Fox et al. (1996) used cluster analyses to examine biological distances among Iberian populations, including the Basque sample studied by de la Rúa (1985). They found that Basques represent the most divergent population of the Iberian Peninsula. In all tests, Basque male and female samples split off first from all other Spanish or Baleric clusters and branches. All remaining populations grouped together, showing a notable degree of homogeneity.

The results of these studies seem contradictory. De la Rúa (1992) and Brace et al. (2006) found that Basques were distinct but not so much as to require separate classification. Lalueza-Fox et al. (1996) found Basques to be the most divergent population in the analysis. One possible explanation for this discrepancy is the effect that different methods of analysis can have on an outcome. Howells (1973) found that when clustering was based on similarities, groups clustered in an arrangement predicted by their physical locations on a map. As a notable exception, Egyptians clustered more closely with Europeans than with Sub-Saharan African populations. When the populations were clustered by successive splits, the method used in many molecular studies, including that of Cavalli-Sforza et al. (1994), generated results that were similar, except that the Egyptian population clustered with Sub-Saharan African groups. When Howells applied a three-dimensional model to males only, European groups remained undifferentiated, clustering together. Egyptians clustered with Europeans, as when clustering by successive mergers, although they deviated toward the African line. Thus, three different methods provide three different outcomes using the same dataset.

The divergence of opinion over whether Basques are highly distinctive or barely distinguishable from other Spanish populations is also found in genetic studies. Aguirre et al. (1991) found that the frequencies of genetic polymorphisms (e.g., genes for blood groups, serum proteins, etc.) differentiated Basques in the province of Vizcaya from other Basque populations as well as from other European populations. Calafell and Betranpetit (1994a, b) averred that no other European group shares Basque genetic composition in terms of either classic markers or mtDNA haplogroups. Flores et al. (2000) found Iberia to be the most heterogeneous and divergent population in Europe, based on gene frequencies for blood groups and enzymes. In contrast, when compared to North African populations using Y-chromosome and mtDNA haplogroups, Iberia appeared significantly less heterogeneous. An *Alu* insertion study in Basques (García-Obregón et al., 2007) found no significant genetic heterogeneity between Basque subpopulations or between Basques and other European populations, suggesting that the heterogeneity seen in other genetic studies is the result of relatively recent admixture with non-Basque populations. These results make it likely that the different findings of de la Rúa (1992) and Lalueza-Fox et al (1996) for cranial measurements are not simply an artifact of the different methods utilized by the researchers.

So how do Vitoria Basques fit into this contradiction? How distinct are Basques from other European and global populations, and how can we characterize the relationships among them? To answer these questions, the results of the cluster analyses are compared with previous studies to discern where there are similarities and differences. In this manner, we can identify how distinct Basques really are from other Iberian and European populations, and in concert with linguistic and molecular studies, discuss what the results suggest about Basque population history.

In Figure 5, Jewish and Muslim populations represent the most divergent populations in the tree. History and mtDNA studies indicate the migration of these populations into Iberia provided a primary source of morphological variability (Alvarez et al., 2010), so this result is not surprising. More unexpectedly, Vitoria males cluster with medieval Catalonia, while Basque males studied by de la Rùa (1985) are the first to branch off from the rest of the Iberian populations. The remaining populations cluster much in the same manner documented by Lalueza-Fox et al. (1996), with a few exceptions. A branch containing Visigoth and Cantabrian populations breaks away next in the current study, whereas in Lalueza-Fox et al. (1996), the Visigoths cluster with the Reconquest-era Catalonia population with much less differentiation from the other groups. These differences are fairly superficial, indicating that the divergence between the two Basque male populations is indicative of actual variations between them.

Both the Vitoria males and females show a deeper and earlier level of divergence than seen in the European (Norse, Berg and Zalávar) populations studied by Howells (1973). In Figure 6, where Vitoria Basque males are compared with Howells world populations, the Bushman and Andaman Islanders branch off first together. In this case, the earliness of the split and geography suggests not a physical or even a temporal resemblance between these two populations, but rather that they have a similar degree of difference from other populations. Males from Vitoria branch off next, even before the split of European and the remaining African populations. However, when other male Iberian populations are added to the cluster analysis in Figure 7, this early divergence disappears. The Basque population studied by de la Rùa (1985) clusters with the Jewish population. Vitoria males again cluster very closely with Medieval Catalonia. In this case, while the male Basque are distinct from other male European and North African populations they are quite similar to other male Iberian populations.

Howells (1973) describes the pitfalls associated with developing and interpreting dendrograms. It is not just the method of analysis or the distance coefficient chosen, but also the populations that are included in the analysis that can have a great effect on the overall outcome. This is because, in multivariate analysis, the individual populations are compared using their deviations from the means. The distance coefficient and the biological distances change with every additional population considered, dramatically altering the manner in which they cluster together (Constandse-Westermann, 1972).

The reliability of the cluster analyses in this study can be seen in the way the trees correspond to results taken from the literature. While some populations clustered differently at a lower level in Figure 7 when compared to the cluster of male Iberian populations in Lalueza-Fox et al (1996), all the Iberian samples nevertheless clustered together as expected, in close association with medieval Norse and Egyptian populations. The New World populations from North (Arikara) and South (Yauyos) America show a close association with European populations, similar to Howell’s clustering by successive mergers. Also similar to Howells' results, the African populations (excepting Bushman noted above) show a close association with most of the Southwest Pacific populations while Eskimos cluster with the Mokapu of Hawaii and the Buriat of Siberia and Egypt clusters with Europe.

Vitoria females cluster more predictably than the males. In Figures 8 and 10, the Basque females align with females from de la Rùa's (1985) sample. In general, these trees conform closely to expected results. In Figure 10, both Basque female populations cluster together in a branch that includes the Visigoths, a Cantabrian population, and a population from Medieval Catalonia. In another biological distance study by du Souich et al. (2003), conducted on females from a cemetery at Almuñecar, Granada, the female Basque sample measured by de la Rùa (1985) clustered closely with Visigoths, Romans, and medieval Cantabrians in a manner similar to the present study. Also of note, in Figure 6, the Buriat of Siberia cluster with New World populations (Hawaiians, Arikara, and Eskimo) in a manner similar to Howells' results, although Peru clusters with Europe. Overall, Figures 8-10 indicate that Vitoria Basque females do not add greatly to the overall variability among Iberian populations, and the general adherence to expected results for other populations attests to the reliability of these clusters.

One of the most striking results of the cluster analysis is the obvious sex dimorphism. Human skulls are expected to be dimorphic, and de la Rùa (1992) notes that both Spanish and Basque skulls show significant morphometric differences between the sexes. The male and female samples from Vitoria were also evaluated separately to control for sex dimorphism. In comparison to males, the female sample shows significantly less overall variation. While the Vitoria females clustered with Basque females from de la Rúa's (1985) study (Figures 8 and 10), the Vitoria males clustered most closely with Medieval Catalonia (Figures 5 and 7). This could be explained as a processing or statistical error, except that both male and female samples behaved similarly when compared with Howells' (1973) populations from outside the region. In Figures 7 and 10, the congruence between the trees comparing males and females from Vitoria as well as the similarity at high level to results obtained by Howells suggest that the differences in the way the Basque samples clustered in Figures 6 and 9 are indicative of actual differences between the male and female skulls from Vitoria, and of actual divergence of the Vitoria male sample from that studied by de la Rúa (1985).

By clustering with Medieval Catalonians, the male skulls from Vitoria show less morphological dissimilarity from other Iberian male populations than do the female skulls. This is not true, however, for male Basques from de la Rúa's (1985) study which represent the second level of divergence in Figure 5. Also, in Figure 7 the male Basque and Jewish populations cluster together, suggesting an earlier divergence and higher degree of morphological differentiation from other European populations. This is notable in the sense that the Jewish population represents variability originating from outside the Iberian Peninsula, whereas the Basque population exhibits a similar degree of variability with less supposed influence from outside and more *in situ* differentiation.

Dendrograms based on the craniometric variation of Basque groups cannot necessarily distinguish between migratory influences and *in situ* differentiation. However, the fact that the two male Basque populations do not cluster together suggests one of two things: (1) Basque populations differ from region to region, and/or (2) Vitoria Basque males exhibit less divergence from other ancient and recent Iberian populations than the Basque population studied by de la Rùa (1985). This could suggest that, while the populations examined by de la Rùa remained more isolated, Vitoria experienced an influx of males from other regions in the Basque country and the rest of Spain, consistent with the city's history as a religious, administrative, and economic center (González del San Román, 2004).

Even though Basques are widely regarded as having been isolated for most of their history, the Basque country is situated across the only overland route between the Iberian Peninsula and Southern France, and from France to the rest of Europe. Because of this, Alzualde et al. (2006) describe the Basque region as less isolated than popularly believed. Calafell and Betranpetit (1994a) note that the genetic gradient moves north-south through the Pyrenees Mountains, suggesting this range is less of a barrier than might be assumed. DNA studies, including classical and restriction fragment length polymorphisms (RFLPs), delineate significant north-south clines, suggesting population movements throughout the Iberian Peninsula.

Migration into and out of Iberia from the rest of Europe has been fairly continuous. Since the Neolithic Period, traces of these movements are visible in the archaeological record. Historically, it is known that the Romans conquered Spain in the last two centuries BC, with Roman influence in the Basque country being greatest in Navarre and Álava (Calderon et al., 1998; Sampietro et al., 2005). But numerous other invasive forces impacted Spain, including the Alans, Suevi, Vandals, Goths, and even the Celts. Christianity was adopted in Iberian cities early in the Roman period. It would continue to spread and solidify its power through the next several centuries, deepening religious and economic relationships between Iberia and the rest of Europe (Casas et al., 2006).

Various non-Basque populations entered Iberia by way of the Mediterranean, via overland routes through the Pyrenees, and along the Atlantic Coast. Migrations through Basque country could have contributed to the variation seen between the Basque studied by de la Rùa (1985) and the Vitoria Basque, particularly as regards males. In Vitoria, it seems, the females are more “Basque,” whereas the males show less divergence from neighboring populations. As noted, de la Rùa included only individuals whose ancestries could be traced to the Basque region. No such documentation was available for the older Basque sample from Vitoria. During the range of time in which human remains were interred at the cathedral, Vitoria was a thriving economic and religious center, on the crossroads to Madrid and the coastal cities. More demographic diversity is expected compared to more isolated regions such as Guipúzcoa.

Genetic evidence supports the theory that Basque country is more regionally heterogeneous than the rest of the Iberian Peninsula (Bauduer et al., 2005; de Pancorbo et al., 2001; Calderon et al., 1998). The terrain and the culture kept populations small, and small population sizes amplify the effects of founder effect and genetic drift, including bottlenecking (Brion et al., 2003). Iriondo et al. (2003) found such regional patterns of genetic diversity using short tandem repeat (STR) DNA polymorphisms to survey geographic structure and barriers to gene flow. As early as 1991, Aguirre et al. noted that samples from seven different Basque provinces showed moderate heterogeneity in the frequencies of DNA polymorphisms.

On the other hand, Flores et al. (2000) summarize the prevailing opinion (see Cavalli-Sforza et al., 1994; Calderón et al., 1997; de Pancorbo et al., 2001) that the Basque language places socio-cultural restrictions on gene flow and admixture by preventing assimilation of immigrants and increasing endogamy, i.e., within group marriage (Alfonso-Sánchez et al., 2005; Barbujani, 1997; Barbujani and Sokal, 1990). The same linguistic and cultural processes that isolate Basques from the genetic influences of non-Basques could also contribute to regional distinctiveness.

The form of *Euskera* taught currently in Basque schools, called *Batua*, has its roots in numerous dialects spoken throughout the region. There is little consensus regarding the origins of these dialects. While *Batua* represents a modern standardized Basque language, regional differences were far more extensive in the past. Evidence for this contention is found in the province of Guipúzcoa, which shares its borders only with other Basque-speaking regions and which often appears as the most differentiated Basque subpopulation both linguistically and genetically (Calderón et al., 1998; de Pancorbo et al., 2001; Pérez-Miranda et al., 2004).

In this context, the Vitoria Basque population is morphologically distinct enough to be distinguished from other European populations, from other Iberian populations, and even from other Basque populations. The closest relationships are with geographic neighbors, but differences still remain, even within the Basque country itself. To provide additional information about the position of Basque cranial morphology within Iberian and European space, individual Vitoria Basque crania were evaluated through discriminant function analysis (FORDISC 2.0). Comparing the results of the discriminant function analysis to a similar study conducted on a 16th-17th century Spanish sample

(Ubelaker et al., 2000) provides a context in which to interpret the results (Tables 14 and 15). The Spanish sample comes from a secondary ossuary in a church in northwestern Spain near the towns of Villanubla and Valladolid, further south than Vitoria on the route to Madrid.

Compared to the Villanubla and Valladolid populations, the Vitoria Basque showed substantially less overall variation. In Table 15, Vitoria Basques classified into 13 total different groups, whereas the Villanubla and Valladolid samples classified into 21 different groups. This reduced amount of variation within the Vitoria Basque population is unexpected, given that the sample was not directly represented in either of the databases used in FORDISC 2.0. It speaks to a homogeneity within the Vitoria Basque population itself, and also indicates a greater similarity to the populations within the Howells database than is exhibited by the Villanubla and Valladolid samples.

The majority of individuals in both populations classify as Egyptian, Medieval Norwegian, or Berg. The percentages of individuals that classified into these three groups are similar between the two studies. The majority of individuals from both the Vitoria Basque and the Villanubla and Valladolid populations classify as either White or Black using the Forensic Databank option, indicating an overall similarity between them. The Vitoria Basque classified predominately as White using either the Sex Unknown or Sex Known options, which would seem to suggest a closer similarity to the populations of European extraction. The Villanubla and Valladolid samples split fairly evenly between White and Black for the Sex Unknown option, whereas for Sex Known the largest percentage classified as Black and with a slimmer majority as Egyptian using the Howells Database, Sex Known option. This hints at a marginally greater degree of similarity to populations of African descent for the Villanubla and Valladolid samples than for the Vitoria Basque.

TABLE 14. Comparison of Group Classification of the Vitoria Basque with Spanish Samples from Ubelaker et al. (2002) Using the Forensic Data Bank

Group	Vitoria Basque				Spanish			
	Sex Unknown		Sex Known		Sex Unknown		Sex Known	
	Number	%	Number	%	Number	%	Number	%
White	47	66%	42	59%	42	44%	29	31%
Black	12	17%	13	18%	33	35%	40	42%
Hispanic	6	8%	6	8%	9	9%	17	18%
Chinese	1	1%	2	3%	2	2%	2	2%
Japanese	1	1%	1	1%	4	4%	3	3%
Amerindian	1	1%	3	4%	4	4%	2	2%
Vietnamese	3	4%	2	3%	1	1%	2	2%

The Vitoria Basque classified as predominately White using the Forensic Databank, Sex Known option and with a larger majority as Egyptian using the Howells Database, Sex Known option. As the actual ancestries of the individuals in the Vitoria Basque population were not available to us, it is possible given the history of the area that the burial population contains some representatives of the European and African (particularly Egyptian) reference groups present in the Howells database. A more likely interpretation of the predominant classification of the Vitoria Basque as Egyptian is that the degree of distinctiveness of Basque cranial morphology is as comparable to that of Egyptians of the second to sixth centuries BC as to that of recent Europeans.

The difference in classification between the Vitoria Basque and the Villanubla and Valladolid populations could indicate the Spanish sample shows more similarity to African populations than to the European populations included in the reference sample. Basques show a greater similarity to Egyptians than to the three European samples, but at

TABLE 15. Comparison of Group Classification of Vitoria Basque samples with Spanish Samples from Ubelaker et al. (2002) Using the Howells Database

Group	Vitoria Basque				Spanish			
	Sex Unknown		Sex Known		Sex Unknown		Sex Known	
	Total		Total		Total		Total	
	No.	% of total sample	No.	% of total sample	No.	% of total sample	No.	% of total sample
Ainu	1	1%	1	1%	--	--	--	--
Andaman Islands	1	1%	2	3%	2	2	7	7
Atayal	--	--	--	--	7	7%	9	9%
Berg	6	8%	5	7%	11	12%	10	11%
Bushman	--	--	--	--	4	4%	6	6%
Dogon	1	1%	2	3%	0	0%	1	1%
Easter Island	3	4%	1	1%	--	--	--	--
Egypt	36	51%	34	50%	19	20%	24	25%
Hainan	--	--	--	--	3	3%	3	3%
Inugsuk Eskimo (ESK)	--	--	--	--	1	1%	1	1%
Guam	--	--	--	--	2	2%	0	0%
Mokapu	--	--	--	--	0	0%	1	1%
Moriori	1	1%	0	0%	2	2%	0	0%
Medieval Norse	13	18%	12	18%	11	12%	9	9%
North Japan	3	4%	4	6%	--	--	--	--
Yauyos District, Peru	2	3%	2	3%	4	4%	3	3%
Phillippines	--	--	--	--	1	1%	1	1%
Santa Cruz	1	1%	2	3%	0	0%	1	1%
South Japan	--	--	--	--	4	4%	2	2%
Tasmania	--	--	--	--	4	4%	2	2%
Teita (Kenya)	2	3%	3	4%	2	2%	3	3%
Tolai	--	--	--	--	2	2%	1	1%
Medieval Hungary, Zalavar	1	1%	1	1%	14	15%	9	9%
Zulu	--	--	--	--	2	2%	2	2%

the same time still relate more closely to European populations than to Sub-Saharan African populations. In Howells' (1973) analysis, Egyptians clustered with Europeans rather than with Sub-Saharan African populations in two types of cluster analyses, a finding entirely in accord with studies of genetic markers (Cavalli-Sforza et al., 1994) and nonmetric tooth crown and root traits (Irish, 1993; Scott and Turner, 1997).

The relationship between Vitoria Basques and other Iberian populations to North Africans is of particular interest. There are two possible explanations for the North African elements seen in Vitoria cranial morphology. First, Basques may have diverged from an ancestral North African group that peopled Iberia early in the Holocene; while other areas saw population replacement by Indo-Europeans during the Neolithic transition, the Basque region and other isolated refuges saw conservation of the ancestral morphology over time. Alternatively, admixture from North Africa since ancient times and most intensively during the Muslim occupation, coupled with the amplifying effects of genetic bottleneck and small population size on genetic frequencies, could explain the convergence of Basque cranial morphology with that of North Africans.

History confirms recent influence from North Africa. The occupation of Iberia by Afro-Asiatic speaking Moors lasted for nearly eight hundred years, between the 8th and 17th centuries A.D, and encompassed nearly the entirety of the Iberian Peninsula at the height of the occupation era. This influx from North Africa included both Muslim and non-Muslim Arabs along with Berbers. North African influence reached the Basque country, as it is recorded that during the 8th-10th centuries AD, the Basque provinces of Navarre and Álava were embroiled in conflicts against the Moors. However, the occupying forces never reached the concentrations experienced in southern Spain. Given this history, the results of the discriminant function analysis using the Forensic Databank option are more understandable. Though Villanubla and Valladolid are still in Northern Spain, north of Madrid and outside the region most tightly controlled during the Moorish invasion, both are further south than Vitoria, closer to Spanish (rather than Basque) speaking areas that experienced a greater concentration of outsiders from Africa.

Admixture from North Africa is not just a recent phenomenon. Studies using Human Leukocyte Antigen (HLA) polymorphisms cluster Basque with Spanish, Portuguese and Algerian populations (Sanchez-Maza, 2000). In particular, HLA class II analysis of North African Berbers shows similar frequencies to those seen in Spanish and Basque samples. In addition, the presence of a rare HLA class I antigen haplotype (A*30-Cw-B*18) shows high frequencies in Basque populations. This haplotype is also found in West African populations in a comparable frequency, which leads Gimaldi et al. (2001) to suggest that it could have been spread by admixture to an early Basque population via the western Mediterranean by a Paleo-North African (Saharan) people. However, examination of Y-chromosome haplogroups and mtDNA lineages finds North African influence to be less ancient. A study of Y-chromosome haplogroups suggests that highly variable frequencies across Iberia of a haplogroup attributed to North Africa, E3b, is related to the different durations and concentrations of Islamic influence during the occupation period (Cruciani et al 2004). A recent mtDNA study (Alvarez et al., 2010) finds greater continuity between Basque and Spanish with more recent North African and even Sub-Saharan lineages, based on regional differences. This hints that the presence of African mtDNA lineages is more likely the result of North African Muslim occupation of portions of the Iberian Peninsula rather than a preserved genetic heritage.

Betranpetit and Cavalli-Sforza (1991) used genetic data to address the question of whether North African elements have an ancient or more recent origin. They performed a principal component analysis of classic genetic markers for populations of the Iberian Peninsula. Included are early genetic studies on Basques that found a high frequency of O blood types and an unusually low frequency of B blood types (Boyd and Boyd, 1937), along with an exceptionally high frequency of the Rh negative allele. Their results found the first principal component of diversity in the Iberian Peninsula to be the Basque population. The authors interpret this as evidence of genetic diversity already present in Neolithic times, given the small population size, isolation and length of time passed.

Subsequently, Calafell and Betranpetit (1994 a,b) conducted a genetic distance study using the available pooled genetic polymorphisms (blood groups, red cell enzymes, serum proteins, immunoglobulin, and HLA antigens) from autochthonous areas in the Spanish and French Basque Country, the Eastern, Western and Central French Pyrenees, three valleys in Catalonia and several European populations. The variables were subjected to average linkage cluster analysis (UPGMA) and the neighbor-joining algorithms to create dendrograms. The clusters show a clear division between the French and Basque samples and the rest of the Spanish and European samples. There is a clear genetic boundary not related to any specific geographic obstacle separating Basque country from the rest of the Iberian Peninsula on the one hand and the rest of the Western Europe on the other. The authors concluded that the differentiation took place in the Basque region itself before the Neolithic transition, and has been preserved until present times. However, Calafell and Betranpetit (1994b) caution that the divergence of Basques may have had much to do with samples sizes. Out of necessity, their study sometimes used single samples from isolated Basque valleys in comparison with the means of other European nations.

Martínez-Laso et al. (2000) argue against extensive admixture between Basques and Berbers or other North African populations prior to the modern day. They suggest that even during periods of North African occupation, the number of invaders was too small and the geographical, linguistic and cultural barriers isolating the Basque country too great. Instead, they interpret the genetic similarities to suggest a pre-Neolithic migration from North Africa. This is further supported by González et al. (2006), who claim the diversity of mtDNA lineage U8a found in Basque populations is evidence of the radiation of that lineage into the region between 23,000 and 51,000 years ago. A study of ancient mtDNA in the historical Basque site of Aldaieta (6th-7th centuries AD) found a lineage originating in Northwest Africa. This lineage, M1c, is scarce in the rest of Europe with the highest frequencies found in the Iberian Peninsula and Italy; M1c was likely introduced into Europe from the southern section of the Iberian Peninsula. Because Aldaieta predates the occupation of Iberia by Moors, the presence of M1c is compelling evidence of contact between the Iberian Peninsula and Northwest Africa prior to Moorish occupation.

The processes at work in these two scenarios – early North African migration or subsequent admixture due to invasion, reconquest, and other north-south population movements – are largely the same, nor are these scenarios in any way mutually exclusive. The proximity of the Iberian Peninsula to North Africa and the lack of major geographic barriers south of the Pyrenees make it likely that gene flow from North Africa has been a frequent phenomenon throughout history. Gonzáles-Perez et al. (2003) describe continuous gene flow across the Straits of Gibraltar, based on *Alu* insertions studied in Iberian, Basque, Berbers from North-Western Africa and Arab-speaking people from Morocco and the Ivory Coast, indicating that gene flow into Basque country is not strictly from Europe. A comparison of prehistoric, historic and modern Basque populations (Alfonso-Sanchez et al. 2008) reveals a low variability of female genetic lineages (mtDNA lineages), for prehistoric and historic populations with an increase prior to the modern era. The authors suggest that this ancestral state persisted over time as a result of low gene flow and high endogamy and consanguinity levels. Alzualde et al (2005) found that a historical population from the 6th and 7th centuries had more similarities in mtDNA with European populations from the Mediterranean, Central Europe and the Atlantic Fringe than to prehistoric populations from the Basque region. The current state of Basque cranial morphology and genetics is likely indicative of a long term state. The increase in genetic heterogeneity seen in more recent Basque populations may be a result of increased gene flow during the modern era.

Chapter 5: Conclusions

Despite intense interest in Basque origins, craniometric data from the Iberian Peninsula is under-represented in European cranial studies seeking to understand the relationships among populations and language, geography and time period. My study used cluster analysis and discriminant function analysis of cranial traits to examine how the historical Basque population of Vitoria relates to other Basque and non-Basque populations. Comparable to other craniometric studies (Lalueza-Fox et al., 1996; du Souich et al., 2003), the cranial morphology of the Vitoria Basque is at once consistent with that of neighboring populations in Spain and yet distinct enough to cluster separately. In none of the clusters, male or female, do the Basque populations show the same degree of distinctiveness seen in the analyses published by Lalueza-Fox et al. (1996). This pattern is also seen in the manner in which the individual crania from the Vitoria Basque population classify using discriminant function analysis when compared with another, unrelated Spanish sample.

Other publications have noted an overall lack of diversity within the Iberian Peninsula. Gerrald and Mesa (1986) examined variation over time within the entire expanse of the Iberian Peninsula, and describe a very stable homogeneity among Iberian populations that persisted throughout history in the face of numerous migrations and invasions. The overall similarity among Iberian populations can be seen clearly also in Figures 3 and 6 of the current study, and genetic studies suggest this homogeneity has been present since ancient times (Sampietro et al., 2005). While Basques are considered physically and genetically unique among Iberian populations, this is in the context of a group of populations which show a close resemblance to one another.

Consistent with the results of other Basque craniometric studies, Vitoria Basque crania display pronounced sexual dimorphism in both size and shape. In the study by de la Rúa, however, males and females still clustered similarly when compared to other Iberian populations. This result was not seen in the Vitoria Basques. While the Vitoria Basque females cluster with the other Basque population and diverge from other Iberian populations as expected, the Vitoria Basque align more closely with males of other Iberian populations than with the other Basque sample used for comparison. This unexpected result suggests a sexually determined variability within the Vitoria Basque population related to consanguinity and other cultural practices.

This study supports the position that populations in the Basque country are regionally diverse. An urban center such as Vitoria, for example, expresses more demographic diversity than isolated valleys and villages. Conversely, smaller populations can be genetically distinct, isolated by linguistic, cultural and geographical barriers. The small population sizes enhance the effects of genetic drift, founder effect and bottleneck.

The results of both the cluster analysis and the discriminant function analysis also show the influence of North African admixture on Basque cranial morphology. Lalueza-Fox et al. (1996) suggest that the massive deportation of Jewish and Muslim populations virtually removed all trace of sub-Saharan variability from Iberian morphology, and examination of Y-chromosome haplogroups find little impact from Northern Africa (Cruciani et al., 2004). However, the results of the FORDISC 2.0 analysis, along with numerous molecular studies suggest this is far from true. The discriminant function analyses classify the majority of Basque individuals as Egyptian rather than as medieval Norwegian, Austrian or Hungarian populations, indicating an influence from North

Africa. The Vitoria Basque tend more towards a European classification than do Spanish crania, but the African contribution cannot be discounted. Though separated by geographic, cultural and linguistic barriers, there is evidence of significant genetic influence from North Africa, even as far north as the Basque country.

Finally, both the cluster analysis and the results of the discriminant function analysis support the conclusion that Basque cranial morphology represents traits present in ancestral populations. There is archaeological and genetic evidence of admixture from Europe and North Africa that has continued since the Neolithic Period, but the ultimate origins of that pre-Neolithic, proto-Basque population remain a mystery.

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