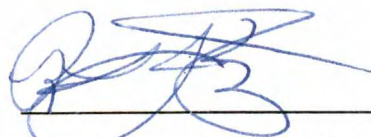


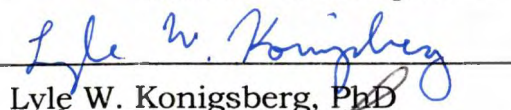
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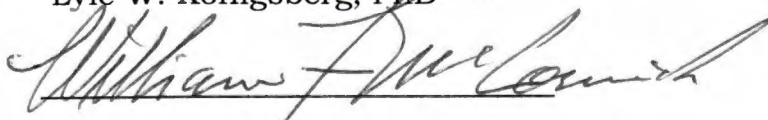


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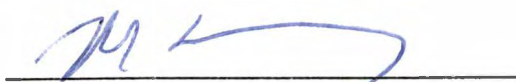
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**Cranial and Post-cranial Metric Variation: Regional
Isolation in Eastern Europe**

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Ann H. Ross

August 2000

To my loving parents Michael and Elena
and to the victims and the families of the recent war in the Former
Yugoslavia who continue to live with the horror.

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ABSTRACT

The purpose of this study is to present comparative analyses of contemporary American White, Croatian, and Bosnian cranial and post-cranial morphology as well as to compare these to other Balkan groups. Presently, the skeletal criteria used to identify Croatian and Bosnian casualties are based on US samples and are inappropriate. Multivariate statistical methods were employed in the analyses.

The cranial results indicate that American Whites are markedly different from the Eastern European groups. Bosnians and Croats differ from American Whites in having shorter, broader cranial vaults. The variation observed between Croats and Bosnians is sufficient to correctly classify them at a rate of over 80%. The difference between American Whites and Eastern Europeans clearly demonstrates the need for local identification standards. In addition, the cranial results reveal significant differences among other Balkan groups. These results are supported by the F_{ST} values generated, which demonstrate strong craniometric variation among European populations.

The post-cranial results indicate that although American Whites, Croats, and Bosnians do not differ in size, their proportions differ considerably. There were also significant differences for femur midshaft ratio, robusticity index, and cross-sectional area between Bosnian-

Croatian and American Whites. These results suggest that considerable variation exists among populations that might normally be considered similar. Discriminant functions are presented to allocate Bosnian and Croatian crania to help in the identification of commingled remains as well as population specific stature prediction equations to aid in present-day identifications.

TABLE OF CONTENTS

1. Introduction	1
Statement of Purpose	3
2. Review of the Literature.	6
I. Cranial Form	6
II. Post-cranial Form	11
3. Balkan History	15
I. Early Medieval Period	15
II. Late Medieval Period	19
III. Ottoman Conquest and Occupation	24
IV. Twentieth Century Yugoslavs	25
4. Materials and Methods	28
I. Materials	28
Samples	30
a. Bosnia	30
b. Croatia	31
c. Forensic Data Bank	31
d. Felix von Luschan Collection	32
e. World War II Casualties	33
II. Methods	33
a. Measurements	34
b. Missing Data	35
c. Cranial Methods	35
d. Post-cranial Methods	43
5. Results	50
I. Craniometric Analyses	50
a. Analyses of Contemporary Groups	50
b. Regional Analyses (using raw measures)	67
c. Regional Analyses (using shape variables)	85
d. Face and Vault Size	91
e. Population Structure	91
II. Post-cranial Analyses	93
a. Proportional Variation	93
b. Femur Measures	94
c. Stature Prediction	101

6. Discussion and Conclusions	108
I. Craniometric Interpretation	108
II. Post-cranial Interpretation	112
Literature Cited	118
Vita	128

LIST OF TABLES

TABLE	PAGE
1. Sample composition	29
2. Definitions of cranial measurements	36
3. Long bone measurement definitions	39
4. Cranial measurements of Bosnian males	51
5. Cranial measurements of Croatian males	52
6. Cranial measurements of American White males	53
7. Within-class covariance matrix for Bosnians	54
8. Within-class covariance matrix for Croatians	56
9. Within-class covariance matrix for American Whites	58
10. Mahalanobis distance	60
11. Significant discriminant functions	61
12. Total canonical structure for Bosnians, Croatians and American Whites	63
13. Classification summary of crossvalidation discriminant fuction	65
14. Linear discriminant function for Bosnians and Croatian classification	66
15. Transformed variables for Bosnians (shape and size)	68
16. Transformed variables for Croatians (shape and size)	69
17. Transformed variables for American Whites (shape and size)	70
18. Raw and transformed variables of 1930's Croatians	71

19.	Raw and transformed variables of WWII Croatians	73
20.	Raw and transformed variables of Greeks	75
21.	Raw and transformed variables of Macedonians	77
22.	Mahalanobis distance using raw variables	79
23.	Significant canonical axes for raw measures	81
24.	Total canonical structure for raw measures	82
25.	Significant canonical axes for transformed shape variables	86
26.	Total canonical structure for shape variables	87
27.	Descriptive summary statistics for American Whites	95
28.	Descriptive summary statistics for Bosnians	96
29.	Descriptive summary statistics for Croatians	97
30.	Significant canonical axes	98
31.	Independent sample t-tests for group differences assuming equal variances	100
32.	Results of RMA regression for $\ln$ TSA and $\ln$ BFL	102
33.	Stature prediction equations for Eastern Europeans and and standard errors (mm)	107

LIST OF FIGURES

FIGURE	PAGE
1. East Central Europe, 9th Century	20
2. Bulgaria, Serbia, Bosnia, and the Ottoman Empire 14th-15th Centuries	23
3. Former Yugoslavia	27
4. Selected cranial measurements	38
5. Class means on canonical variables	64
6. Class means on CAN1 and CAN2 (raw measures)	83
7. Class means on CAN1 and CAN3 (raw measures)	84
8. Class means on CAN1 and CAN2 (shape variables)	89
9. Class means on CAN1 and CAN3 (raw measures)	90
10. Comparison of sample means of face size and vault size	92
11. Class means on canonical variables (post-cranial shape variables)	99
12. 95% confidence intervals from Bayesian analysis and Trotter and Gleser '52 (femur)	103
13. 95% confidence intervals from Bayesian analysis and Trotter and Gleser '52 (humerus)	104
14. 95% confidence intervals from Bayesian analysis and Trotter and Gleser '52 (tibia)	105

CHAPTER 1

Introduction and Statement of Purpose

A key objective in physical anthropology is to document the vast range of human variability of past and present populations and to investigate the evolutionary and environmental forces responsible for phenotypic variation. The patterns of human variation among geographic populations have been examined using genetic markers, linguistics, and anthropometrics. Because the mean skull measurements between subpopulations differ in size and shape, the human cranium is useful to examine both genetic and cultural differences of past and present populations (Sjøvold, 1984). Craniofacial variation defined by skull dimensions of size and shape is determined by intrinsic (genetic) and extrinsic (environmental) factors (Larsen, 1997). In particular, much attention has been directed at whether the major trends in craniofacial variation observed throughout human evolution are related to biomechanical adaptations of the masticatory apparatus to technological advances in food processing (Brace, 1977, 1979; Larsen, 1997).

However, investigations of skeletal variation, especially quantitative studies of modern Eastern Europeans, in particular from the Balkan region is limited if nonexistent. In addition, the scant literature that is

available for this geographic region is primarily restricted to Neolithic and Medieval populations (Alekseeva, 1974; Miskiewicz, 1974; Necrasov, 1974; Šlaus, 1996, 2000). To introduce yet another dimension to the study of human skeletal remains, recent and historical catastrophic events in Eastern Europe have made the study of European skeletal variation and population structure a controversial endeavor. However, because of these recent events, it is even more imperative that skeletal investigations are completed at a time when the development of local standards is critical to the identification process. The development of population specific criteria would be impossible without the preservation and documentation of skeletal information. This approach has been used to good effect in the formation of the Forensic Anthropology Data Bank, which was assembled to develop better methods for skeletal identifications. Likewise, Trotter's work on WWII casualties has formed the basis of stature estimation for several generations of forensic anthropologists (Trotter and Gleser, 1952). To discard vital information from forensic cases and war victims would be a disservice to the victims whose remains require identification.

A discovery that has had a major impact on the study of modern human origins and the concept of "race" is the low levels of genetic variation observed among geographic regions compared to high levels of genetic variation within regions (Relethford, 1994). Existing evidence

indicates that there is much diversity between local European populations. Population origins traced to early demic expansion are one preferred explanation for present-day European variability (Sokal, 1991; Piazza et al., 1995). Another area of exploration is the association of European variability among different language families (with the assumption that a common language indicates a common origin) that act as barriers to gene flow and influence the formation of population structures operating much like geographic isolation (Barbujani and Sokal, 1990; Sokal et al., 1992). However, the use of skeletal remains in the study of micro-evolutionary processes of peoples of European ancestry has been limited. Increased understanding of the forces that influence the variability present through the analysis of skeletal remains will expand the knowledge of biological formations as well as provide methods to improve local forensic identification standards.

The purpose of this study is to present comparative analyses of contemporary American White, Croatian, and Bosnian cranial and post-cranial morphology as well as to compare these to other Balkan groups. The goals of this investigation can be summarized as follows:

- To examine craniometric variation between recent American Whites and recent Eastern European groups using various multivariate methods.

- To determine the craniometric variation among multi-temporal Balkan populations.
- To provide an estimate of F_{ST} from craniometric variables to further examine among-group variation.
- To generate discriminant functions to allocate Bosnian and Croatian crania to help in the identification of commingled remains.
- To examine proportional differences in the post-crania among American Whites, Bosnians and Croatians.
- To explore differences in the cross-sectional geometry of the femur using a biomechanical model.
- To present population specific stature prediction equations to aid in present-day identifications.
- To test the pattern of variation within a historical context.

Chapter 2 briefly reviewing the salient points in the study of cranial and post-cranial form follows this introductory chapter. Then a brief history of the Balkans outlining the critical events that have shaped the biological configuration of contemporary Eastern Europeans is addressed in chapter 3. The samples and methods used in this investigation are described in detail in Chapter 4. The methods segment is further divided into separate sections describing

in full cranial and post-cranial methodologies. The results of the various analyses are presented in Chapter 5, which are also divided into cranial and post-cranial sections. Finally, discussion and conclusions are presented in Chapter 6.

CHAPTER 2

Review of the Literature

(Allometry and Secular Change)

I. Cranial Form

Boas (1899) suggested that the cephalic index, the ratio of head breadth and head length, was a means of describing racial types but by 1912 in his monograph, "Changes in Bodily Form in Descendants of Immigrants," he recognized the plasticity of the cranium in response to environmental changes. He observed that the descendants of Hebrew immigrants, who had relatively short heads, became longer headed; and that Italians who were relatively long-headed became shorter headed. Both groups changed to become a more "uniform type" in the US. Boas concluded that the cephalic index was an unsuitable marker for assessing "race", because physiological changes take place in a new environment and genetic factors alone could not account for changes in head form (Boas, 1916). Darnell (1982:105) postulates that "Plasticity of form must be assumed even though it cannot be explained." These assumptions still appear to be true today.

There is a weak association between post-cranial secular changes (any change in size, shape, or timing over successive generations in a given population) and cranial changes. Miller (1970) observed that

stature and average head length increased in the Western Apache between 1940 and 1967, while the width of the head remained essentially constant. He concluded that improved living conditions are responsible for the observable changes towards a positive secular shift.

Angel (1976) noted secular changes in cranial morphology in American Whites from the colonial period to modern times with an increase in vault height and a narrowing of the face. These results are further supported by Jantz et al. (1998) and Jantz (1999) who observed that American crania are becoming longer, more narrow and higher vaulted, lending support for an "American" type.

However, instead of attempting to disentangle genetic effects from environmental effects, perhaps evaluating the interaction between the two forces would be a more fruitful endeavor. Because human longitudinal studies with diet restrictions are not possible, animal research can offer useful models in inquiries of genetic and environmental interactions. In animal studies the direct effects of the environment and nutrition have demonstrated the inseparable nature of genetics and the environment. For example, in 1775, Captain Cook introduced the English domestic pig to New Zealand; some escaped becoming feral pigs. Several generations later these feral pigs were indistinguishable in conformation from the wild boar (Hammond, 1960). Mills (1967) demonstrated the importance of nutrition on the phenotypic

expression of sheep. The horns of Cheviot sheep have been bred out since this trait was selected against. However, when these sheep were placed on a zinc-deficient diet they grew horns. These results suggest that nutrition influences certain biological processes such as methylation that are responsible for switching genes on and off. The Mills (1967) study also illustrates that nutrition has a direct influence on the expression of specific traits. Nutrition plays an important role in the phenotypic expression of an individual. A change in nutrition due to a change in environment could account for some of the variation observed in modern human crania. Unfortunately, the specific environmental stimuli and mechanisms responsible for human cranial changes remain largely unknown.

A common argument in physical anthropology associates the reduction of craniofacial size to a relaxation of natural selection for large faces as a direct result of using teeth and jaws less for food procurement and processing (Brace, 1977, 1979; Brace et al., 1991; Calcagno and Gibson, 1991). Larsen (1997) suggests that the worldwide trend of cranial shortening and gracilization throughout human evolution is related to biomechanical adaptations of the masticatory apparatus to technological advances in food processing. He maintains that craniofacial rugosity reflects the stress produced by anterior dental loading and other features of the masticatory apparatus. However, this

does not appear to be a plausible explanation because simply not needing a particular structure as much (e.g. large teeth) does not produce evolutionary pressure (Hunter, 1990). In addition, recent *in vivo* primate studies by Hylander and coworkers (1991) concluded that masticatory forces did not produce enough strain on the supraorbital region to account for supraorbital torus development. Alternatively, Ravosa (1991) concluded from primate studies that overall body and skull morphology were the most important influences on brow ridge morphology. The response of the cranium to environmental stimuli has long been noted, although not well understood, and a strong genetic component driven by a complex mode of inheritance of craniofacial variation, which is subject to strong environmental influences, should not be ignored (Molnar, 1992). The face does not serve solely as means for alimentation but also houses the eyes, which have an important role in the growth and development of the face; and the maxillae, which provides enclosure and maintains proper anatomic position of the nasopharyngeal airway (Oyen, 1990).

In the study of contemporary population affinities, individuals are treated as continuous members of the human species with distinctive local variations (Howells, 1995). People of European ancestry are traditionally lumped into a general category of "white" for the purpose of identification. However, it is inappropriate to use a generic European

type for assessing population affinity. For the purpose of forensic identification there is a pressing need for local identification criteria (Boas, 1912; Angel, 1976; Jantz et al., 1998; 1999; Ross et al., 1999). For instance, Bosnians and Croatians who have been thought to be relatively homogenous and historically to originate from the same Slav ancestry show local variations (Ross et al., 1999). It is possible that the differences in cranial morphology observed between Croatians and Bosnians are a result of a relatively long-term isolation of the breeding populations demarcated by different religious sects.

Historically, the term "race" is a major source of contention that has acquired many political overtones. It has been used to describe various groups from as small as local breeding populations or demes, to large groups such as geographical populations, political and cultural groups (Molnar, 1992). To avoid this complication, in this inquiry the populations under study are defined as local breeding populations that occupy a distinct geographic region distinguished by different religious membership. This definition follows Hiernaux (1971:40): "The most suitable units of study are smaller local populations, groups of intermarrying persons whether tribes, castes, or inhabitants of a particular region."

II. Post-cranial Form

Improvement of environmental conditions, in particular nutrition, is the foremost argument used to explain secular change (Cameron et al. 1990). According to Cameron and colleagues (1990) a reduction of cranial base height and an increase in cranial length along with the absence of secular trends in the post-crania are the result of a decrease in the standard of living.

In 1847, Bergman postulated that within a polytypic species body size increases as mean temperature decreases. Subsequently, Allen (1877) further outlined that as mean temperature decreased, the relative body size of exposed portions also decreased. By and large, these mammalian ecological rules appear to hold true for human geographical populations, which are summarized by Roberts (1953) classic inquiry stating that populations living in hot arid environs have relatively smaller trunks, longer limbs and a lower body mass index, while those populations inhabiting colder climes have relatively larger trunks, shorter limbs and a higher body mass index. In their study of sub-Saharan Africans and Mbuti pygmies, Froment and Hiernaux (1984) concluded that the short stature of the pygmies allows for more efficient heat loss in the harsh environment of the humid tropical rain forest. These conclusions are also consistent with body proportions of Amazonian groups inhabiting South American tropical rain forests

(Bogin, 1988). Ruff (1994) also argues that body proportions are primarily adaptations to different climatic environments. Alternatively, Shea and Bailey (1996) concluded that differences in limb proportions are accounted for by size differences alone.

Many researchers maintain that body proportions are relatively constant and thus are mostly influenced by genetics. Since size is more labile, it is primarily influenced by the environment (Norgan, 1998). However, the soundness of this model has recently been disputed. Meadows and Jantz (1995) and Meadows Jantz (1996) show that the tibia is more positively allometric than the femur. Kondo and Eto (1975) noted in a study of Japanese children between 1950 and 1970 that body proportions changed and not simply stature, where leg-length became relatively longer in relation to final stature. Tanner et al. (1982) confirmed these findings while concluding that Japanese adults were becoming more similar in proportion to American and Europeans. According to Bogin (1988), these studies suggest that the difference in growth observed between contemporary Japanese and Europeans appears to be related to overall size rather than body proportions. Although, which segments, whether proximal or distal segments were affected in this positive shift in secular trends, were not noted. These results indicate that not only does stature increase with improved environmental conditions, but that limb proportions are also affected.

This should not be surprising, since it is known that different parts of the human body mature and achieve adult proportions at different rates (Humphrey, 1998; Norgan, 1998). The head, whose growth is driven by the neural structures of the brain and eyes, achieves adult size in early childhood (Humphrey, 1998). At the age of peak growth velocity, the upper limbs are more developed than the lower limbs and the distal segments, such as the tibia and fibula and forearm precede the proximal segments (Norgan, 1998). Thus, it is logical to reason that nutritional and/or disease stresses at a particular developmental and growth stage would affect the various biological systems differently, resulting in limb proportional variations among populations.

Allometric (change in shape with size) variation among different populations has several applications, including interpreting climatic adaptations and implications in stature estimation (Corrucini, 1987). Recent studies of secular changes and allometry have observed differential limb proportions between sexes and among populations (Meadows and Jantz, 1995; Meadows Jantz, 1996; Ross et al., 1999b). Trinkaus (1981), Holliday (1997), Ruff (1994) and others have argued that limb proportions reflect climatic adaptation, while Porter (1999) suggests that biomechanical factors may be important. Ross et al. (1999b), however, found that although American Whites, Croatians, and Bosnians are similar in size, there is significant shape or proportional

variation among the populations. Furthermore, these results indicate that neither biomechanical nor thermoregulatory models adequately explain proportional limb variation among contemporary groups of European ancestry and forcefully illustrate the need for population-specific stature prediction formulae.

CHAPTER 3

Balkan History

I. Early Medieval Period (6th to 11th centuries)

According to classical sources the pre-Slavic indigenous populations of the Balkans included the Greeks who inhabited the area south of Albania, Macedonia, and Thrace. To the north were the Illyrians, Thracians and Dacians. Other groups that contributed both culturally and biologically were the Celts, Romans, and various German tribes (Fine, 1983).

Later on the Romanization of the Balkan Peninsula can be attributed to the advent of Christianity (Schevill, 1966). However, the Empire did not become officially Christian until Constantine. The Holy Roman Empire was divided in 395 when Theodosius I died and split the empire into east and west between his two sons (Fine, 1983). This division became a permanent feature of the modern Balkan states that would separate the Roman Catholics from the Eastern Orthodox Christians.

Thus the Balkans became the border region between Old Rome and New Rome (Byzantium) and between Latin and Greek. The Balkans also served as a borderland between civilization (the empire) and the barbarian world beyond the Danube (Fine 1983:15).

Traditionally, the Slavs that settled in the Balkans are identified as South Slavs or Jugo-Slavs (Schevill, 1966). The evidence for the origins of these numerous disunited tribes come from linguistic evidence and the archaeological record. Adherents of one theory believe that the Slavs that were to invade and settle in the Balkans were divided into two groups the Slaveni and the Antes. According to Fine (1983) linguists have argued that Antes is not a Slavic word but Iranian in origin. He also cites that the Bulgarian historian Zlatarski asserts that the Slaveni were the ancestors of the linguistic group Serbo-Croatian while the Antes were the ancestors of the Bulgaro-Macedonians (Fine, 1983). However, Schevill (1966) maintains that the numerous Slavic tribes that initially entered the Balkans differentiated after a few centuries into four distinct Slavic groups: Slovenes, Croats, Serbs and Bulgars.

Before the late 560's Slav activity was primarily in the form of raids and did not result in settlement of the Balkans. Settlement began in the middle of the sixth century when the Slavic infiltration of the Balkans was facilitated by Byzantine military conflict with the Persians.

Slavic dispersal throughout the Balkans continued through the 7th and 8th centuries, aided by the invasion of new Asian warriors, the Avars and the Bulgars (representing several Tukic-speaking tribes). During this time the Slavs were able to disperse throughout most of the Balkans

with the aid of the Avars who served as leaders or allies in military campaigns against the Byzantine armies (Magocsi, 1993).

During this period of active Slav settlement many of the indigenous peoples (Illyrians, Thracians and Dacians) were killed, captured, or fled to the mountains or other remote areas. According to Fine (1983) many of these pre-Slavic peoples could have sought refuge in inaccessible areas such as Bosnia and Herzegovina, and Montenegro.

Many revolts against the Avars ensued from 620 to 640 and the militarily superior Croats and Serbs finally liberated the western Balkans. The arrival and settlement of the Croats and Serbs is described by Constantine Porphyrogenitus who states that the mass settlement of the Slaveni over what is today the former Yugoslavia were one people and that the Croatians and Serbs were described by Constantine as a different migration of a different people (Fine, 1983). The Croats and Serbs settled along the Adriatic in the former Roman province of Dalmatia, later to become the center of the South Slavic States (Magocsi, 1993). The Croats and Serbs formed the military aristocracy that provided a ruling class and unity for the disunited Slaveni. The Croats and Serbs intermarried with the more numerous Slavs and became assimilated into the Slav majority. Ironically, the Slavic language that had been spoken before the Croat and Serbian arrival came to be named after the Iranian newcomers (Fine, 1983).

In 681, the Bulgars brought under control seven Slavic tribes and settled along the lower Danube and established the first Bulgarian Empire. By the end of the ninth century the Turkic Bulgars had merged with the more numerous Slavs to also become a Slavic state (Magocsi, 1993).

In the ninth century southern Pannonia and Dalmatia remained under the control of the Croat princes and other South Slavs, but these rulers were at various times either independent or vassals to Frankish, Byzantine and Bulgarian empires (Magocsi, 1993).

Ethnic diversity was grounded in political and religious foundations, as well as geographical and migratory patterns (Burks, 1973). The Croats and Slovenes remained faithful to the Western Roman Empire, while the Serbs remained faithful to the Eastern (Byzantine) Empire (Ristelhueber, 1971).

The South Slavs thus constituted two groups divided between two empires and two churches. This duality persists to the present day; although united in one nation (Yugoslavia) the two Slav peoples perpetuate their church differences (Ristelhueber, 1971:30).

This religious boundary between Roman Catholicism and Eastern Orthodoxy divided Eastern Europe down the middle geographically and also was to become a cultural frontier (Burks, 1973). The sixth to the twelfth centuries was a critical period that determined whether a region was to be Catholic or Orthodox, with the exception of Bosnia, which

because of its mountainous terrain remained relatively geographically isolated (see Figure 1).

II. Late Medieval Period (12th century to the Ottoman conquest)

Bosnia has been an obscure presence in the historical record and never had a clearly defined national identity during the Middle Ages contrasting with the Croats and Serbs (Singleton, 1989). Between the ninth and eleventh century much of Bosnia belonged to the Croatian Kingdom and Herzegovina was part of Serbia. Late in the twelfth century Herzegovina went over to Hungary (Singleton, 1989). With its mountainous terrain and poor communication system and because of its location was seen as the meeting ground between East and West. The mountainous terrain encouraged geographic localism, which in turn encouraged different religious faiths in different areas (Fine, 1993). In the east near Serbia, Drina and most of Hum (present-day Herzegovina) Orthodoxy prevailed, while the west, north and central Bosnia, Roman Catholicism predominated. However, during the middle of the thirteenth century the Bosnian Church also known as Bogomil emerged (Fine, 1987). "Bosnia was nominally Catholic and under the jurisdiction of the archbishop of Dubrovnik" (Fine, 1987:18). Dubrovnik had traditionally been tolerant of Bosnia's local customs by allowing Bosnia to conduct its liturgy in Slavic



Figure 1-East Central Europe, 9th Century. From Historical Atlas of East Central Europe by Paul Robert Magocsi. Copyright 1993. Reproduced by permission of University of Washington Press.

instead of Latin. However, A major argument used by the Hungarians to exalt control over Bosnia was to accuse its church followers of heresy.

The Hungarians began a crusade to try to reestablish the international Catholic Church in Bosnia that resulted instead in the severance of the Bosnian monastic order and the establishment of the Bosnian Church. These actions increased Bosnian antipathy towards the Hungarians and even contributed to the Ottoman conquest of Bosnia in 1463. Fine (1987:147) argues:

That the Bosnian Church emerged primarily to assert local independence from foreign interference; perhaps there was a little heretical or dualist influence upon it, but such influence certainly did not form the core of its beliefs.

During the late medieval period the Balkans were plagued by territorial fragmentations that were ruled by minor principalities, and which were unable to cooperate with each other and often at war with one another. Because of this constant turmoil there was also a general military decline. All these weaknesses facilitated the Ottoman conquest of the Balkans (Fine, 1987).

The Ottoman conquest of the Balkans was a relatively slow process that occurred in stages. The Muslim Turks encouraged and used to their advantage the many local civil wars and rivalries that predominated. During this period the Balkan states were also faced with threats from Hungary and many preferred the Turks, known for their religious

tolerance, to the intolerant Hungarians. The vassal stage was the first stage following indirect annexation by the Ottomans where local princes, who accepted the Sultan's suzerainty and promised tribute and military service, were kept in power. As the Ottoman power increased so did the amount of tribute demanded increase. Consequently, the local rulers raised the taxes on the peasant's in order to pay tribute. Although the Ottomans received tribute they continued periodical raids. The continuous tax increases and constant raids deteriorated the peasant population. Subsequently, the Ottomans promised the peasants lower taxes if they would accept direct Ottoman rule (Fine, 1987). " This enabled the Ottomans to initiate the next and final stage, direct annexation, which meant the removal of the native dynasty and the incorporation of the state under Ottoman administration" (Fine, 1987:609).

The Ottoman conquest of the Balkans during the 14th and 15th centuries followed from southeast to the northwest (Magocsi, 1993). The first Balkan state to fall was Bulgaria, then Constantinople and what remained of Byzantium (1453 and 1460), Serbia (1459), and Bosnia-Herzegovina (1463-1482), see Figure 2 (Magocsi, 1993).

III. Ottoman Conquest and Occupation

Bosnia was rapidly conquered by the Ottoman Empire in 1463. Many historians have inaccurately credited the Bosnian Christians, in particular those of the Bogomil faith, with converting *en masse* after the Ottoman conquest. Because of Bosnia-Herzegovina's geographical and political importance, this view has been endorsed by many contemporary Bosnian Muslims to give legitimacy to the claim that they were not recent arrivals to the region (Fine, 1993). More accurately there was not one dominant religion in Medieval Bosnia; members of all three faiths (Bogomil, Catholics, and Orthodox) were present in different geographical areas. According to Fine (1993) the Ottoman conquest brought about changes in both religion and population. Many Bosnian Catholics fled to other unconquered territories and Orthodox Serbs had been migrating into various parts of Bosnia during the Ottoman pressure on Serbia. During the first two centuries of Ottoman rule the Balkans witnessed a constant movement of people. There was an influx of Ottoman Turks in urban centers such as Sarajevo and Mostar to supply administrative positions; internal migration of local peoples in particular Catholics and Orthodox Christians; and immigration of Jews fleeing from the Spanish Inquisition (Sugar, 1977). Historically, Bosnia-Herzegovina has always been a frontier region between the West and the East lacking an organized church leadership. This absence of an organized religion

would explain such a large-scale and relatively effortless shift to Islam (Friedman, 1996; Malcolm, 1994; Stavrianos, 1958). Malcolm (1994) also mentions slavery as an important factor that contributed to the Ottomization of Bosnia.

The taking of slaves in war- not just enemy soldiers, but the local inhabitants too- was standard Ottoman practice...Large numbers of slaves were seized by the Turks in their campaigns against the Habsburgs: 7000 were taken from Croatia in 1494, for example, and 200,000 (reportedly) in Hungary and Slavonia in 1526. Slaves who converted to Islam could apply for freedom; and those slaves who were brought to Bosnia, mainly from the surrounding Slav lands of Dalmatia, Croatia, and Slavonia, must have made a significant contribution to the growth of the Muslim population...In 1528 these freed slaves made up nearly 8 percent of the population in Sarajevo (Malcolm 1994:66-67).

Thus, the conversion to Islam in Bosnia was a wide-ranging multidirectional event. For the next hundreds of years before the formation of the first Yugoslav State in 1918, various political and cultural pressures dominated the Balkan States (Singleton, 1989). Bosnia-Herzegovina remained under Ottoman occupation until late in the nineteenth century.

IV. Twentieth Century Yugoslavs

The recent crisis in the former Yugoslavia has been naively explained as simply a continuation of endemic communal ethnic strife and that the atrocities are merely rekindled hatreds the Serbs, Croats,

and Muslims have inflicted on each other over centuries. While history has served to set the stage for the recent events that have taken place, it has not been the deterministic factor. Significantly, all three religious communities lived for centuries in relative conformity. Islamic-Christian coexistence was the rule under the five hundred years of Ottoman domination.

If there is one overriding historical factor that has had an enduring impact on current political developments, it is the emergence of a modern nationalistic ideology. The quest for a "Greater Serbia" developed as the basis of the Serbian nationalistic movement with the rise of an independent Serbian state in the nineteenth-century. The Serbian nationalist movement with its focus on territorial expansion wanted to draw together all Serbs, assimilate non-Orthodox, and exterminate Muslims. These problems re-emerged after the Balkan Wars of 1912-1913, in 1918 after WWI, and again during WWII in 1941 when Croats and Serbs established Fascist states allied with Germany (Davis, 1996). During WWII Serbians, Croatians, and Muslims participated in killings and atrocities. Approximately, one million people perished in Yugoslavia from all causes in WWII. This same nationalistic ideology during the collapse of communist Yugoslavia after the death of Tito was what set the stage for the recent genocide at the time when the divided republics were seeking independence (see Figure 3).



Figure 3- Former Yugoslavia.

Source: Francine Friedman, "The Bosnian Muslims: Denial of a Nation."
Boulder, Colorado: Westview Press, 1996.

CHAPTER 4

Materials and Methods

I. Materials

The recent Balkan samples utilized in this study derive from several sources and time periods and are composed of only male individuals. The cranial and post-cranial Bosnian sample consists of individuals obtained by the author on three trips to Bosnia. The author also collected cranial data from the Von Luschan Collection, curated at the American Museum of Natural History. The Croatian samples were obtained from Douglas W. Owsley, Curator of Physical Anthropology, Smithsonian Institution, and include both cranial and post-cranial measurements. Several observers collected the Croatian data. The American White data were obtained from the Forensic Data Bank housed at the University of Tennessee, Knoxville. Finally, American White World War II casualties collected by Mildred Trotter were used as a reference in calculating the new Balkan stature formulae. Mean stature for Balkan populations was derived from the literature (Tomazo-Ravnik, 1988). Sample composition is presented in Table 1.

Table 1. Sample Composition.

Sample	Cranial N	Post-cranial N	Measurer	(Age Range) Mean	Date of Death
Amer. White					
<i>Total (N)</i>	243	133	N/A	(17-87)	After 1960
<i>Shape Analysis (N)</i>	151	110		39	
Bosnian					
<i>Total (N)</i>	132	80	AHR	(17-60)	1991/1996
<i>Shape Analysis (N)</i>	101	54		33	
Croatian					
<i>Total (N)</i>	153	99	N/A	(17-83)	1991
<i>Shape Analysis (N)</i>	53	38		41	
Croat 1930					
<i>Total (N)</i>	6	--	N/A	(45-65)	1930-1945
<i>Shape Analysis (N)</i>	4	--		53	
Croat 1945					
<i>Total (N)</i>	30	--	N/A	(17-49)	1945
<i>Shape Analysis (N)</i>	21	--		28	
Greek					
<i>Total (N)</i>	32	--	AHR	+21	<1900
<i>Shape Analysis (N)</i>	18	--			
Macedonia					
<i>Total (N)</i>	11	--	AHR	+21	<1900
<i>Shape Analysis (N)</i>	8	--			

II. Samples

a. Bosnia

The data from Bihac consists of cranial measurements. Thirteen males are from Hrgar, Jama-Bezdan site, Bihac, which is located on the North Western border with Croatia. These individuals were massacred concentration camp detainees (1991 deaths). These data were collected with permission from Prim. Dr. Semira MEŠIĆ-Pašalić, Specijalista patolški anatomije I sudke medicine (local pathologist). The Bosnian male sample that resulted from the 1996 Srebrenica massacre totals 132 individuals consisting of both cranial and post-cranial measurements. Srebrenica is located along the eastern border with Serbia, and the casualties are stored at the Komemorativni Centar, Tuzla. Permission to conduct complete skeletal examinations and database storage was granted by Amor Mašović, President, of the State Commission for Missing Persons on June 22, 1998. The sex of individuals was assessed using pelvic morphology when available, however, many sex assessments were based on cranial morphology. A combination of several indicators (pubic morphology, rib, cranial suture closure) were used to estimate age when available. Only adult individuals (over 18) were included in this investigation.

b. Croatia

The contemporary Croatian cranial and post-cranial sample consists of a total of 153 males, also from the recent war. These casualties are from different towns, which are grouped into regions. The towns (sites) included in this investigation include the following: from Eastern Croatia (Vukovar, Marinovci, Antunovac, Ernestinovo, Bogdanovici, Karadzicevo, Tenja, Erdut, Dalj; Western Croatia (Petrinja, Hrvatska Kostajnica, Bjelovar, Mirosevac, Virovitica, Zagreb, Glina, Pakrac, and Lika); Southern Croatia (Split and Dubrovnik).

The 1945 Croatian cranial male sample (Croat45) totals 30 individuals and are of unknown provenience. In addition, six individuals of unknown provenience, roughly from 1930-1945 and designated as Croat30, were included. Croat45 and Croat30 samples are curated in the Department of Forensic Pathology at the University of Zagreb, Croatia. The Croatian casualties are from various mass graves and were obtained from Douglas W. Owsley, Curator of Physical Anthropology at the Smithsonian Institution.

c. Forensic Data Bank

The Forensic Data Bank (FDB) is a computerized database that was developed to assemble data for new identification methods for skeletal remains. Additionally, recording procedures and protocols for

measurement and computer storage are standardized to facilitate in the initial collection, analysis, and interpretation of comparable sets of data. The data includes specimens from forensic cases, and donated skeletal materials that have been reported by a range of academic and research institutions and forensic laboratories around the nation. The American White sample used in this investigation totals 243 males. Only adult individuals with positive identifications were included in this investigation.

d. Felix von Luschan Collection

The Felix von Luschan Collection is housed at the American Museum of Natural History in New York City. It is comprised of a series of roughly five thousand human skulls from various parts of the world that was amassed by the medical doctor and anthropologist Felix von Luschan over many field trips. The American Museum of Natural History acquired the collection in 1924 upon his death. Specific information regarding the provenience of each skull is limited. Generally, all that is known is the location and the date of acquisition of the specimens. In this study the following cranial samples from the Balkan region were included for comparison: Greek (N=18), and Macedonian (N=8). The Greek sample is from a Modern Greek cemetery in Adalia (present-day city of Antalya, Turkey). The Macedonian sample is also

categorized as Greek and is from Janitsa. Von Luschan purchased the Macedonian sample from Dr. Kiessling in 1904. The author assessed the sex of the specimens via gross visual cranial morphology. Adult age was estimated using dental markers (e.g. eruption of third molars) and suture closure.

e. World War II Casualties

The sample included in this study as a reference sample for stature estimation is 545 white males. Mildred Trotter (1952) collected metric and demographic data on over 1200 WWII casualties during her tenure at the Central Identification Laboratory (Meadows Jantz, 1996). Stature was taken at the individual's time of induction into the military and long bone measurements were recorded at death (Meadows Jantz, 1996).

III. Methods

A general consideration in traditional morphometry is the question of size adjustment. Corruccini (1987), Jungers et al. (1995) are pro-Mosimann and colleagues (Mosimann, 1970; Mosimann and James, 1979; Darroch and Mosimann, 1985) in their treatment and solution to shape and size adjustment in morphometrics. According to Mosimann's school of 'size vectors' and 'shape-variables', size is defined as the "actual characters, their sum and their geometric mean"; shape is defined as

some proportion of the size variable (Reyment et al., 1984:123). Other less favorable shape adjustments are regression residuals, which have incorrectly been used as "size-free" variables. Log transformation of variables is not recommended for standard normal data, since these can become curvilinear under these conditions. Furthermore, Corrucini (1987) maintains that positively skewed variables can be rendered negatively skewed upon logarithmization. In addition, log transforming metric data detaches the investigator even further from the biological organism under study (Reyment, 1971).

a. Measurements

Metric data allows for a more objective analysis of population relationships. Twenty-two cranial measurements were utilized in this study and are defined in Martin (1956), Howells (1973), and Moore-Jansen et al. (1994) and are presented in Table 2 and Figure 4. The maximum lengths of the humerus, radius, femur and tibia were used for the post-cranial analyses and are defined in Martin (1957), Bass (1995), and Moore-Jansen et al. (1994) (Table 3). Additional femoral measures were used to compute a femoral robusticity index and a femoral midshaft ratio (Table 3).

Table 2. Definitions of Cranial Measurements.

Measurement	Description
Maximum Cranial Length (GOL):	Howells 1973:170; Martin 1956:453 #1; Moore-Jansen et al. 1994:49 #1.
Maximum Cranial Breadth (XCB):	Howells 1973:172; Martin 1956:455 #8; Moore-Jansen et al. 1994:49 #2.
Bizygomatic Breadth (ZYB):	Martin 1956:476 #45; Moore-Jansen et al. 1994:50 #3.
Basion-Bregma Height (BBH):	Howells 1966:6 #5; Martin 1956:459 #17; Moore-Jansen et al. 1994:50 #4.
Cranial Base Length (BNL):	Howells 1966:6 #4; Martin 1956:455 #5; Moore-Jansen et al. 1994:51 #5.
Basion-Prosthion Length (BPL):	Martin 1956:474 #40; Moore-Jansen et al. 1994:51 #6.
Maxillo-Alveolar Breadth (MAB):	Howells 1973:176; Martin 1956:480 #61; Moore-Jansen et al. 1994:51 #7.
Maxillo-Alveolar Length (MAL):	Martin 1956:480 #60; Moore-Jansen et al. 1994:51 #8.
Biauricular Breadth (AUB):	Howells 1973:173; Moore-Jansen et al. 1994:52 #9.
Upper Facial Height (UFHT):	Howells 1966:6; Martin 1956:476 #48 Moore-Jansen et al. 1994:53 #10.
Minimum Frontal Breadth (WFB):	Martin 1956:457 #9; Moore-Jansen et al. 1994:53 #11.
Nasal Height (NLH):	Howells 1966:6 #14; Martin 1956:479 #55; Moore-Jansen et al. 1994:54 #13.
Nasal Breadth (NLB):	Howell 1973:176; Martin 1956:479 #54; Moore-Jansen et al. 1994:54 #14.
Orbital Breadth (OBB):	Howells 1973:175; Martin 1956:477-478 #51a; Moore-Jansen et al. 1994:55 #15.
Orbital Height (OBH):	Martin 1956:478 #52; Moore-Jansen et al. 1994:55 #16.

Table 2 <i>cont.</i>	
Biorbital Breadth (EKB):	Howells 1973:178; Moore-Jansen et al. 1994:55 #17.
Interorbital Breadth (DKB):	Martin 1956:477 #49a; Moore-Jansen et al. 1994:55 #18.
Frontal Chord (FRC):	Howells 1973:181; Martin 1956:465 #29; Moore-Jansen et al. 1994:55 #19.
Parietal Chord (PAC):	Howells 1973:182; Martin 1956:466 #30; Moore-Jansen et al. 1994:56 #20.
Occipital Chord (OCC):	Howells 1973:182; Martin 1956:466 #31; Moore-Jansen et al. 1994:56 #21.
Foramen Magnum Length (FOL):	Martin 1956:455 #7; Moore-Jansen et al. 1994:56 #22.
Foramen Magnum Breadth (FOB):	Martin 1956:459 #16; Moore-Jansen et al. 1994:57 #23.

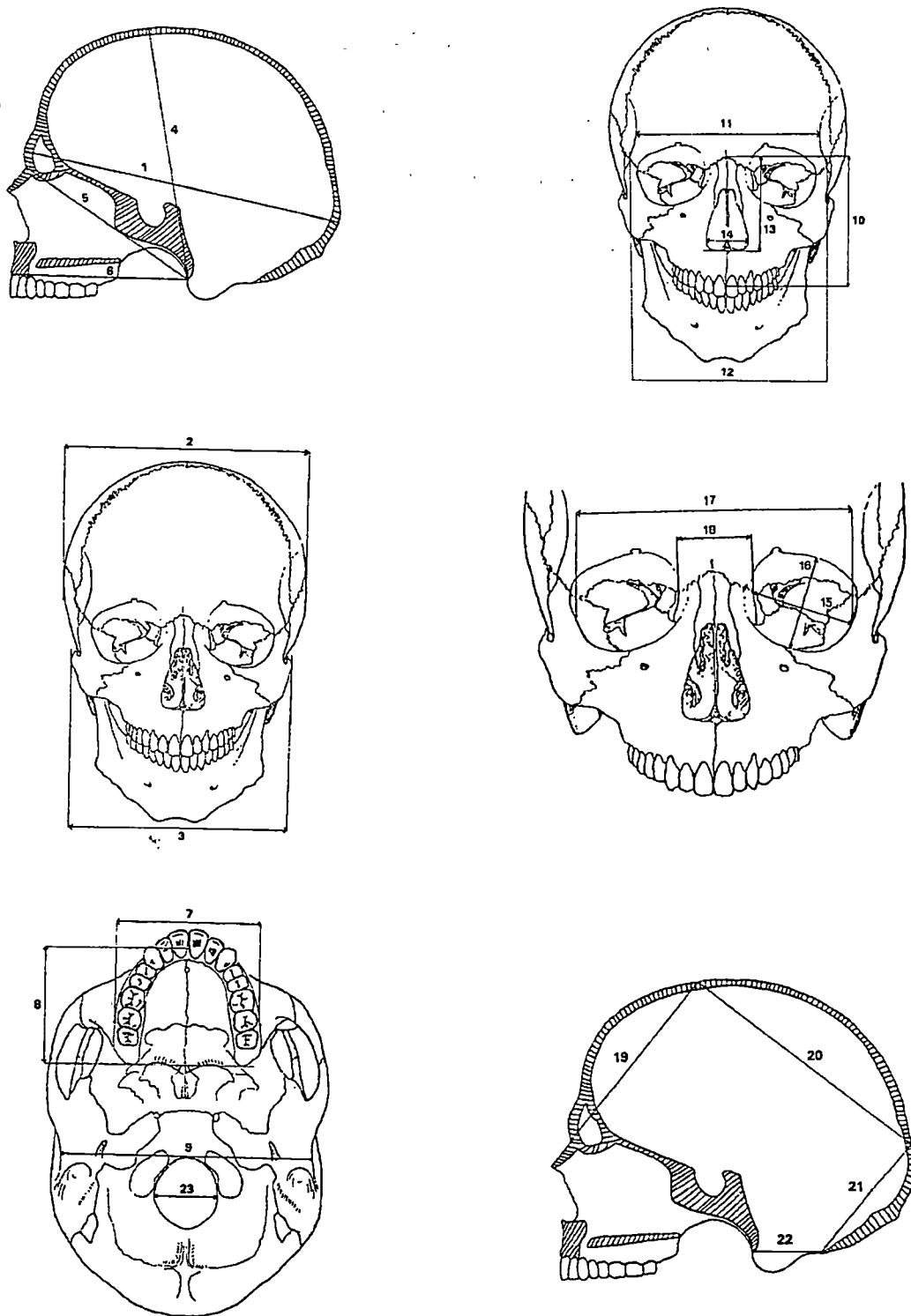


Figure 4- Selected Cranial Measurements. *Source:* Adapted from Moore-Jansen PM et al. (1994) Data Collection Procedures for Forensic Skeletal Material. The University of Tennessee, Knoxville.

Table 3. Long bone measurement definitions.

Measurement	Description
Max. Length of the Humerus (MLH):	Bass 1995:152; Martin 1957:532 #1; Moore-Jansen et al. 1994:63 #40.
Max. Length of the Radius (MLR):	Bass 1995:167; Martin 1957:535-536 #1; Moore-Jansen et al. 1994:64 #45.
Max. Femur Length (MFL):	Bass 1995:223; Martin 1957:561 #1; Moore-Jansen et al. 1994:68 #60.
Bicondylar Femur Length (BFL):	Bass 1995:224; Martin 1957:561-562 #2; Moore-Jansen et al. 1994:68 #61.
Anterio-posterior Diameter of the Femur at Midshaft (APM):	Martin 1957:563 #6; Moore-Jansen et al. 1994:69 #66.
Transverse Diameter of the Femur at Midshaft (TVM):	Martin 1957:563 #7; Moore-Jansen et al. 1994:69 #67.
Length of the Tibia (TML):	Bass 1995:245; Martin 1957:572 #1; Moore-Jansen et al. 1994:70 #69.

b. Missing Data

Missing cranial variable values were estimated for Croatians, WWII Croatians, Bosnians, Greeks, and Macedonians to increase sample sizes using the program NORM: Multiple imputation of incomplete multivariate data under a normal model (Schafer, 1999), which was downloaded from the web. The general guidelines followed were not to accept any case for data replacement that had more than 20% of missing values (this translates to no more than four variables per case). NORM is an iterative simulation technique that uses a type of Markov chain Monte Carlo technique to generate random draws, where the distribution of each draw depends on the previous draw (Schafer, 1999).

c. Cranial Methods

In this study, standard craniometric measurements are utilized to examine craniofacial variation among contemporary American Whites, Bosnians, and Croatians. Additionally, craniofacial variation among other Balkan groups is also investigated.

Analyses of Contemporary Populations

First, a canonical discriminant analysis was used to assess relationships among American Whites, Croatians, and Bosnians using twenty-two raw cranial measurements. The objective of discriminant

functions as proposed by Fisher (1936) is to maximize the separation of the populations. The discriminant functions are based on the reference samples that are available for each population (Reyment et al., 1984). To reduce bias the crossvalidation method, which treats $n-1$ out of n observations was applied to obtain the discriminant functions.

Canonical variates, linear combinations of predictor variables that summarize between-population variation, are derived to examine the interrelationships among Bosnians, Croatians, and American Whites in order to graphically represent the differences on canonical axes. These canonical axes are chosen to maximize population differences.

The degree of differentiation among the three groups was measured using Mahalanobis D^2 or generalized distance, which is a function of the group means and the pooled variances and covariances (Afifi and Clark, 1996). D^2 is used to test whether group centroids are significantly different.

For the second part of this analysis, a stepwise discriminant analysis to select the best measurements for discriminating between Croatians and Bosnians was executed. Stepwise selection begins by entering the variable with the lowest Wilk's Lambda in the model. The variable that least contributes to the discriminatory power is removed from the model if it fails to meet the criterion to stay. Otherwise the variable that contributes the most to the discriminatory power that is not

in the model is entered. The procedure stops when all variables meet the criterion to stay and no others can be entered. Then a second discriminant function analysis was conducted in order to classify crania into the Eastern European groups using the variables selected by the stepwise procedure.

Regional Analyses (Multiple Eastern European Groups)

Next, craniofacial variation among Bosnians, Croatians (contemporary, from the 1930's, and from WWII were treated as separate groups), American Whites, Greeks, and Macedonians was investigated. Jantz and Owsley (1998), Jantz (1999), and Jantz and Meadows Jantz (2000) have shown that significant changes due to secular increases have occurred in the cranium in the past 150 years. To circumvent the effects of size differences due to possible secular changes, size and shape variables are computed according to Mosimann and colleagues (Mosimann and James 1979; Darroch and Mosimann 1985) using raw measurements. Size is defined as the geometric mean. The size variable for the twenty-two cranial measurements is calculated as follows:

$$SIZE = (\prod_{i=1}^{22} X_i)^{1/22}$$

The new shape variables are simple proportions of the geometric mean and are expressed as the ratio of $Y = X/SIZE$.

A one-way analysis of variance (ANOVA) was performed on the size variables to test the null hypothesis that the mean size is not significantly different among the populations. A canonical discriminant analysis was then performed on the new shape variables to investigate craniofacial variation among the populations. In addition, face size and vault size were evaluated separately using the following variables:

$$\text{FaceSize} = (\text{ZYB} * \text{NLH} * \text{NLB} * \text{OBH} * \text{OBB} * \text{DKB} * \text{EKB} * \text{UFHT})^{1/8};$$

$$\text{VaultSize} = (\text{GOL} * \text{BNL} * \text{BBH} * \text{XCB} * \text{WFB} * \text{AUB} * \text{BPL})^{1/7}.$$

The craniometric analyses were performed using the SAS System for Windows Version 7 (1998). Plots were constructed using Microsoft Excel 2000.

Population Structure

To further investigate the amount of variation among the populations a multivariate method by Relethford (1994:55) that estimates F_{ST} ("ratio of among-group variation to total variation expected under panmixia") values from craniometric data enabling comparisons to genetic markers was applied. To derive the F_{ST} values, RMET 4.0 was used. RMET is a computer program that performs population genetics analyses using metric data, which can be downloaded from the web. (Relethford, nd.). The analysis was first performed assuming complete

heritability (1.0) and then assuming average heritability (0.55) obtained from Devor (1987) as described by Relethford (1994) for craniometric traits. Others have derived lower estimates of heritability (0.4 and 0.41) for anthropometric traits (Cheverud, 1988; Ousley and Konigsberg, 1995). However, the estimate used by Relethford (1994) is more appropriate for this study because it was used to derive F_{ST} values for actual craniometric traits that can be directly compared.

d. Post-cranial Methods

Allometry is the approach to examining differential rates of growth of anatomical structures relative to the body as a whole (Huxley 1932). Allometric variation of different populations is of interest to many researchers and has several applications, from interpreting climatic adaptations to implications in stature estimation. Recent studies of secular change and allometry have observed differential limb proportionality between sexes and among races (Meadows and Jantz 1995; Meadows Jantz 1996). Meadows Jantz (1996) concluded that it is not likely that changes in function are solely responsible for differences in proportional relationships. However, the forces responsible for the variation in limb proportions remain unclear. The static or adult allometric relationships among contemporary American White, Croatian, and Bosnian males are examined.

Proportional Variation

To examine the static allometric relationships among the three populations size and shape variables are also computed for long bones according to Mosimann and colleagues (Mosimann and James 1979; Darroch and Mosimann 1985) using raw measurements.

A one-way analysis of variance (ANOVA) was performed on size to test the null hypothesis that the mean size is not significantly different among the populations. In addition, a canonical discriminant analysis was conducted on the shape variables. These analyses were performed using the SAS System for Windows Version 7 (1998).

Femur Measures

To generate structural comparisons among the populations, an average femoral robusticity index, a midshaft diaphyseal shape, and a subperiosteal midshaft area for cross-sectional and allometric comparison were calculated (Cole, 1994; Rockhold, 1998).

Robusticity index (R-index):

$$\text{R-index} = (\text{APM} + \text{TVM}) \times 100 / \text{BFL}$$

The average robusticity index was used to measure relative femoral robusticity (Demes and Jungers, 1989). Bicondylar femur length was selected because it more closely approximates the length of the femur shaft (Rockhold, 1998).

Femur cross-sectional shape (S-ratio) is expressed as a ratio of anterior-posterior diameter and the transverse diameter (APM/TVM). A ratio greater than 1.0 suggests that the cross-section is elongated along the sagittal plane, while a ratio less than 1.0 is wider in the medio-lateral aspect (Ruff, 1987). Multiple t-tests were performed to examine group differences.

Ruff and colleagues (Brock and Ruff, 1988; Ruff, 1987; Ruff and Hayes, 1983; Ruff et al., 1984) have shown that cross-sectional geometry of leg bones is related to biomechanical effects of different subsistence activities. To examine the biomechanical relationship of the femur, cross-sectional external measures were transformed into an elliptical model of total subperiosteal area of the femur midshaft as follows:

$$TSA = \pi (APM/2 * TVM/2)$$

Reduced major axis regression (RMA) was used to examine the allometric relationship of the natural log transformed variables for cross-sectional area (lnTSA) and bicondylar length (lnBFL). RMA is the ratio of the

standard deviation of the y and x variables (Hens, 1998). RMA is not affected by the correlation coefficient and provided that the variance ratio remains constant the slope will remain the same (Aiello, 1992; Hens, 1998). Thus, isometry is indicated by a slope value of 2.0, which is the total cross-sectional area against bicondylar length. The RMA procedure was conducted in Microsoft Excel 2000.

Stature prediction

Local standards for stature prediction formulae using a Bayesian approach are presented. Bayes' theorem states that the probability of s is equal to s, given

$$P_T(s|lb) = \frac{P_R(lb|s) \times P_T(s)}{\int \{P_R(lb|s) \times P_T(s)\} ds}$$

where $P_T(s | lb)$ is the posterior distribution for s.

Basically, Bayesian inference is based on the idea of using probabilities, both unconditionally (the prior probability of a particular stature in the target sample, shown as $P_T(s)$) and conditionally (the probability from the reference sample of obtaining the observed long bone length conditional on a given stature) to produce informed parameters. In the past, the use of a Bayesian approach to data analysis is an area of controversy among

classical statisticians, who do not accept the use of informative or known priors and argue that this method produces biased estimates (Manly, 1997). However, Konigsberg and coworkers (1998) discuss the arguments for applying a Bayesian versus a maximum likelihood approach to stature estimation. They argue that in forensic anthropology the Bayesian model is the preferred method. Alternatively, for exploratory investigations such as in paleoanthropology, where there is little evidence that a case is sampled from the same stature distribution as the reference population, a maximum likelihood approach is more appropriate. In this study a Bayesian solution to stature estimation is proposed where the reference sample provides information about the relationship between long bone length and stature shown above as $P_R(lb | s)$ but the prior for stature comes from the known stature distribution for the living population from which the forensic case is drawn, shown above as $P_T(s)$.

The humerus, femur and tibia were used for stature prediction. The contemporary Eastern European sample is 86 Bosnians and 91 Croats for a total of 177. For the reference sample, 545 white males from World War II are employed.

Because the actual statures for the Balkan war dead are not known, the mean and standard deviation of stature for 19-year-old males was taken from the literature (Tomazo-Ravnik, 1988). It was then

utilized as the informative prior for stature prediction for Eastern Europeans.

In this study a Bayesian approach is applied to derive univariate stature equations for Eastern Europeans. The following formula includes the parameters for stature prediction:

$$\hat{s} = \frac{\beta \bar{S}_T V_{cl} - V_{s_T} \alpha}{\beta (V_{cl} + V_{s_T})} + \frac{V_{s_T}}{\beta (V_{cl} + V_{s_T})} \times lb$$

where: $V_{cl} = V_{s_R} (r^{-2} - 1)$

$$s.e.(\hat{s}) = \sqrt{\frac{V_{cl} V_{s_T}}{V_{cl} + V_{s_T}}}$$

Here β and α are just the slope and intercept from the reference sample for the regression of a long bone on stature, while $\bar{S}_T$ is the mean stature in the target sample while V_{s_T} is the variance of stature in the reference sample. Similarly, V_{s_R} is the variance for stature in the reference sample. V_{cl} is the variance for stature estimates from the reference sample under a uniform prior, which yields the classical calibration estimator. Finally, r is the correlation between the long bone and stature from the reference sample, while lb would be an actual long

bone length for a forensic case. Microsoft Excel 2000 was used in this part of the analysis.

CHAPTER 5

Results

I. Craniometric Analyses

a. Analyses of Contemporary Groups

Summary descriptive statistics for twenty-two cranial variables along with the within-class covariance matrices for contemporary Bosnians, Croatians, and American Whites are presented in tables 4-6, and tables 7-9, respectively. Mahalanobis D^2 is shown in Table 10. There are significant differences between centroid means. American Whites are the most dissimilar, but are closer to Croatians than to Bosnians, Croatians falling in between. As expected, Croatians and Bosnians are the most similar morphologically.

A canonical discriminant analysis was used to assess relationships among American Whites, Croatians, and Bosnians, using twenty-two cranial measurements (Table 11). Two significant canonical axes were extracted suggesting that American Whites are markedly different from the Eastern European groups. The first axis, accounting for 84% of the among group variation, shows American Whites to differ strongly from Croatians and Bosnians. The second axis, accounting for 16% of among group variation, differentiates Croatians and Bosnians.

Table 4. Cranial Measurements (mm) of Bosnian Males.

	N	Mean	Std Dev	Minimum	Maximum
GOL	101	177.98	6.69	161	199
BNL	101	101.14	3.99	89	114
BBH	101	138.54	5.20	127	150
XCB	101	149.61	5.17	139	165
WFB	101	99.69	5.28	87	111
ZYB	101	134.56	5.09	121	145
AUB	101	128.79	4.95	116	139
BPL	101	94.07	5.58	83	110
NLH	101	51.89	4.71	29	65
NLB	101	23.71	1.87	20	28
MAB	101	62.60	4.06	54	73
MAL	101	101.04	3.55	44	60
OBH	101	32.71	2.28	29	42
OBG	101	38.50	2.36	34	47
DKB	101	22.77	2.92	17	33
EKB	101	96.27	4.45	86	107
FRC	101	113.25	4.73	99	125
PAC	101	111.61	6.71	95	133
OCC	101	93.52	5.42	80	107
FOL	101	37.74	2.47	32	43
FOB	101	31.90	2.26	26	37
UFHT	101	73.19	4.69	64	88

Table 5. Cranial Measurements (mm) of Croatian Males.

	N	Mean	Std Dev	Minimum	Maximum
GOL	53	180.17	6.60	166	195
BNL	53	104.70	4.66	95	116
BBH	53	139.04	6.25	117	150
XCB	53	151.23	5.71	141	166
WFB	53	99.55	4.25	89	110
ZYB	53	135.60	5.49	123	145
AUB	53	128.64	5.82	107	140
BPL	53	95.06	6.70	82	113
NLH	53	101.32	3.70	45	60
NLB	53	24.70	2.37	19	30
MAB	53	60.74	5.07	45	71
MAL	53	50.72	4.72	42	62
OBH	53	33.68	2.49	29	40
OBB	53	40.64	2.84	35	49
DKB	53	23.57	2.83	16	30
EKB	53	98.23	3.99	88	107
FRC	53	113.19	4.55	102	122
PAC	53	110.39	6.70	98	125
OCC	53	96.26	7.36	81	115
FOL	53	37.21	2.71	30	44
FOB	53	32.02	2.94	23	39
UFHT	53	71.94	5.00	60	84

Table 6. Cranial Measurements (mm) of American White Males.

	N	Mean	Std Dev	Minimum	Maximum
GOL	243	187.60	7.39	164	211
BNL	244	105.37	4.80	86	120
BBH	240	140.88	5.45	112	155
XCB	241	141.28	5.81	125	158
WFB	242	97.34	4.70	82	111
ZYB	238	130.84	4.93	118	144
AUB	237	123.71	4.80	110	136
BPL	219	96.38	5.91	82	110
NLH	241	52.94	3.18	45	66
NLB	242	23.84	1.99	19	29
MAB	204	61.36	4.42	50	74
MAL	207	101.52	3.62	42	62
OBH	242	33.50	1.93	29	38
OBB	241	40.49	2.37	35	49
DKB	238	21.72	2.55	15	29
EKB	239	97.92	3.81	88	107
FRC	242	114.41	5.34	100	128
PAC	239	117.77	6.72	97	134
OCC	239	100.02	5.55	84	118
FOL	243	37.27	2.29	31	44
FOB	225	31.60	2.11	27	39
UFHT	200	71.45	4.26	60	83

Table 7. Within-class Covariance Matrix for Bosnians.

Variable	GOL	BNL	BBH	XCB	WFB	ZYB
GOL	44.81960396	9.81277228	3.98089109	2.83227723	13.42386139	7.74128713
BNL	9.81277228	15.94059406	7.82376238	-0.88594059	4.46297030	3.73099010
BBH	3.98089109	7.82376238	27.09049505	4.82237624	3.21881188	3.67960396
XCB	2.83227723	-0.88594059	4.82237624	26.69940594	11.24029703	8.31009901
WFB	13.42386139	4.46297030	3.21881188	11.24029703	27.83485149	6.18495050
ZYB	7.74128713	3.73099010	3.67960396	8.31009901	16.18495050	25.86831683
AUB	1.67584158	3.16910891	4.18435644	11.95891089	10.41554455	9.02851485
BPL	7.95138614	14.91029703	5.86188119	-1.72297030	2.65148515	5.44049505
NLH	3.76782178	2.29524752	0.45990099	3.65752475	7.19623762	6.04207921
NLB	1.47425743	0.50019802	-0.64207921	0.68801980	3.94099010	4.66366337
MAB	-4.08792079	2.93544554	-0.17217822	2.65554455	3.90722772	5.79574257
MAL	4.92079208	6.50445545	3.16821782	-0.55455446	2.18227723	2.46742574
OBH	-0.46574257	-0.17980198	3.04792079	2.02801980	1.48099010	2.62366337
OBH	-0.18009901	2.25069307	3.72772277	2.50306931	3.56346535	4.83782178
DKB	7.07544554	0.60188119	-3.54475248	0.52118812	6.32940594	3.99980198
EKB	10.19534653	4.84257426	3.51297030	5.42425743	16.14287129	6.33762376
FRC	14.30495050	5.54534653	10.97386139	6.45653465	5.51673267	3.53891089
PAC	22.05227723	-0.17594059	7.77237624	7.68940594	7.92029703	3.70009901
OCC	13.84049505	4.35653465	10.19138614	0.78465347	3.20267327	0.89089109
FOL	4.71485149	3.59603960	3.02158416	-0.11039604	2.32019802	2.85673267
FOB	2.02801980	1.32386139	4.36445545	0.84138614	1.56930693	3.15643564
UFHT	4.14376238	4.02366337	3.32653465	6.06336634	6.87831683	5.64277228

Table 7 cont.

Variable	AUB	BPL	NLH	NLB	MAB	MAL
GOL	1.67584158	7.95138614	3.76782178	1.47425743	-4.08792079	4.92079208
BNL	3.16910891	14.91029703	2.29524752	0.50019802	2.93544554	6.50445545
BBH	4.18435644	5.86188119	0.45990099	-0.64207921	-0.17217822	3.16821782
XCB	11.95891089	-1.72297030	3.65752475	0.68801980	2.65554455	-0.55455446
WFB	10.41554455	2.65148515	7.19623762	3.94099010	3.90722772	2.18227723
ZYB	19.02851485	5.44049505	6.04207921	4.66366337	5.79574257	2.46742574
AUB	24.48633663	2.13455446	4.21712871	3.63970297	6.93683168	1.51831683
BPL	2.13455446	31.12514851	1.22762376	0.55009901	3.64772277	14.30722772
NLH	4.21712871	1.22762376	22.13801980	1.30841584	1.80643564	4.40435644
NLB	3.63970297	0.55009901	1.30841584	3.48673267	1.80514851	0.90148515
MAB	6.93683168	3.64772277	1.80643564	1.80514851	16.52158416	3.12584158
MAL	1.51831683	14.30722772	0.40435644	0.90148515	3.12584158	2.61841584
OBH	2.89970297	-2.99990099	2.92841584	-0.06326733	-0.32485149	-1.36851485
OBH	4.62396040	2.03534653	1.80445545	0.74356436	1.86801980	1.11019802
DKB	0.05217822	1.80594059	1.98495050	0.86396040	-0.08108911	0.53910891
EKB	10.57613861	5.51128713	4.89940594	4.19752475	4.59693069	3.08930693
FRC	1.28198020	3.22267327	3.73722772	-0.17821782	-2.67099010	3.75009901
PAC	1.60891089	-1.39297030	2.73752475	0.87801980	-2.21445545	-0.37455446
OCC	1.56019802	4.12326733	-2.09227723	0.67217822	-3.81009901	3.86900990
FOL	2.53594059	3.54801980	1.81168317	0.09534653	1.24702970	2.89029703
FOB	3.32920792	1.21693069	0.15910891	0.34128713	0.37039604	1.04396040
UFHT	5.15950495	0.51683168	13.04069307	0.32455446	2.46524752	0.98247525

Table 7 cont.

Variable	OBH	OBB	DKB	EKB	FRC	PAC
GOL	-0.46574257	-0.18009901	7.07544554	10.19534653	14.30495050	22.05227723
BNL	-0.17980198	2.25069307	0.60188119	4.84257426	5.54534653	-0.17594059
BBH	3.04792079	3.72772277	-3.54475248	3.51297030	10.97386139	7.77237624
XCB	2.02801980	2.50306931	0.52118812	5.42425743	6.45653465	7.68940594
WFB	1.48099010	3.56346535	6.32940594	16.14287129	5.51673267	7.92029703
ZYB	2.62366337	4.83782178	3.99980198	16.33762376	3.53891089	3.70009901
AUB	2.89970297	4.62396040	0.05217822	10.57613861	1.28198020	1.60891089
BPL	-2.99990099	2.03534653	1.80594059	5.51128713	3.22267327	-1.39297030
NLH	2.92841584	1.80445545	1.98495050	4.89940594	3.73722772	2.73752475
NLB	0.06326733	0.74356436	0.86396040	4.19752475	-0.17821782	0.87801980
MAB	-0.32485149	1.86801980	-0.08108911	4.59693069	2.67099010	-2.21445545
MAL	-1.36851485	1.11019802	0.53910891	3.08930693	3.75009901	-0.37455446
OBH	5.20673267	2.97356436	-1.47603960	1.14752475	1.14178218	0.79801980
OBB	2.97356436	5.55247525	-1.70613861	4.19633663	2.89623762	-1.19693069
DKB	-1.47603960	-1.70613861	8.53762376	5.87148515	-0.02306931	4.93118812
EKB	1.14752475	4.19633663	5.87148515	19.83782178	2.15316832	3.54425743
FRC	1.14178218	2.89623762	-0.02306931	2.15316832	22.40811881	3.04653465
PAC	0.79801980	-1.19693069	4.93118812	3.54425743	3.04653465	44.97940594
OCC	0.25217822	0.84762376	-0.82930693	2.87831683	7.57881188	-3.24534653
FOL	0.40534653	0.87871287	1.27079208	2.50950495	0.98435644	0.29960396
FOB	0.50128713	0.86950495	0.90722772	2.51673267	1.07475248	2.14138614
UFHT	5.33455446	2.81594059	1.36326733	6.35920792	6.06297030	-1.57663366

Table 7 cont.

Variable	OCC	FOL	FOB	UFHT
GOL	3.84049505	4.71485149	2.02801980	4.14376238
BNL	4.35653465	3.59603960	1.32386139	4.02366337
BBH	10.19138614	3.02158416	4.36445545	3.32653465
XCB	0.78465347	-0.11039604	0.84138614	6.06336634
WFB	3.20267327	2.32019802	1.56930693	6.87831683
ZYB	0.89089109	2.85673267	3.15643564	5.64277228
AUB	1.56019802	2.53594059	3.32920792	5.15950495
BPL	4.12326733	3.54801980	1.21693069	0.51683168
NLH	-2.09227723	1.81168317	0.15910891	13.04069307
NLB	0.67217822	0.09534653	0.34128713	0.32455446
MAB	-3.81009901	1.24702970	0.37039604	2.46524752
MAL	3.86900990	2.89029703	1.04396040	0.98247525
OBH	0.25217822	0.40534653	0.50128713	5.33455446
OBB	0.84762376	0.87871287	0.86950495	2.81594059
DKB	-0.82930693	1.27079208	0.90722772	1.36326733
EKB	2.87831683	2.50950495	2.51673267	6.35920792
FRC	7.57881188	0.98435644	1.07475248	6.06297030
PAC	-3.24534653	0.29960396	2.14138614	-1.57663366
OCC	29.41188119	2.96643564	2.22247525	-0.44970297
FOL	2.96643564	6.11306931	3.01425743	0.56891089
FOB	2.22247525	3.01425743	5.09009901	0.70881188
UGHT	-0.44970297	0.56891089	0.70881188	22.03425743

Table 8. Within-class Covariance Matrix for Croatians.

Variable	GOL	BNL	BBH	XCB	WFB	ZYB
GOL	43.56676343	12.89840348	10.76269956	11.76850508	14.53991292	3.03011611
BNL	12.89840348	21.71480406	8.03084180	5.83889695	9.39912917	7.70500726
BBH	10.76269956	8.03084180	39.07547170	17.26052250	8.65203193	11.03447025
XCB	11.76850508	5.83889695	17.26052250	32.64005806	10.08526851	17.22605225
WFB	14.53991292	9.39912917	8.65203193	10.08526851	18.09869376	13.70174165
ZYB	13.03011611	7.70500726	11.03447025	17.22605225	13.70174165	30.16690856
AUB	15.86973875	10.10123367	13.68686502	19.71734398	11.46915820	24.81676343
BPL	19.16328012	19.32510885	4.17089985	1.98693759	9.21843251	4.86901306
NLH	4.15602322	5.82946299	4.77612482	6.57982583	-0.67888244	0.76415094
NLB	7.03301887	2.29172714	2.74238026	4.28120464	2.62989840	6.58962264
MAB	6.39187228	7.20718433	3.16400581	6.71480406	7.03193033	8.27793904
MAL	6.26052250	5.08599419	5.81857765	2.58454282	4.52322206	2.86647315
OBH	0.01705370	1.57438316	-1.23766328	-1.17597968	-0.89804064	-0.41799710
OBG	4.88896952	5.88969521	6.39840348	6.60195936	6.62300435	7.02830189
DKB	5.57510885	3.15493469	-1.65638607	3.77322206	2.89586357	4.26705370
EKB	7.98004354	8.06966618	0.97206096	4.98621190	11.62373004	12.62989840
FRC	14.33272859	3.13497823	11.14658926	10.78338171	7.68323657	9.03773585
PAC	23.82256894	2.89876633	18.81313498	9.45573295	13.72314949	10.22169811
OCC	18.20428157	5.13896952	13.52830189	19.65058055	7.10268505	8.14513788
FOL	8.13715530	2.64078374	2.91509434	1.24056604	2.57656023	1.58381713
FOB	4.95827286	1.85195936	6.76850508	3.74564586	1.79716981	1.58454282
UFHT	4.47133527	6.04027576	5.25217707	11.18613933	0.78156749	2.66944848

Table 8 cont.

Variable	AUB	BPL	NLH	NLB	MAB	MAL
GOL	15.86973875	19.16328012	4.15602322	7.03301887	6.39187228	6.26052250
BNL	10.10123367	19.32510885	5.82946299	2.29172714	7.20718433	5.08599419
BBH	13.68686502	4.17089985	4.77612482	2.74238026	3.16400581	5.81857765
XCB	19.71734398	1.98693759	6.57982583	4.28120464	6.71480406	2.58454282
WFB	11.46915820	9.21843251	-0.67888244	2.62989840	7.03193033	4.52322206
ZYB	24.81676343	4.86901306	0.76415094	6.58962264	8.27793904	2.86647315
AUB	33.84978229	10.71298984	7.02104499	5.88969521	16.67271408	7.43505080
BPL	10.71298984	44.82365747	2.11611030	3.78664731	10.39985486	18.76632801
NLH	7.02104499	2.11611030	13.72206096	1.09869376	3.83635704	0.70791001
NLB	5.88969521	3.78664731	1.09869376	5.59941945	1.39949202	1.04753266
MAB	16.67271408	10.39985486	3.83635704	1.39949202	25.73657475	7.98149492
MAL	7.43505080	18.76632801	-0.70791001	1.04753266	7.98149492	22.28374456
OBH	-0.90566038	-1.61611030	3.66255443	-0.57946299	-1.77866473	-2.82329463
OBG	8.48439768	2.90529753	2.23258345	1.29354136	3.98040639	2.28120464
DKB	2.41835994	3.15965167	-0.47351234	1.50108853	-0.77068215	-0.45210450
EKB	8.94811321	9.04462990	-1.15094340	3.33889695	4.75326560	4.50761974
FRC	6.79970972	2.95065312	-2.40783745	2.53882438	0.10849057	1.26596517
PAC	9.72714078	7.74854862	0.01741655	4.45645864	-2.36502177	6.41110305
OCC	16.44267054	7.31168360	5.39441219	4.71589260	7.66727141	2.73004354
FOL	4.09506531	2.62264151	3.10522496	2.10232221	-0.29027576	0.90602322
FOB	5.87227866	1.42198839	3.43613933	1.65965167	1.90892598	2.62082729
UFHT	8.24854862	3.31095791	13.01850508	0.04027576	7.06168360	2.29136430

Table 8 cont.

Variable	OBH	OB	DKB	EKB	FRC	PAC
GOL	0.01705370	4.88896952	5.57510885	7.98004354	14.33272859	3.82256894
BNL	1.57438316	5.88969521	3.15493469	8.06966618	3.13497823	2.89876633
BBH	-1.23766328	6.39840348	-1.65638607	0.97206096	11.14658926	8.81313498
XCB	-1.17597968	6.60195936	3.77322206	4.98621190	10.78338171	9.45573295
WFB	-0.89804064	6.62300435	2.89586357	11.62373004	7.68323657	3.72314949
ZYB	-0.41799710	7.02830189	4.26705370	12.62989840	9.03773585	0.22169811
AUB	-0.90566038	8.48439768	2.41835994	8.94811321	6.79970972	9.72714078
BPL	-1.61611030	2.90529753	3.15965167	9.04462990	2.95065312	7.74854862
NLH	3.66255443	2.23258345	-0.47351234	-1.15094340	-2.40783745	0.01741655
NLB	-0.57946299	1.29354136	1.50108853	3.33889695	2.53882438	4.45645864
MAB	-1.77866473	3.98040639	-0.77068215	4.75326560	0.10849057	-2.36502177
MAL	-2.82329463	2.28120464	-0.45210450	4.50761974	1.26596517	6.41110305
OBH	6.22206096	1.34433962	0.24274311	-0.23367199	-1.39985486	-2.07510885
OB	1.34433962	8.08055152	0.34143687	6.04426705	0.29970972	4.36175617
DKB	0.24274311	0.34143687	7.98113208	5.29245283	3.37191582	3.65856313
EKB	-0.23367199	6.04426705	5.29245283	15.98621190	1.18722787	7.26342525
FRC	-1.39985486	0.29970972	3.37191582	1.18722787	20.69448476	12.23875181
PAC	-2.07510885	4.36175617	3.65856313	7.26342525	12.23875181	44.92670537
OCC	-1.35595065	4.50036284	-0.69085631	1.38134978	5.41074020	-1.26959361
FOL	0.76015965	2.71044993	0.18795356	1.22641509	-0.61901306	3.30079826
UFHT	3.55841800	3.71008708	1.74419448	1.45537010	-3.10449927	-1.19085631

Table 8 cont.

Variable	OCC	FOL	FOB	UFHT
GOL	18.20428157	8.13715530	4.95827286	4.47133527
BNL	5.13896952	2.64078374	1.85195936	6.04027576
BBH	13.52830189	2.91509434	6.76850508	5.25217707
XCB	19.65058055	1.24056604	3.74564586	11.18613933
WFB	7.10268505	2.57656023	1.79716981	0.78156749
ZYB	8.14513788	1.58381713	1.58454282	2.66944848
AUB	16.44267054	4.09506531	5.87227866	8.24854862
BPL	7.31168360	2.62264151	1.42198839	3.31095791
NLH	5.39441219	3.10522496	3.43613933	13.01850508
NLB	4.71589260	2.10232221	1.65965167	0.04027576
MAB	7.66727141	-0.29027576	1.90892598	7.06168360
MAL	2.73004354	0.90602322	-2.62082729	2.29136430
OBH	-1.35595065	0.76015965	0.85232221	3.55841800
OB	4.50036284	2.71044993	2.83381713	3.71008708
DKB	-0.69085631	0.18795356	-1.72242380	1.74419448
EKB	1.38134978	1.68287373	1.22641509	1.45537010
FRC	5.41074020	0.90239478	-0.61901306	-3.10449927
PAC	-1.26959361	5.11647315	3.30079826	-1.19085631
OCC	54.12119013	4.55950653	5.61030479	12.13062409
FOL	4.55950653	7.35994194	4.61139332	2.49274311
FOB	5.61030479	4.61139332	8.67271408	2.82801161
UFHT	12.13062409	2.49274311	2.82801161	25.05442671

Table 9. Within-class Covariance Matrix for American Whites.

Variable	GOL	BNL	BBH	XCB	WFB	ZYB
GOL	54.94057395	19.57055188	16.65324503	0.20114790	8.85955850	6.93337748
BNL	19.57055188	23.91655629	12.79735099	0.72110375	5.46675497	7.04132450
BBH	16.65324503	12.79735099	31.18975717	2.97315673	4.64878587	4.31178808
XCB	0.20114790	0.72110375	2.97315673	33.10896247	11.33911700	13.92008830
WFB	8.85955850	5.46675497	4.64878587	11.33911700	22.31726269	9.32560706
ZYB	6.93337748	7.04132450	4.31178808	13.92008830	9.32560706	25.33077263
AUB	3.65086093	5.71249448	2.99986755	16.41505519	9.17933775	19.33673289
BPL	18.36286976	20.94609272	9.43289183	3.23907285	5.23112583	7.79355408
NLH	4.13037528	3.83792494	1.10353201	0.54075055	1.97766004	3.96490066
NLB	1.60560706	2.07487859	1.17041943	0.79121413	0.67209713	2.84812362
MAB	9.29439294	7.63178808	6.73624724	0.78211921	2.92790287	7.03854305
MAL	10.96362031	8.99527594	6.01995585	2.24057395	3.05311258	4.21668874
OBH	1.08229581	0.49554084	-1.60035320	1.76459161	2.74490066	2.56017660
OBH	5.47196468	3.65894040	1.22790287	2.67059603	4.36618102	5.28604857
DKB	-1.07796909	0.60092715	0.30891832	3.23739514	3.43792494	3.40887417
EKB	6.85894040	6.18821192	2.59041943	7.13788079	10.88543046	12.54145695
FRC	19.48790287	3.01708609	10.36339956	4.29580574	4.53033113	2.08830022
PAC	29.03995585	5.13867550	12.62154525	-1.98675497	4.14772627	3.28922737
OCC	19.54476821	7.90304636	15.34644592	8.64953642	4.81222958	3.99011038
FOL	4.83796909	2.14573951	1.09774834	-0.29072848	0.62207506	2.97112583
FOB	2.94370861	1.95125828	1.70353201	1.82741722	1.80432671	3.67156733
UFHT	8.38379691	3.90724062	2.36044150	1.80759382	4.64887417	5.51311258

Table 9 cont.

Variable	AUB	BPL	NLH	NLB	MAB	MAL
GOL	3.65086093	18.36286976	4.13037528	1.60560706	9.29439294	10.96362031
BNL	5.71249448	20.94609272	3.83792494	2.07487859	7.63178808	8.99527594
BBH	2.99986755	9.43289183	1.10353201	1.17041943	6.73624724	6.01995585
XCB	16.41505519	3.23907285	0.54075055	0.79121413	0.78211921	2.24057395
WFB	9.17933775	5.23112583	1.97766004	0.67209713	2.92790287	3.05311258
ZYB	19.33673289	7.79355408	3.96490066	2.84812362	7.03854305	4.21668874
AUB	23.04962472	7.14763797	2.73222958	1.62507726	5.48158940	3.85876380
BPL	7.14763797	33.92768212	1.72520971	1.06136865	12.26529801	15.91143488
NLH	2.73222958	1.72520971	8.53165563	0.96238411	1.16428256	1.35518764
NLB	1.62507726	1.06136865	0.96238411	4.29836645	1.52163355	0.04613687
MAB	5.48158940	12.26529801	1.16428256	1.52163355	20.11169978	8.26052980
MAL	3.85876380	15.91143488	1.35518764	0.04613687	8.26052980	12.48847682
OBH	2.15011038	-1.13518764	2.36816777	0.24909492	-1.36909492	-0.43885210
OBH	4.31461369	2.54649007	2.16807947	1.04816777	1.07183223	1.83598234
DKB	2.95637969	0.63015453	0.57209713	1.04035320	0.48631347	-0.15231788
EKB	9.39174393	6.89470199	3.52238411	2.77169978	5.65496689	3.34613687
FRC	0.99518764	-0.58715232	0.59055188	1.08079470	4.10587196	1.02061810
PAC	0.67660044	7.73311258	1.10843267	0.42520971	1.75479029	5.50331126
OCC	2.66048565	5.72384106	0.94927152	0.87735099	6.54264901	4.66238411
FOB	2.30362031	1.36317881	1.20123620	0.27298013	0.08035320	0.92565121
FOL	2.98556291	0.04520971	0.90498896	0.26905077	0.69094923	0.54852097
UFHT	5.21902870	3.19898455	9.14812362	-0.26136865	3.16136865	4.65523179

Table 9 cont.

Variable	OBH	OBB	DKB	EKB	FRC	PAC
GOL	1.08229581	5.47196468	-1.07796909	6.85894040	19.48790287	29.03995585
BNL	0.49554084	3.65894040	0.60092715	6.18821192	3.01708609	5.13867550
BBH	-1.60035320	1.22790287	0.30891832	2.59041943	10.36339956	12.62154525
XCB	1.76459161	2.67059603	3.23739514	7.13788079	4.29580574	-1.98675497
WFB	2.74490066	4.36618102	3.43792494	10.88543046	4.53033113	4.14772627
ZYB	2.56017660	5.28604857	3.40887417	12.54145695	2.08830022	3.28922737
AUB	2.15011038	4.31461369	2.95637969	9.39174393	0.99518764	0.67660044
BPL	-1.13518764	2.54649007	0.63015453	6.89470199	-0.58715232	7.73311258
NLH	2.36816777	2.16807947	0.57209713	3.52238411	0.59055188	1.10843267
NLB	0.24909492	1.04816777	1.04035320	2.77169978	1.08079470	0.42520971
MAB	-1.36909492	1.07183223	0.48631347	5.65496689	4.10587196	1.75479029
MAL	-0.43885210	1.83598234	-0.15231788	3.34613687	1.02061810	5.50331126
OBH	3.56918322	1.71452539	0.02145695	2.48242826	0.56494481	-1.32684327
OBB	1.71452539	5.80582781	0.00490066	5.25483444	2.90935982	0.58061810
DKB	0.02145695	0.00490066	5.98154525	2.42701987	-0.69818985	0.08445916
EKB	2.48242826	5.25483444	2.42701987	12.92503311	2.98079470	0.65854305
FRC	0.56494481	2.90935982	-0.69818985	2.98079470	28.03240618	5.95836645
PAC	-1.32684327	0.58061810	0.08445916	0.65854305	5.95836645	47.93077263
OCC	-0.00092715	2.93991170	-0.73492274	3.64401766	10.00975717	0.27655629
FOL	0.39187638	2.12843267	-0.67487859	1.47964680	1.02485651	3.65554084
FOB	1.06150110	1.74807947	-0.85456954	2.30238411	0.86388521	0.52176600
UFHT	3.39518764	3.44684327	0.18984547	4.87196468	3.34715232	3.71355408

Table 9 cont.

Variable	OCC	FOL	FOB	UFHT
GOL	19.54476821	4.83796909	2.94370861	8.38379691
BNL	7.90304636	2.14573951	1.95125828	3.90724062
BBH	15.34644592	1.09774834	1.70353201	2.36044150
XCB	8.64953642	-0.29072848	1.82741722	1.80759382
WFB	4.81222958	0.62207506	1.80432671	4.64887417
ZYB	3.99011038	2.97112583	3.67156733	5.51311258
AUB	2.66048565	2.30362031	2.98556291	5.21902870
BPL	5.72384106	1.36317881	0.04520971	3.19898455
NLH	0.94927152	1.20123620	0.90498896	9.14812362
NLB	0.87735099	0.27298013	0.26905077	-0.26136865
MAB	6.54264901	0.08035320	0.69094923	3.16136865
MAL	4.66238411	0.92565121	0.54852097	4.65523179
OBH	-0.00092715	0.39187638	1.06150110	3.39518764
OBB	2.93991170	2.12843267	1.74807947	3.44684327
DKB	-0.73492274	-0.67487859	-0.85456954	0.18984547
EKB	3.64401766	1.47964680	2.30238411	4.87196468
FRC	10.00975717	1.02485651	0.86388521	3.34715232
PAC	0.27655629	3.65554084	0.52176600	3.71355408
OCC	31.95858720	-0.46507726	2.42927152	1.02949227
FOL	-0.46507726	5.08821192	1.94790287	2.25682119
FOB	2.42927152	1.94790287	4.78498896	0.78812362
UFHT	1.02949227	2.25682119	0.78812362	19.18101545

Table 10. Mahalanobis Distance (D^2)*

	Bosnian	Croatian	Am. White
Bosnian	0		
Croatian	4.35	0	
Am. White	10.45	7.97	0

* All groups Prob < 0.0001

Table 11. Significant Discriminant Functions.

No.	Eigenvalue	Cumulative %	Proportion	Canonical Correlation	Likelihood Ratio	Approx F	DF	Pr > F
1	2.236	0.836	0.836	0.831	0.215	14.79	44	0.0001
2	0.439	1.000	0.164	0.510	0.695	5.90	21	0.0001

The total canonical structure indicates that the variation on the first canonical axis is related to vault shape (Table 12). American Whites have long, narrow, and high cranial vaults in contrast to Croatsians and Bosnians, which have shorter, broader, and lower vaults. The second canonical axis separates Croatsians from Bosnians. Croatsians have wide orbits and short palates, while Bosnians and American Whites demonstrate narrow orbits and long palates. Figure 5 is a graphical representation of the class means on canonical variables illustrating the variation among the three groups. The cranial difference between Bosnian-Croatian and American Whites suggest that identification criteria based on American Whites should not be applied to Eastern Europeans.

Next, a separate two-group Bosnian-Croatian discriminant function analysis using the variables (OBB, MAL, MAB, BNL, NLH, FOL, OCC, DKB, WFB, and UFHT) that were selected by the stepwise procedure was performed. The results indicate that the difference between Croatsians and Bosnians is sufficient to correctly allocate them at a rate of over 80%. The correct classification rate using crossvalidation for Bosnian is 84.16%, and 79.25% for Croatsians for a total correct classification rate of 81.7% (Table 13). Linear discriminant function coefficients and constant or classification criteria used for allocating Croatsians and Bosnians are presented in Table 14.

Table 12. Total Canonical Structure for Bosnians, Croatians, and American Whites.

	CAN1	CAN2
GOL	0.624056	0.010833
BNL	0.414771	-0.330429
BBH	0.250499	0.017026
XCB	-0.724033	-0.345725
WFB	-0.281860	-0.061576
ZYB	-0.457407	-0.245398
AUB	-0.535546	-0.135110
BPL	0.225168	-0.038775
NLH	0.046618	-0.224097
NLB	-0.059907	-0.310652
MAB	-0.120165	0.224320
MAL	0.155113	0.415258
OHB	0.144652	-0.237102
OB	0.328452	-0.413771
DKB	-0.280644	-0.257673
EKB	0.150336	-0.260269
FRC	0.110297	0.038593
PAC	0.487785	0.242321
OCC	0.513385	-0.115760
FOL	-0.062725	0.120313
FOB	-0.107839	-0.061665
UFHT	-0.188600	0.11386

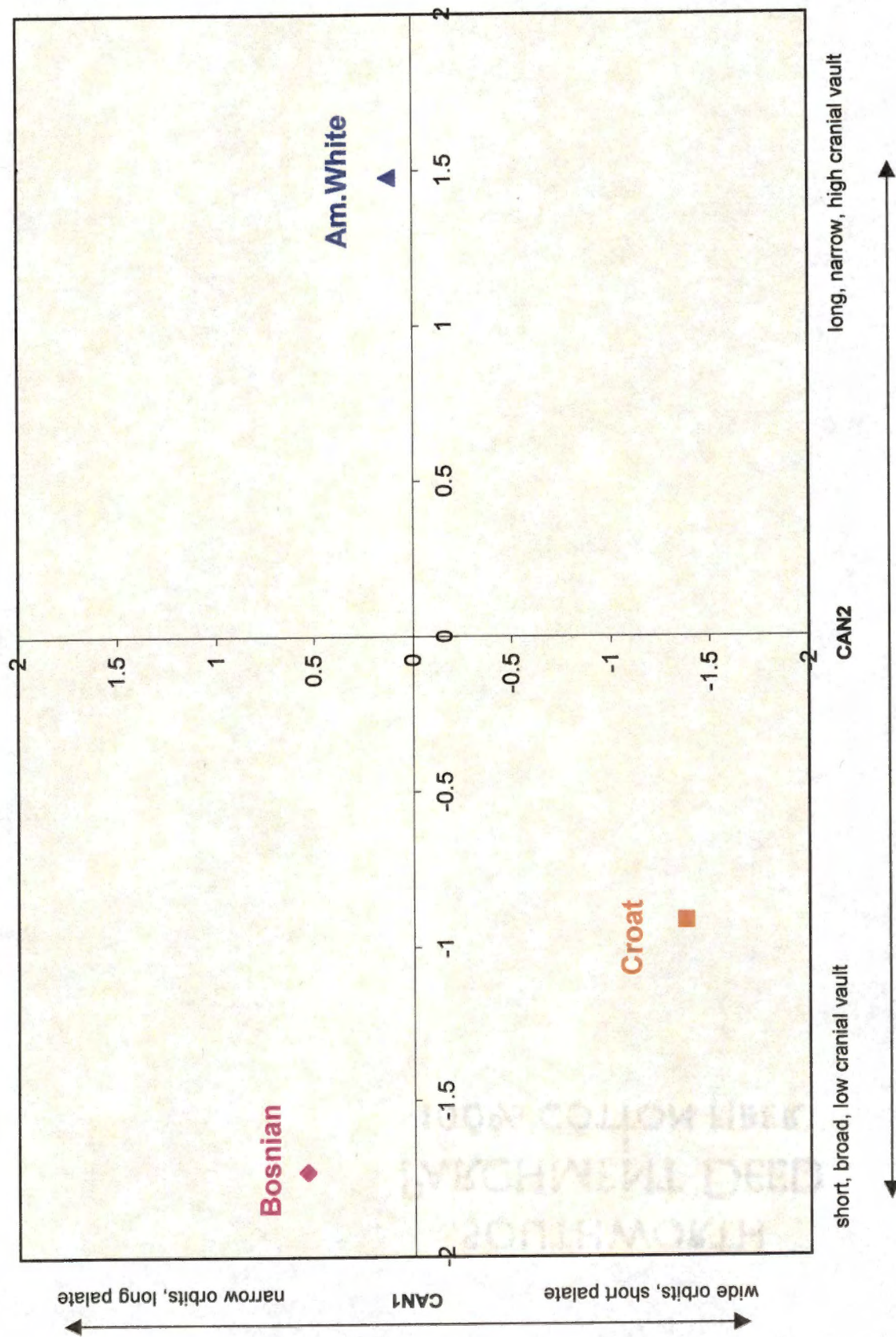


Figure 5- Class Means on Canonical Variables.

Table 13. Classification Summary of Crossvalidated Linear Discriminant Function. Number of Observations and Percent Classified into Group.

Group	Into Bosnian	Into Croatian	Total
From Bosnian	85 84.16%	16 15.84%	101 100%
From Croatian	11 20.75%	42 79.25%	53 100%
Total	96 62.34%	58 37.66%	154 100%
Priors	0.5	0.5	

Table 14. Linear Discriminant Function for Bosnian and Croatian Classification.

Constant	13.69384
OBB	-0.101497
MAL	0.2079
MAB	0.09305
BNL	-0.27924
NLH	-0.22436
FOL	0.32603
OCC	-0.10831
DKB	-0.27754
WFB	0.16834
UFHT	0.26475
Bosnian Mean	2.08
Croatian Mean	-2.08

If the number is positive it would classify as Bosnian and if the number is negative it would classify as Croatian. This discriminant function would be a useful tool to separate Bosnians and Croatians in a situation of commingled or unknown ancestry.

b. Regional Analyses (multiple groups using raw measures).

For the next part of this investigation craniofacial variation among Bosnians, Croatians (contemporary, from the 1930's, and from WWII, were treated as separate groups), American Whites, Greeks, and Macedonians was examined using both raw and newly derived shape variables. Descriptive summary statistics for raw and shape variables are presented in Tables 15-21 (see Tables 4-6 for Bosnian, Croatian, and American white raw measures).

The D^2 values are presented in Table 22. It is clear that the populations that are furthest removed from the rest are Macedonians and Greeks. This disparity is probably due in large part to significant size differences that reflect secular changes observed among populations of different temporal periods. Among the recent eastern European populations Bosnians are closest to WWII Croatians than to contemporary Croatians. Croatians from the 1930's are the furthest removed from all recent eastern European populations. American

Table 15. Transformed Variables for Bosnians (Shape and Size).

	N	Mean	Std Dev	Minimum	Maximum
GOLS	101	2.4787	0.0818	2.2470	2.675
BNLS	101	1.4085	0.0485	1.2495	1.5083
BBHS	101	1.9297	0.0711	1.7348	2.0581
XCBS	101	2.0840	0.0733	1.9279	2.2732
WFBS	101	1.3878	0.0554	1.2491	1.4953
ZYBS	101	1.8737	0.0508	1.7217	1.9795
AUBS	101	1.7935	0.0579	1.6084	1.9531
BPLS	101	1.3099	0.0709	1.1647	1.5245
NLHS	101	0.7222	0.0596	0.4274	0.8762
NLBS	101	0.3301	0.0235	0.2791	0.3931
MABS	101	0.8719	0.05426	0.7444	1.0002
MALS	101	0.7385	0.0451	0.6177	0.8384
OBHS	101	0.4556	0.0305	0.3944	0.5895
OBBS	101	0.5360	0.0294	0.4725	0.6596
DKBS	101	0.3169	0.0378	0.2399	0.4387
EKBS	101	1.3402	0.0427	1.1873	1.4179
FRCS	101	1.5773	0.0630	1.3898	1.7244
PACS	101	1.5545	0.0910	1.3210	1.8175
OCCS	101	1.3026	0.0742	1.0961	1.4876
FOLS	101	0.5254	0.0299	0.4637	0.5991
FOBS	101	0.4441	0.0283	0.3668	0.5072
UFHTS	101	1.0189	0.0569	0.9161	1.2045
SIZE	101	71.8178	1.8902	67.5015	76.1251
VAULTSIZE	101	123.9169	3.0838	116.2371	132.1931
FACESIZE	101	48.9352	1.9921	43.2468	54.1903

Table 16. Transformed Variables for Croatians (Shape and Size).

	N	Mean	Std Dev	Minimum	Maximum
GOLS	53	2.4874	0.06887	2.3582	2.6548
BNLS	53	1.4454	0.0517	1.3583	1.5542
BBHS	53	1.9197	0.0786	1.6683	2.0816
XCBS	53	2.0879	0.0653	1.9198	2.2475
WFBS	53	1.3742	0.0459	1.2781	1.4869
ZYBS	53	1.8721	0.06138	1.7399	1.9992
AUBS	53	1.7755	0.0539	1.6140	1.8883
BPLS	53	1.3119	0.0790	1.1513	1.5425
NLHS	53	0.7360	0.0458	0.6232	0.8293
NLBS	53	0.3407	0.0283	0.2799	0.4097
MABS	53	0.8382	0.0637	0.6788	0.9786
MALS	53	0.6999	0.0592	0.5773	0.8127
OBHS	53	0.4652	0.0357	0.3814	0.5623
OBBS	53	0.5608	0.0310	0.4944	0.6410
DKBS	53	0.3252	0.0372	0.2249	0.4056
EKBS	53	1.3562	0.0471	1.2512	1.4453
FRCS	53	1.5632	0.0666	1.4391	1.7648
PACS	53	1.5235	0.0832	1.3251	1.6826
OCCS	53	1.3286	0.0899	1.1550	1.5704
FOLS	53	0.5135	0.0325	0.4437	0.5756
FOBS	53	0.4418	0.0361	0.3280	0.5149
UFHTS	53	0.9930	0.0611	0.8721	1.1358
SIZE	53	72.4473	2.2620	66.2956	76.8586
VAULTSIZE	53	125.1446	3.8782	116.9785	133.7216
FACESIZE	53	50.1506	1.9940	45.3882	54.3074

Table 17. Transformed Variables for American Whites (Shape and Size).

	N	Mean	Std Dev	Minimum	Maximum
GOLS	151	2.5938	0.0816	2.4022	2.7516
BNLS	151	1.4606	0.0531	1.2584	1.5992
BBHS	151	1.9558	0.7136	1.5663	2.1143
XCBS	151	1.9582	0.0767	1.8012	2.1523
WFBS	151	1.3487	0.0543	1.2233	1.4927
ZYBS	151	1.8085	0.05031	1.6925	1.9551
AUBS	151	1.7144	0.0530	1.5863	1.8624
BPLS	151	1.3383	0.0683	1.1846	1.5078
NLHS	151	0.7277	0.0354	0.6249	0.8077
NLBS	151	0.3287	0.0267	0.2642	0.3937
MABS	151	0.8493	0.0548	0.7048	1.0010
MALS	151	0.7423	0.0416	0.6433	0.8539
OBHS	151	0.4638	0.0252	0.4102	0.5199
OBBS	151	0.5602	0.0271	0.5082	0.6580
DKBS	151	0.2998	0.0324	0.1992	0.4075
EKBS	151	1.3545	0.0332	1.2808	1.4343
FRCS	151	1.5830	0.0720	1.4544	1.7871
PACS	151	1.6295	0.0926	1.3279	1.8505
OCCS	151	1.3833	0.0722	1.1954	1.6596
FOLS	151	0.5181	0.0292	0.4479	0.6013
FOBS	151	0.4366	0.0281	0.3639	0.5451
UFHTS	151	0.9901	0.0528	0.8587	1.1265
SIZE	151	72.1414	1.9006	67.0312	77.3364
VAULTSIZE	207	124.0869	3.4317	112.7430	134.5999
FACESIZE	185	48.9392	1.7595	44.2795	54.2720

Table 18. Raw and Transformed Variables of 1930's Croatians.

	N	Mean	Std Dev	Minimum	Maximum
GOL	6	181.00	7.07	173	190
BNL	6	99.67	4.84	91	103
BBH	6	137.33	3.44	131	140
XCB	6	150.17	5.74	142	156
WFB	6	101.67	4.32	99	109
ZYB	6	135.50	5.09	127	142
AUB	6	126.17	5.49	117	133
BPL	6	93.17	4.79	85	97
NLH	6	53.17	3.06	50	58
NLB	6	23.33	1.97	20	26
MAB	4	61.25	2.99	58	65
MAL	6	53.83	4.22	50	60
OBH	6	33.83	2.86	29	38
OBG	6	40.50	3.02	36	44
DKB	6	20.67	1.86	19	24
EKB	6	99.00	3.03	95	103
FRC	6	117.83	4.45	112	123
PAC	6	114.17	8.50	104	123
OCC	6	95.33	5.75	85	101
FOL	5	38.20	2.17	36	41
FOB	5	30.80	2.17	29	34
UFHT	5	70.60	3.05	67	75
GOLS	4	2.4815	0.0821	2.4255	2.5995
BNLS	4	1.3948	0.0507	1.3266	1.4441
BBHS	4	1.8986	0.0637	1.8054	1.9488
XCBS	4	2.1157	0.0312	2.0750	2.1456

Table 18 cont.

WFBS	4	1.4221	0.0642	1.3540	1.4992
ZYBS	4	1.9019	0.0425	1.8600	1.9570
AUBS	4	1.7742	0.0495	1.7089	1.8293
BPLS	4	1.3050	0.0510	1.2404	1.3600
NLHS	4	0.7386	0.0433	0.7014	0.7993
NLBS	4	0.3314	0.0187	0.3163	0.3556
MABS	4	0.8457	0.0408	0.7993	0.8890
MALS	4	0.7595	0.0672	0.6891	0.8206
OBHS	4	0.4657	0.0478	0.4066	0.5237
OBBS	4	0.5728	0.0328	0.5328	0.6064
DKBS	4	0.2728	0.0145	0.2599	0.2894
EKBS	4	1.3807	0.0364	1.3403	1.4167
FRCS	4	1.6359	0.0457	1.4581	1.6822
PACS	4	1.5629	0.1201	1.4581	1.6822
OCCS	4	1.3014	0.0908	1.1715	1.3677
FOLS	4	0.5352	0.0321	0.5060	0.5651
FOBS	4	0.4317	0.0351	0.3966	0.4767
UFHTS	4	0.9699	0.0437	0.9394	1.0336
SIZE	4	72.4272	0.7714	71.3255	73.1170
VAULTSIZE	6	123.6972	3.1329	118.5325	128.1673
FACESIZE	5	49.1547	1.6909	46.9211	51.6797

Table 19. Raw and Transformed Variables of WWII Croatians.

	N	Mean	Std Dev	Minimum	Maximum
GOL	24	176.46	3.55	169	184
BNL	24	100.96	3.86	92	108
BBH	26	136.23	6.66	124	151
XCB	25	148.88	6.04	138	164
WFB	24	97.88	3.71	91	104
ZYB	23	133.17	4.28	125	142
AUB	23	126.26	5.50	115	136
BPL	24	95.46	4.77	86	105
NLH	28	51.50	2.80	47	56
NLB	26	23.65	2.02	20	28
MAB	26	63.04	3.59	54	71
MAL	28	52.54	3.07	45	71
OBH	26	33.42	2.10	29	38
OBG	26	39.46	2.10	35	43
DKB	25	21.88	2.24	18	25
EKB	24	96.21	2.86	89	101
FRC	23	111	5.84	101	119
PAC	26	109.23	5.10	96	117
OCC	25	93.40	5.26	84	111
FOL	27	37.48	2.23	33	42
FOB	27	30.78	2.22	27	36
UFHT	28	70.07	4.84	61	77
GOLS	21	2.4736	0.0540	2.3766	2.5405
BNLS	21	1.4202	0.0347	1.3606	1.4839
BBHS	21	1.9081	0.06806	1.7824	2.0609
XCBS	21	2.0979	0.0698	1.9699	2.2406

Table 19 cont.

WFBS	21	1.3759	0.0567	1.2697	1.4834
ZYBS	21	1.8651	0.0296	1.8145	1.9401
AUBS	21	1.7687	0.0535	1.6924	1.8581
BPLS	21	1.3418	0.0583	1.2160	1.4386
NLHS	21	0.7184	0.0315	0.6737	0.7813
NLBS	21	0.3340	0.0251	0.2836	0.3847
MABS	21	0.8921	0.0369	0.8398	0.9843
MALS	21	0.7397	0.0423	0.6352	0.8116
OBHS	21	0.4672	0.0267	0.3985	0.5090
OBBS	21	0.5486	0.0224	0.5080	0.5915
DKBS	21	0.3067	0.0306	0.2476	0.3484
EKBS	21	1.3481	0.0307	1.2734	1.4135
FRCS	21	1.5563	0.0643	1.4386	1.6497
PACS	21	1.5346	0.0667	1.3735	1.6403
OCCS	21	1.3214	0.0817	1.1816	1.5882
FOLS	21	0.5294	0.0280	0.4834	0.5782
FOBS	21	0.4360	0.0320	0.3840	0.4936
UFHTS	21	0.9802	0.0521	0.9129	1.0919
SIZE	21	71.2476	1.6333	67.9183	74.4764
VAULTSIZE	22	123.1428	2.8186	116.1866	126.8028
FACESIZE	22	48.5596	1.6180	45.6615	52.2559

Table 20. Raw and Transformed Variables of Greeks.

	N	Mean	Std Dev	Minimum	Maximum
GOL	32	179.59	5.76	165	192
BNL	29	101.28	4.67	95	111
BBH	29	130	5.73	116	142
XCB	32	139.09	5.35	129	150
WFB	31	96.81	5.07	89	109
ZYB	27	130.56	4.21	119	139
AUB	32	122.88	4.90	113	136
BPL	18	95.83	3.81	89	104
NLH	30	53.83	2.95	49	61
NLB	30	25.20	1.97	22	29
MAB	23	59.74	2.78	55	64
MAL	19	53.37	1.89	50	57
OBH	32	36.13	2.54	30	43
OBB	32	40.31	1.65	37	44
DKB	31	22.44	2.33	19	29
EKB	30	98.37	2.98	93	104
FRC	32	109.69	6.36	94	121
PAC	32	112.66	5.78	100	123
OCC	31	96.26	5.90	85	110
FOL	29	36.52	2.47	33	41
FOB	28	30.82	2.28	27	36
UFHT	19	71.42	3.56	64	81
GOLS	18	2.5144	0.0610	2.4130	2.6824
BNLS	18	1.4007	0.0363	1.3336	1.4515
BBHS	18	1.8095	0.0590	1.7296	1.9295
XCBS	18	1.9579	0.0724	1.8447	2.1228

Table 20 *cont.*

WFBS	18	1.3343	0.0456	1.2735	1.4295
ZYBS	18	1.8233	0.0458	1.7443	1.9050
AUBS	18	1.7217	0.0575	1.6357	1.8629
BPLS	18	1.3457	0.0512	1.2783	1.4435
NLHS	18	0.7550	0.0343	0.6849	0.8110
NLBS	18	0.3473	0.0252	0.3012	0.3908
MABS	18	0.8416	0.0336	0.7873	0.8932
MALS	18	0.7496	0.0227	0.7076	0.7915
OBHS	18	0.5006	0.0299	0.4537	0.5888
OBBS	18	0.5592	0.0203	0.5236	0.5896
DKBS	18	0.3065	0.0290	0.2602	0.3436
EKBS	18	1.3759	0.0315	1.3093	1.4177
FRCS	18	1.5453	0.0749	1.4490	1.7124
PACS	18	1.5911	0.0837	1.4577	1.7736
OCCS	18	1.3370	0.0720	1.2081	1.4860
FOLS	18	0.5185	0.0254	0.4782	0.5786
FOBS	18	0.4345	0.0229	0.3821	0.4691
UFHTS	18	1.0052	0.0405	0.9381	1.1133
SIZE	18	71.2265	1.5345	68.2221	73.6695
VAULTSIZE	18	119.9710	3.0456	114.7644	124.4311
FACESIZE	19	49.6731	1.4020	46.1890	52.6163

Table 21. Raw and Transformed Variables of Macedonians.

	N	Mean	Std Dev	Minimum	Maximum
GOL	11	176.82	6.85	166	189
BNL	11	101.36	3.32	96	107
BBH	11	135.09	7.25	121	146
XCB	11	134.36	1.69	132	137
WFB	11	94.64	4.46	88	103
ZYB	11	127.18	3.74	120	132
AUB	11	120.73	3.50	116	128
BPL	8	92.88	2.53	90	97
NLH	11	51.09	2.98	46	55
NLB	11	23.55	1.44	21	26
MAB	8	56	1.93	54	60
MAL	8	51.13	2.36	48	55
OBH	11	33.82	1.60	31	36
OBB	11	39.27	1.19	38	41
DKB	11	21.45	2.77	17	26
EKB	11	95.36	2.91	90	99
FRC	11	108.64	4.90	102	117
PAC	11	116.27	6.83	105	130
OCC	11	94.45	3.75	87	100
FOL	11	37.91	1.51	36	41
FOB	11	32.09	2.59	28	38
UFHT	8	66.25	2.96	62	72
GOLS	8	2.5376	0.1068	2.3620	2.6525
BNLS	8	1.4397	0.0456	1.3497	1.4870
BBHS	8	1.9222	0.0950	1.7222	2.0105
XCBS	8	1.9212	0.0440	1.8460	1.9723

Table 21 cont.

WFBS	8	1.3430	0.0521	1.2782	1.4088
ZYBS	8	1.8096	0.0411	1.7489	1.8846
AUBS	8	1.7134	0.0440	1.6655	1.7934
BPLS	8	1.3288	0.0333	1.2654	1.3664
NLHS	8	0.7223	0.0418	0.6704	0.7829
NLBS	8	0.3395	0.0189	0.3114	0.3656
MABS	8	0.8013	0.0302	0.7686	0.8453
MALS	8	0.7312	0.0245	0.6949	0.7634
OBHS	8	0.4827	0.0238	0.4494	0.5190
OBBS	8	0.5653	0.0209	0.5343	0.5932
DKBS	8	0.3052	0.0352	0.2521	0.3609
EKBS	8	1.3680	0.0254	1.3341	1.4091
FRCS	8	1.5643	0.0549	1.4815	1.6260
PACS	8	1.6624	0.0869	1.5571	1.8066
OCCS	8	1.3017	0.0686	1.2653	1.4385
FOLS	8	0.5437	0.0234	0.5135	0.5799
FOBS	8	0.4593	0.0386	0.3985	0.5281
UFHTS	8	0.9478	0.0390	0.8717	0.9993
SIZE	8	69.9080	1.6975	67.4337	72.0491
VAULTSIZE	8	118.8551	1.9933	116.7003	122.2112
FACESIZE	8	47.7725	1.9288	45.2455	51.1575

Table 22. Mahalanobis Distance Using Raw Variables (D²)

	Bosnian	Croatian	Croat 1930	WWII Croat	Greek	Macedonia	Am. white
Bosnian	0						
Croatian	5.0759	0					
Croat 1930	11.7366*	14.1926*	0				
WWII Croat	3.1976*	4.5889	9.3232	0			
Greek	20.1216	20.1552	22.7947	16.6924	0		
Macedonia	37.9912	37.9252	43.4794	37.5377	14.4587	0	
Am. white	10.9339	8.5435	18.0960	10.4265	11.8223	26.4625	0

All groups significant at Prob < 0.0001 level except * which are significant at Prob < 0.05 level.

Whites are closest to contemporary Croatians, then to WWII Croatians, followed by Bosnians.

The significant canonical roots are presented in Table 23 and the total canonical structure for CAN1, CAN2, and CAN3 are given in Table 24. Approximately sixty percent of the variation is accounted for on CAN1, twenty percent on CAN2, and ten percent on CAN3. Figure 6 is a plot of the first and second canonical axes. The plot of CAN1 and CAN2 using raw measures shows American Whites as having long, narrow and high cranial vaults with narrow faces. Macedonians have long and narrow vaults with narrow faces, but contrast with American Whites in that they have very low cranial vaults. Bosnians, by contrast, have broad, short, and high cranial vaults, and broad faces. Greeks show broad, short and somewhat low cranial vaults with broad faces. Croatians from the 1930's and WWII Croatians have relatively broad, short, and low cranial vaults. Contemporary Croatians, however, have longer and narrower cranial vaults than either Bosnians or earlier temporal Croatian groups, falling in-between them and American Whites. Conversely, contemporary Croatians show rather low cranial vaults in contrast to the other groups, with the exception of Macedonians. The first and third canonical axes are shown in Figure 7. The third canonical axis separates the groups according to nasal breadth, orbit breadth, and maxillo-alveolar length. Bosnians, 1930 Croatians, followed by American

Table 23. Significant Canonical Axes for Raw Measures.

No.	Eigenvalue	Cumulative %	Proportion	Canonical Correlation	Likelihood Ratio	Approx F	DF	Pr > F
1	2.357	0.565	0.565	0.839	0.070	7.58	138	0.0001
2	0.923	0.785	0.220	0.693	0.236	4.74	110	0.0001
3	0.447	0.891	0.106	0.556	0.454	3.24	84	0.0001

Table 24. Total Canonical Structure for Raw Measures.

Variable	Can1	Can2	Can3
GOL	0.545023	-0.438123	0.170796
BNL	0.321300	-0.554507	-0.137200
BBH	0.099332	-0.699447	0.282493
XCB	-0.754209	-0.210213	-0.269495
WFB	-0.320587	-0.202064	0.020973
ZYB	-0.476511	-0.157701	-0.182051
AUB	-0.535795	-0.161342	-0.061597
BPL	0.188878	-0.094524	-0.025711
NLH	0.057004	-0.028007	-0.218529
NLB	-0.027519	0.039815	-0.329978
MAB	-0.199944	-0.084050	0.229855
MAL	0.122502	0.087514	0.386512
OBH	0.187941	0.240481	-0.326979
OBB	0.294143	-0.219706	-0.359107
DKB	-0.248255	-0.118021	-0.204805
EKB	0.137431	-0.106941	-0.229982
FRC	0.043551	-0.313815	0.166737
PAC	0.468421	-0.145823	0.313522
OCC	0.450978	-0.332008	-0.006767
FOL	-0.071814	0.027263	0.116443
FOB	-0.087311	-0.099256	-0.004512
UFHT	-0.184670	-0.097385	0.162281

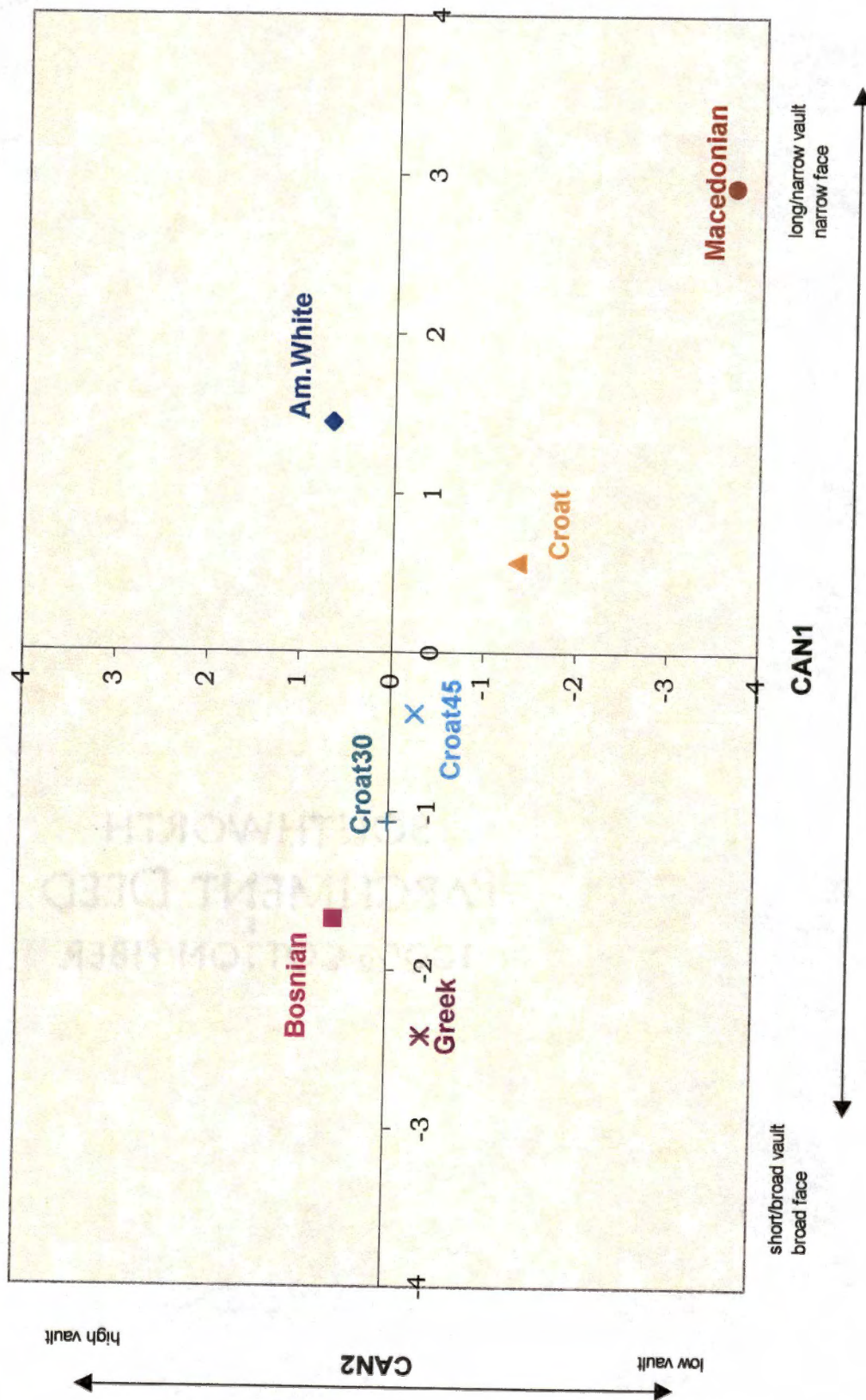


Figure 6- Class Means on CAN1 and CAN2 (raw measures).

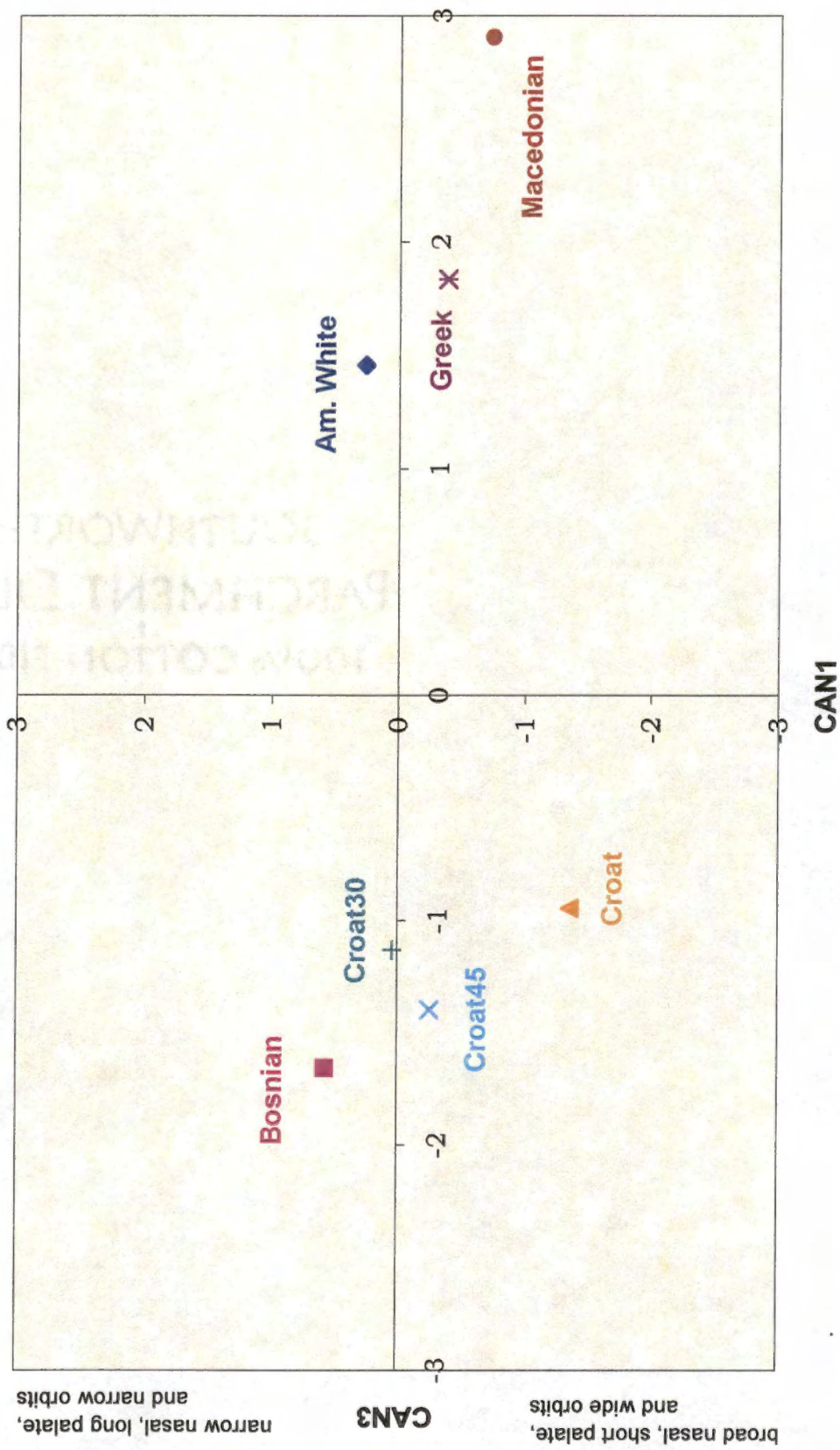


Figure 7- Class Means on CAN1 and CAN3 (raw measures).

Whites demonstrate narrow nasal breadth, long palates, and narrow orbits. Croatians have relatively broad nasal breadth, along with short palates and wide orbits compared to the other eastern European groups.

c. Regional Analyses (multiple groups using shape variables).

Refer to Tables 15-21 for descriptive summary statistics of the transformed shape variables. The ANOVA's for face and vault size yielded significant differences among the populations (R-square 0.0661, $PR > F$ 0.0002; R-square 0.1133, $PR > F$ 0.0001), respectively.

The significant canonical axes for the transformed shape variables are presented in Table 25, while the total canonical structure for CAN1, CAN2, and CAN3 are reported in Table 26. The first canonical axis accounts for roughly sixty-seven percent of the among-group variation, while approximately fourteen percent is accounted for on CAN2, and eleven percent on CAN3. These new variables, while they do not remove absolute size from the analysis provide a better insight into the "geometric similarity" among the populations. The plots of the canonical axes of the shape variables not surprisingly differ from the plots of the canonical variates of the raw measurements and are a more insightful representation of the among-group variation. The first canonical axis separates the groups with respect to vault shape, while the second axis

Table 25. Significant Canonical Axes for Transformed Shape variables.

No.	Eigenvalue	Cumulative %	Proportion	Canonical Correlation	Likelihood Ratio	Approx F	DF	Pr > F
1	2.388	0.664	0.664	0.840	0.106	6.85	132	0.0001
2	0.538	0.814	0.150	0.591	0.357	3.60	105	0.0001
3	0.381	0.920	0.106	0.525	0.550	2.67	80	0.0001

Table 26. Total Canonical Structure for Shape Variables.

Variable	Can1	Can2	Can3
GOLS	0.628538	0.320123	0.231468
BNLS	0.381801	0.478885	-0.152285
BBHS	0.094499	0.605038	0.322970
XCBS	-0.785576	0.000070	-0.235574
WFBS	-0.393113	0.034223	0.067082
ZYBS	-0.617460	-0.083512	-0.173683
AUBS	-0.651049	-0.044788	-0.015145
BPLS	0.213000	-0.062515	0.011344
NLHS	0.065971	-0.118786	-0.210733
NLBS	-0.026684	-0.171240	-0.327301
MABS	-0.218822	-0.055853	0.293709
MALS	0.137520	-0.224153	0.478809
OBHS	0.195972	-0.387552	-0.288598
OBBS	0.343604	0.084867	-0.396415
DKBS	-0.261879	0.052372	-0.209073
EKBS	0.191062	-0.157591	-0.256969
FRCS	0.038914	0.152329	0.209850
PACS	0.480849	0.056434	0.350332
OCCS	0.470704	0.228079	0.011169
FOLS	-0.073308	-0.165998	0.169309
FOBS	-0.094949	0.000771	0.019230
UFHTS	-0.213115	-0.035615	0.224959

isolates the groups on vault height. Figure 8 is a plot of the first and second canonical axes. This figure reveals that the variation observed in Figure 6 among the three Croatian groups, Bosnians, Greeks, and Macedonians, was primarily influenced by size. More intuitively, Figure 8 shows early Croatian samples (1930's and WWII), Bosnians and Croats as being more similar to each other than to American Whites, Greeks or Macedonians. Croats, Bosnians, and early Croatian groups have short, broad cranial vaults, and broad faces, while Croats have the greatest vault height. In contrast, American Whites, Macedonians, and Greeks, have long, narrow cranial vaults, and narrow faces. American Whites have higher vaults and Greeks have the lowest vault height. However, the variation observed among the populations along the third canonical axis using the shape variables is consistent with the variation observed using raw measures suggesting that the difference observed along CAN3 is not heavily influenced by size (see Figure 9). The three Croatian groups have wide orbits with short palates (in variable degrees) with contemporary Croats having the largest orbits and shortest palates. Bosnians differ from Croats showing narrow orbits and long palates. American Whites are similar to Bosnians having narrow orbits and long palates, while Macedonians and Greeks are more similar to Croatian groups exhibiting wide orbits and short palates.

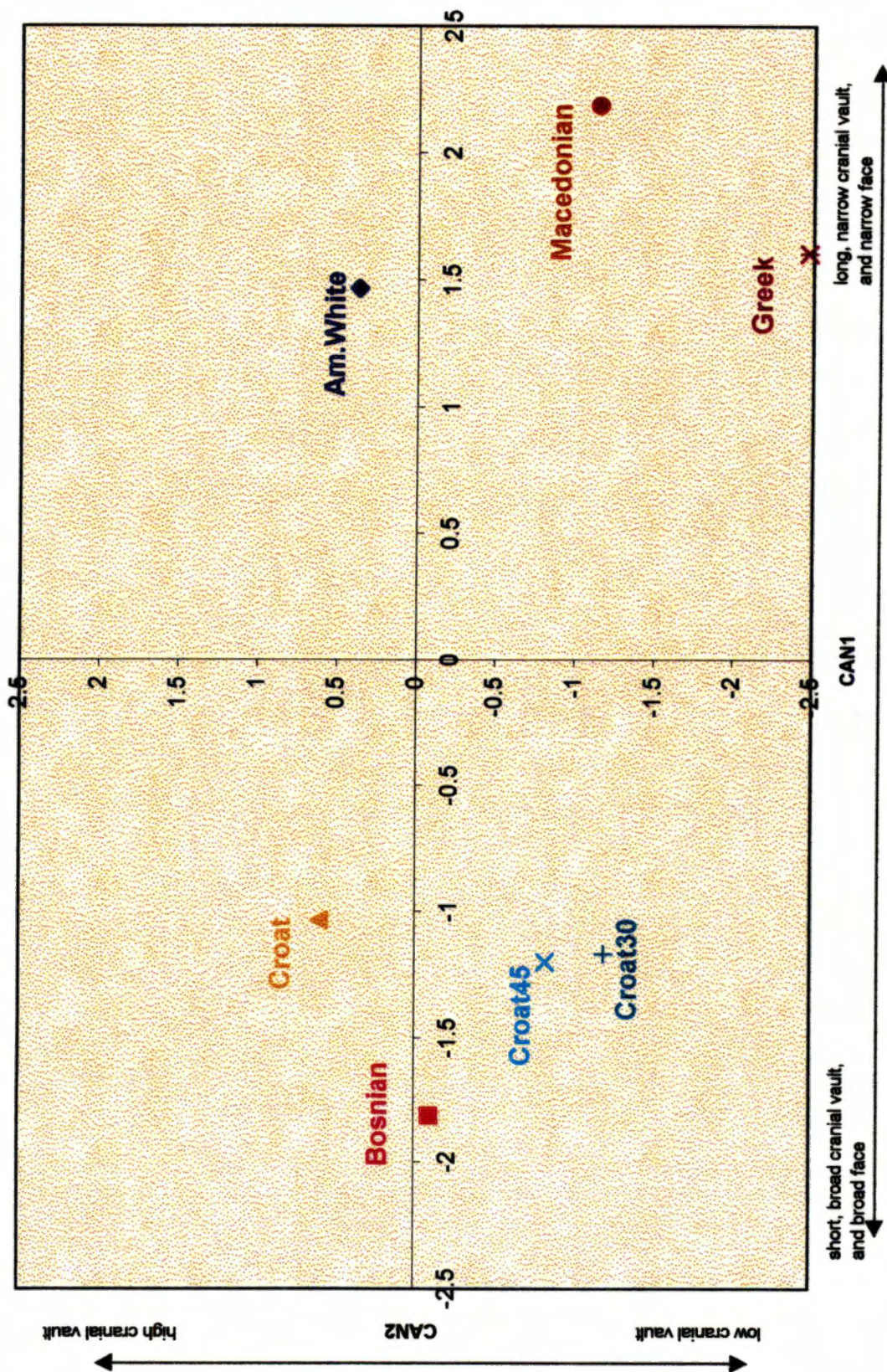


Figure 8. Class Means on CAN1 and CAN2 (shape variables).

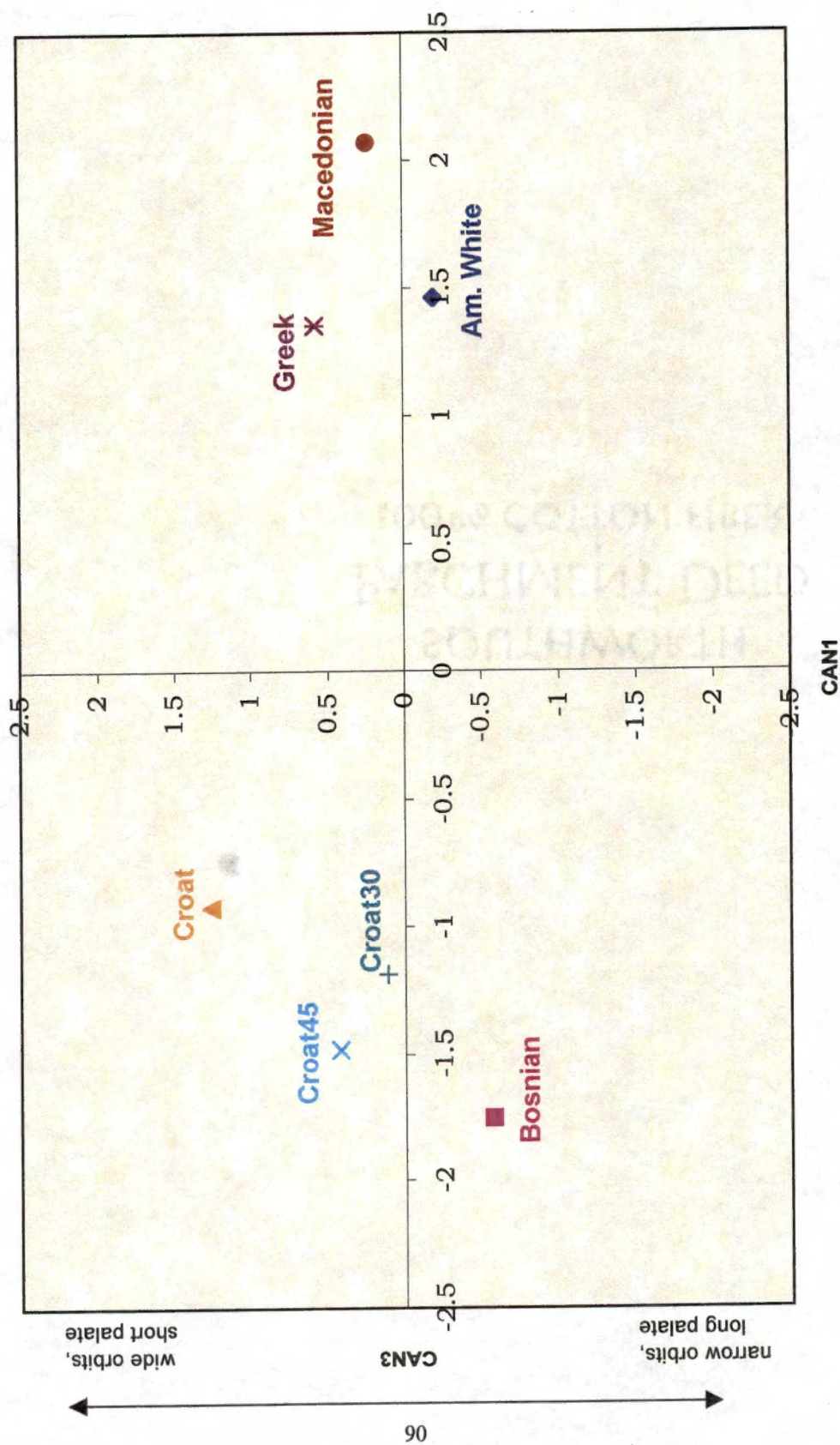


Figure 9. Class Means on CAN1 and CAN3 using shape variables.

d. Face and Vault Size

Finally, face size and vault size were compared among the groups using the sample means of the transformed variables (see Chapter 5 for description). Figure 10 is a plot of the sample means for face size by vault size. Bosnians and American Whites appear to be closest in size showing relatively large cranial vaults and medium sized faces. Contemporary Croatians are the largest with very large faces and cranial vaults. WWII Croatians are the smallest among the Croatian groups. Macedonians and Greeks are unsurprisingly the most disparate. Macedonians have the smallest faces and cranial vaults. Greeks, however, have large faces and small cranial vaults.

e. Population Structure

Minimum F_{ST} (phenotypic) was first proposed by Williams-Blangero and Blangero (1989) and Relethford and Blangero (1990) to distinguish it from the real or genetic F_{ST} . The unbiased minimum F_{ST} , which is used to measure the degree of differentiation among subpopulations, for the seven-region analysis is 0.097 with a standard error of 0.0105 (assuming complete heritability). This value is reasonably comparable to results by Relethford (1994) three-region (Europe, Sub-Saharan Africa, Far East; $F_{ST} = 0.065$) analysis. However, when using an estimate of $h^2 = 0.55$ (average heritability for craniometric traits), the unbiased F_{ST} is 0.182

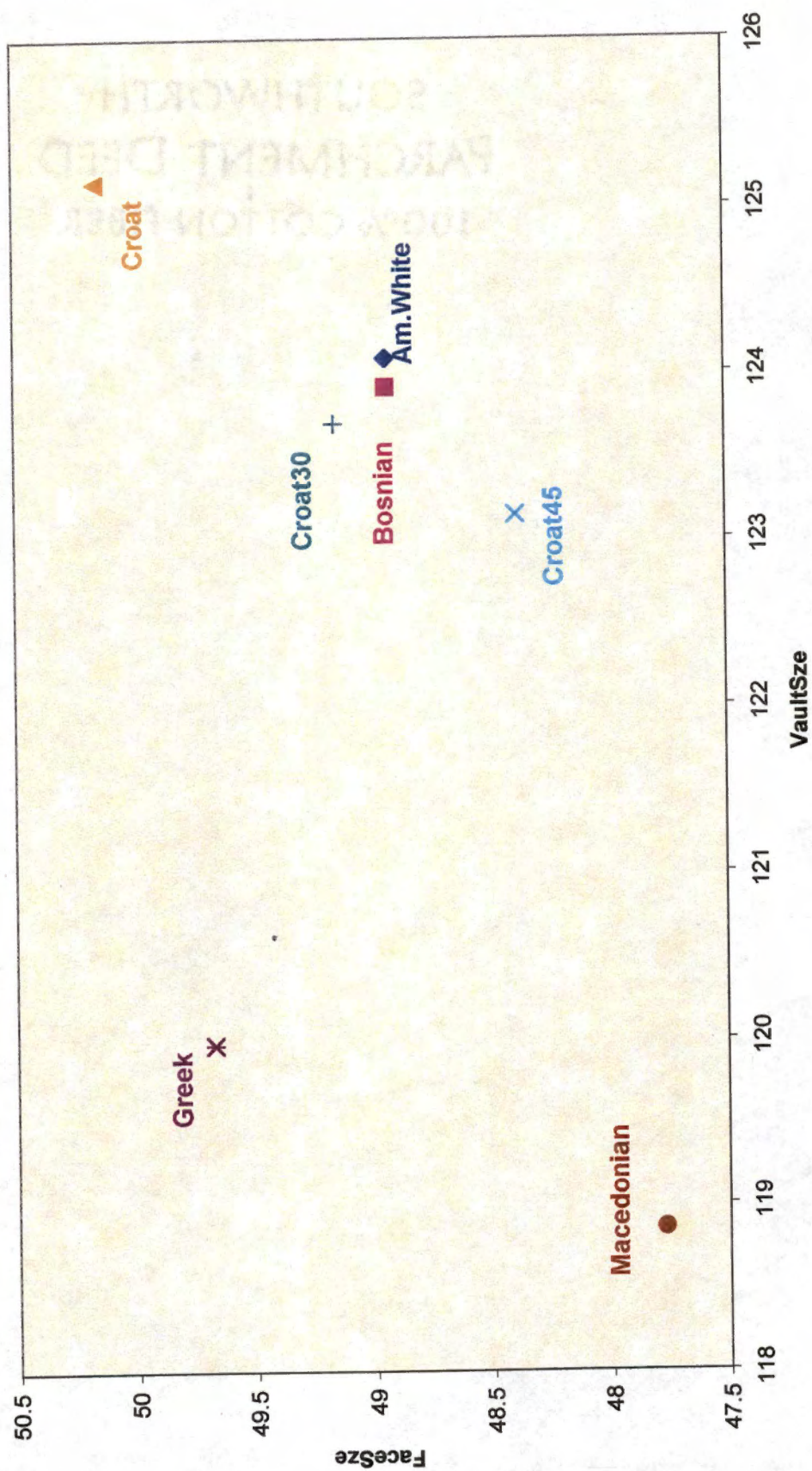


Figure 10. Comparison of Sample Means of Face Size and Vault Size.

(se = 0.0115) very similar to results derived from global genetic studies (average F_{ST} estimates of 0.10-0.11). These results suggest that even though all groups are of European ancestry, they are highly differentiated. In addition, F_{ST} values were derived using ten European groups, which included the aforementioned groups as well as Howells European male samples (Zalavar, Berg, and Norse) also yielding high values ($h^2 = 1.0$, $F_{ST} = 0.132$, se = .008; $h^2 = .55$, $F_{ST} = 0.216$, se = .009). Interestingly, these F_{ST} values are considerably larger than those obtained by Relethford (1994) comparing different geographic regions. These relatively high values are probably a product of both the number and quality of variables included in the analysis. Whereas Relethford (1994) used a battery of 57 craniometric measures including variables that are not highly variable among populations such as subtense measures, while in this study, 22 highly discriminatory variables were used.

II. Post-cranial Analyses

a. Proportional Variation

Descriptive summary statistics of raw and transformed variables for Bosnian, Croatian, and American White post-crania are presented in Tables 27-29. The ANOVA did not yield a strong relationship between the dependent variable size and group. The $Pr > F$ 0.5309 suggests that mean size is not significantly different among the groups. Only one

Table 27. Descriptive Summary Statistics for American Whites.

	N	Mean	Std Dev	Minimum	Maximum
Humerus	127	335.72	16.92	298	393
Radius	124	253.94	12.21	222	295
Femur	131	475.63	23.37	423	547
Tibia	133	393.24	21.95	336	456
Hshape	110	0.9461	0.0199	0.8830	0.9892
Rshape	110	0.7154	0.0121	0.6814	0.7473
Fshape	110	1.3367	0.0243	1.2897	1.4084
Tshape	110	1.1062	0.0226	1.0500	1.1654
S-ratio	117	1.1162	0.0931	0.7667	1.3333
R-index	117	12.3982	0.9362	10.3586	15.4762
TSA	117	668.3604	9.2564	469.6681	1005.31

Table 28. Descriptive Summary Statistics for Bosnians.

	N	Mean	Std Dev	Minimum	Maximum
Humerus	72	341.47	15.66	301	386
Radius	57	254.07	16.32	216	293
Femur	80	474.16	22.95	417	531
Tibia	80	393.99	23.83	335	498
Hshape	54	0.9559	0.0199	0.8805	0.9962
Rshape	54	0.7120	0.0314	0.6747	0.9188
Fshape	54	1.3329	0.0284	1.2250	1.3903
Tshape	54	1.1039	0.0237	1.0090	1.1521
S-ratio	75	1.0808	0.1093	0.8000	1.3846
R-index	75	12.9665	0.7243	11.6732	16.2896
TSA	75	732.0539	10.5799	569.4137	1068.142

Table 29. Descriptive Summary Statistics for Croatians.

	N	Mean	Std Dev	Minimum	Maximum
Humerus	84	334.68	19.32	286	390
Radius	56	253.02	14.38	215	285
Femur	99	467.73	26.14	406	555
Tibia	82	386.35	26.51	317	453
Hshape	38	0.9535	0.0135	0.9074	0.9970
Rshape	38	0.7119	0.0160	0.6828	0.7438
Fshape	38	1.3387	0.0412	1.1478	1.4136
Tshape	38	1.1018	0.0304	1.0614	1.2258
S-ratio	55	1.0752	0.1284	0.8421	1.5000
R-index	55	12.7982	0.8879	11.3422	15.0538
TSA	55	704.445	13.3224	527.7876	955.0442

significant canonical was extracted, which accounts for 96 percent of the among group shape variation (Table 30). CAN1 is substantially influenced by relative humerus length. The plot of the canonical means reflects the distance among the groups (Figure 11). American Whites have relatively short humeri, while Bosnians have relatively long humeri, and Croatsians fall in between. Although CAN2 is not significant, it was included to allow graphical representation. Bosnians and American Whites show relatively short femora and relatively long tibiae, while Croatsians show the opposite proportions, relatively long femora and relatively short tibiae.

b. Femur Measures

T-test results are presented in Table 31. The *t*-test procedure did not yield significant differences in either S-ratio or R-index between Bosnians and Croatsians. A significant difference in robusticity index was detected between American Whites and Bosnians, and between American Whites and Croatsians. Bosnians and Croatsians are significantly more robust in the femoral midshaft than American Whites. Midshaft shape ratio difference was also significant between Bosnians and American Whites, and between Croatian and American White. American Whites have slightly higher midshaft values, suggesting greater antero-posterior elongation.

Table 30. Significant Canonical Axes.

No.	Eigenvalue	Cumulative %	Proportion	Canonical Correlation	Likelihood Ratio	Approx F	DF	Pr > F
1	0.1148	0.962	0.962	0.321	0.893	2.86	392	0.0043
2	0.0046	1.000	0.038	0.068	0.995	0.30	197	0.824

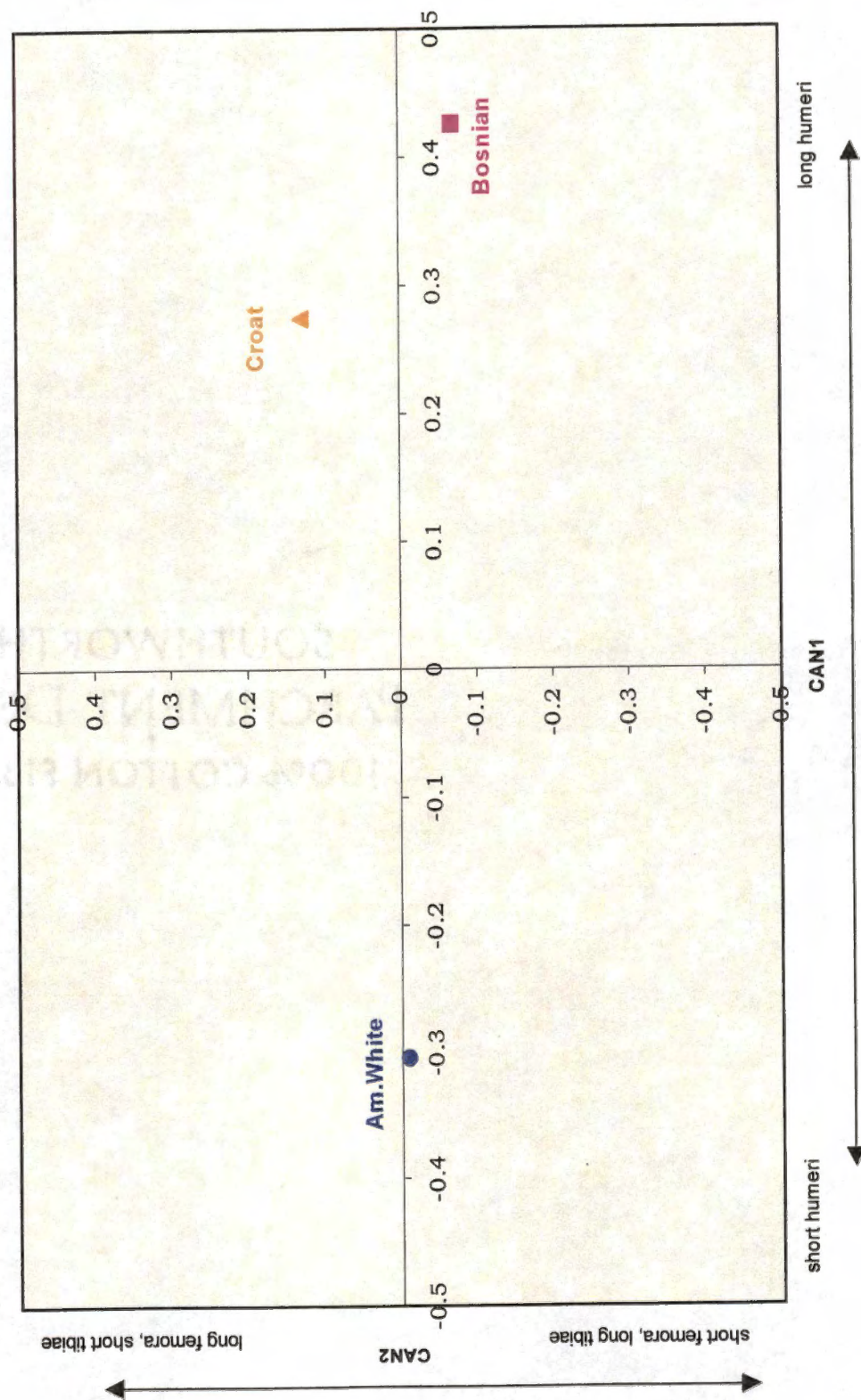


Figure 11. Class Means on Canonical Variables (post-cranial shape variables).

Table 31. Independent sample t-tests for group differences assuming equal variances.

	Variable	T statistic	P value
Bosnian-Croatian	S-ratio	0.27	0.7908
Bosnian-Croatian	R-index	1.19	0.2368
Bosnian-Amwhite	S-ratio	-2.40	0.0171
Bosnian-Amwhite	R-index	4.47	0.0001
Croatian-Amwhite	S-ratio	-2.38	0.0186
Croatian-Amwhite	R-index	2.66	0.0086

Table 32 presents the RMA regression results for cross-sectional area ($\ln$ TSA) and bicondylar length ($\ln$ BFL). The results of the RMA analysis suggest that bicondylar femur length is increasing more rapidly than cross-sectional area, which is indicated by all groups having a slope greater than 2.0, the expected value for isometry.

c. Stature Prediction

The univariate results show that formulae based on Trotter and Gleser systematically underestimate stature in the Balkans (Figures 12-14). Figure 12 illustrates how Trotter and Gleser underestimate femur stature on both the lower and upper limits of the confidence interval. For the humerus, Trotter and Gleser underestimate stature on the lower bounds of the confidence interval, while on the upper limits it overestimates stature because of a larger standard error in the Trotter and Gleser prediction equation (Figure 13). These results appear to be consistent with earlier findings that suggest that eastern European humeri are relatively longer than American humeri. Estimates for the tibia, per contra, Trotter and Gleser overestimate stature on the upper bounds of shorter long bones, while underestimating stature on the lower bounds, and overestimates stature of longer long bones (Figure 14). This could also coincide with differences in standard errors between the prediction equations and possible proportional differences between the populations.

Table 32. Results of RMA regression for $\ln$ TSA and $\ln$ BFL.

	N	y-intercept	slope
American Whites	117	-11.6655	2.95098
Bosnians	75	-8.14983	2.39476
Croatians	55	-8.50695	2.44863

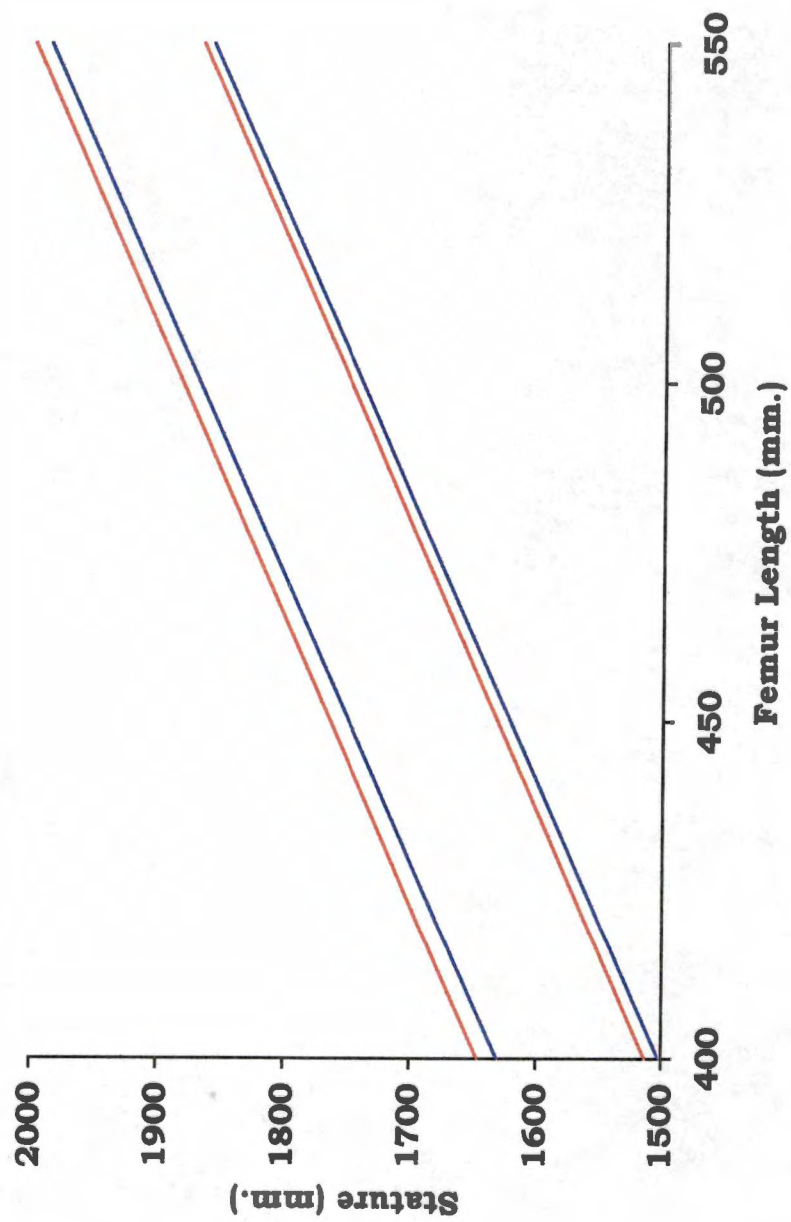


Figure 12. 95% Confidence Intervals from **Bayesian** Analysis and Trotter and Gleser '52.

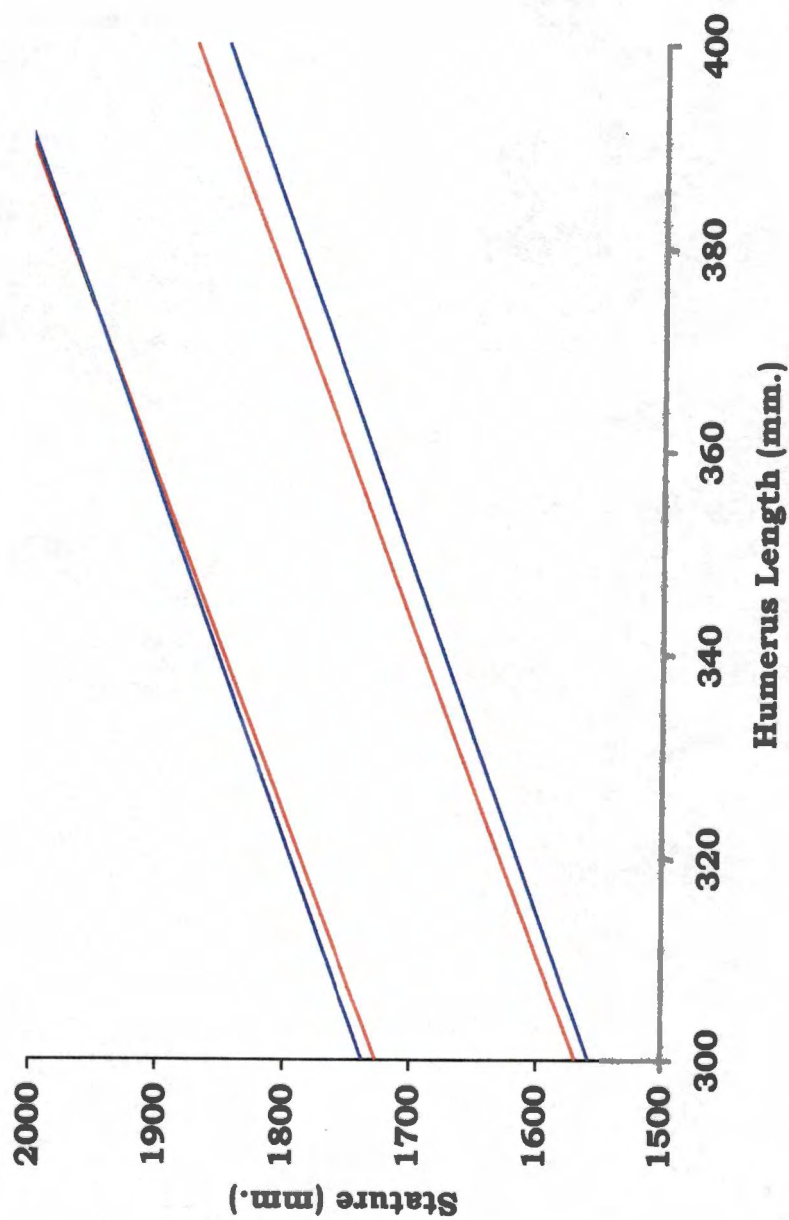


Figure 13. 95% Confidence Intervals from **Bayesian** Analysis and Trotter and Gleser '52.

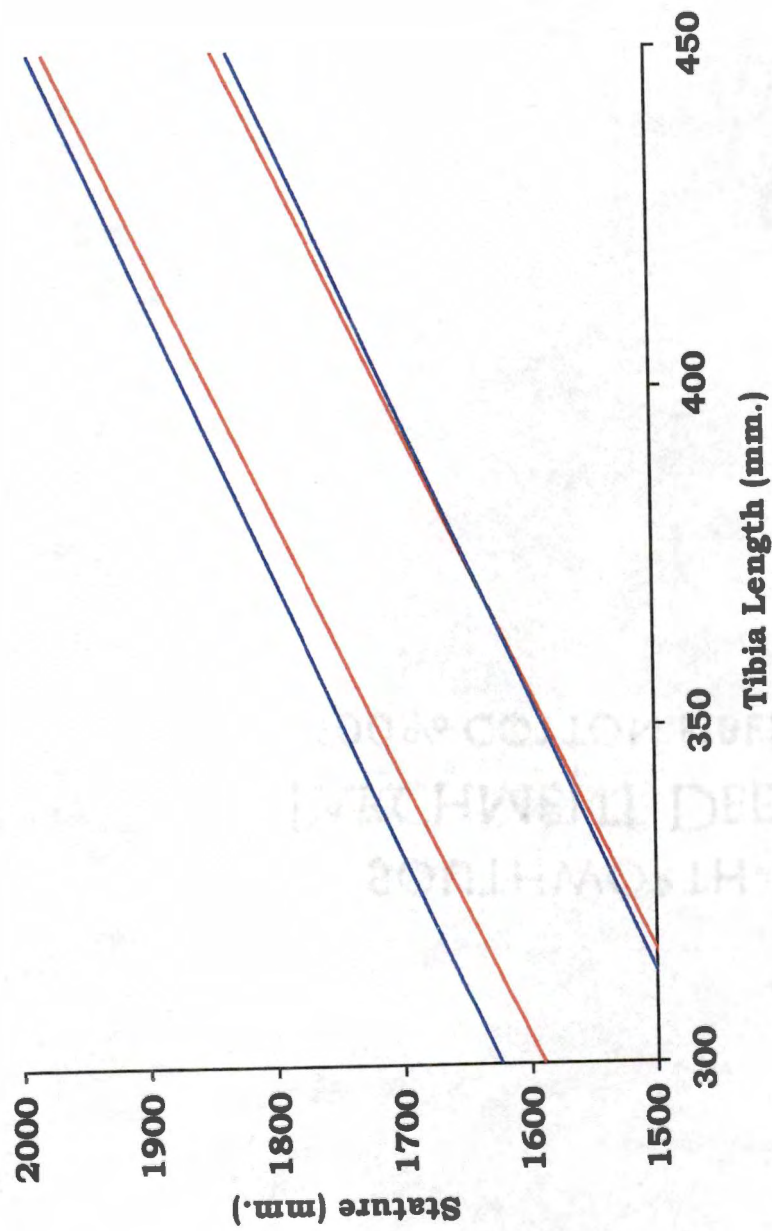


Figure 14. 95% Confidence Intervals from **Bayesian** Analysis and Trotter and Gleser '52.

In conclusion, results show that formulae based on Trotter and Glezer systematically underestimate stature in the Balkans. Because Eastern Europeans are taller than American Whites it is appropriate to use this as an "informative prior" that can be applied to future cases. This informative prior can then be used in the predictive formulae, since it is assumed to be similar to the sample from which Balkan forensic cases were drawn. Based on Bayes' Theorem new predictive stature univariate regression equations are presented for Eastern Europeans to aid in present-day identifications of war casualties from the recent conflict (Table 33).

Table 33. Stature Prediction Equations for Eastern Europeans and Standard Errors (in mm).

<i>Equations</i>	<i>Se</i>
Stature = 736.45 + 3.0379 x <i>humerus</i>	(+/- 40.3)
Stature = 634.56 + 2.3622 x <i>femur</i>	(+/- 33.0)
Stature = 751.85 + 2.5712 x <i>tibia</i>	(+/-33.9)

CHAPTER 6

Discussion and Conclusions

I. Craniometric Interpretation

Traditionally, in the forensic realm people of European ancestry are lumped into a general category of white for the purpose of identification. However, this study demonstrates that there is considerable variation among different groups of European ancestry. The results show that American Whites differ strongly from Croatians and Bosnians. In addition, the cranial difference between Bosnian-Croatian and American Whites suggest that identification criteria based on American Whites should not be broadly applied to Eastern Europeans or other groups of European ancestry. These results further emphasize the importance of developing population specific identification standards. The discriminant function presented in this study is a useful tool to separate Bosnians and Croatians in circumstances of commingled or unknown ancestry.

The results also demonstrate marked cranial differences among other Balkan groups. These results complement the vast literature addressing the diversity of European gene frequencies (Sokal, 1991; Sokal et al., 1993). In addition, Sokal and colleagues and others have exhaustively investigated the link of language families with genetic

variation, concluding that language affiliation has had a major effect in sustaining and possibly producing genetic differentiation among European groups (Sokal, 1988; Sokal et al., 1988, 1989, 1990; Barbuji and Sokal, 1990; Sujoldžić et al., 1987). For instance, Sujoldžić et al. (1987) found significant anthropometric differences between the local populations inhabiting the eastern and western parts of the island of Korčula, Croatia. This differentiation was ascribed to the different dialects of Serbo-Croatian spoken in each part of the island. The introduction of these dialects was traced historically to distinct waves of immigration from the mainland. Conversely, Rudan et al. (1988) maintain that language differences do not operate as gene flow barriers and should be regarded instead as a result not a cause of population diversity.

The marked differentiation among the eastern European groups as a whole (e.g. Slavic groups vs. other Indo Europeans-Greeks and Macedonians, and American Whites) was not as unanticipated as the striking differentiation observed between Bosnians and Croatians, who are members of the same language family and thought to be relatively homogenous and historically to originate from the same Slav ancestry. Recently, much attention has been given to secular changes observed in American crania, which has been largely attributed to the effects of environmental plasticity (Jantz and Owsley, 1998; Owsley and Jantz,

1997; Jantz, 1999, 2000; and Jantz and Meadows Jantz, 2000).

Environmental plasticity with selection is a reasonable explanation for the changes observed in American White crania, given that historically the population of the US is seen as an amalgamation of various groups of European ancestry. In addition, the improved environment (especially for groups emigrating from pre-industrialized nations) would be expected to have a positive effect on secular trends. For example, Rösing and Schwidetzky (1986) as cited by Sokal and Uytterschaut (1987), concluded that medieval craniometric differentiation was a result of culture changes, such as urbanization and were more significant than climatic adaptation or migration in producing changes in the phenotype.

However, environmental plasticity is not a satisfactory explanation for the variation observed between Bosnians and Croatians, given that both are neighboring groups and inhabit similar environments. While the standard of living is slightly higher for Croatians (economically better off as a nation) than Bosnians, both have relatively the same diet, which is dependent upon seasonal availability. Therefore, the morphological differences observed between Bosnians and Croatians cannot be attributed to environmental plasticity.

The Balkan region has historically been a region of numerous population influxes and settlement patterns. According to Barbujani and Sokal (1990) European genetic variation is not related to environmental

adaptation, but rather reflects the ethnohistorical origins of the local populations. It is recognized that Bosnians and Croatians originated from the same Slav ancestry. Critical historical events such as the Ottoman conquest of the Balkans have had a lasting effect on the population structure of this region. Population differentiation did not occur through gene flow, but through the shifting of cultural factors. It is clear from the results of this investigation that groups of Slavic ancestry can be differentiated from other Indo Europeans. This can most likely be attributed to the initial settlement pattern of the original populations. Furthermore, I conclude that the differentiation between Bosnians and Croatians cannot be attributed to either environmental plasticity, geographic nor linguistic isolation, but to another cultural factor that has functioned as a gene flow or reproductive barrier, genetic isolation as a result of culturally imposed religious segregation. Religious isolation began in the late fourteenth century when Bosnia was Islamicized and has since persisted as a major form of cultural isolation, which has helped to maintain and perpetuate morphological differentiation, as witnessed by the regions numerous religious wars and acts of genocide waged throughout the twentieth century. Although, religion as a cultural isolate can be traced much further back in time (i.e. division of the Holy Roman Empire), it is not likely associated with the variation observed between Bosnians and Croatians, because it predates

Slavic settlement and Bosnia lacked a national identity until the Middle Ages. Therefore, the variation observed in cranial morphology between Bosnians and Croats can be attributed to relatively long-term (>600 years) isolation of the breeding populations isolated by religious secularization. Drift has historically functioned and contributed to group differences in human populations. Unfortunately in much of the recent literature, this evolutionary force has been disregarded as an important basis for population differentiation among contemporary human populations.

The F_{ST} results lend further support for the strong craniometric variation detected among groups of European ancestry. The minimum F_{ST} values computed from craniometric variables range from 0.097-0.132 and for the estimated values range from 0.182-0.216 depending on the region included in the analysis, suggest that even though all groups are of European ancestry, they are highly differentiated.

II. Post-cranial Interpretation

Allometric variation of different populations is of interest to many researchers and has several applications, from interpreting climatic adaptations to implications in stature estimation. Trinkaus (1981), Holliday (1997), Ruff (1994) and others have argued that limb proportions reflect climatic adaptation, while Porter (1999) suggests that

biomechanical factors may be important. The results of this study indicate that neither biomechanical nor thermoregulatory models can adequately explain proportional limb variation among contemporary groups of European ancestry.

Recent studies of secular change and allometry have observed differential long-bone proportions between sexes and among races (Meadows and Jantz, 1995; Meadows Jantz, 1996). Meadows Jantz (1996) concluded that it is not likely that changes in function are solely responsible for differences in proportional relationships. However, the precise forces responsible for the variation in limb proportions remain unclear.

The results of this study suggest that although American Whites, Croatians, and Bosnians are similar in size, there is significant shape or proportional variation among the populations. Mean measures for long-bone lengths show that Americans and Bosnians have shorter femora and longer tibiae, while Croatians exhibit the opposite, longer femora and shorter tibiae. These proportional differences could to some degree reflect differential environmental stresses such as disease and/or nutrition during growth. The canonical discriminant analysis for shape variables indicate that Croatians and Bosnians have relatively longer humeri as compared to American Whites that show relatively short humeri in relation to geometric size. These results suggest that

considerable variation exists among populations that might normally be considered similar. While biomechanical and nutritional factors can probably explain the difference observed between American Whites (more sedentary) and Eastern Europeans, they cannot satisfactorily explain the variation observed between Bosnians and Croatsians.

In addition, these results support recent conclusions reached by Katzmarzyk and Leonard (1998:483) who state, "...although climatic factors continue to be significant correlates of world-wide variation in human body size and morphology, differential changes in nutrition...have moderated their influence." Conceivably environmental factors (i.e. nutritional and/or disease stress) at a particular developmental or growth stage are in part responsible for proportional variations observed in contemporary populations. However, again the role of drift has been disregarded as a viable explanation for population differentiation.

a. Femur Measures

There were significant differences for both midshaft ratio and robusticity index between Bosnian-Croatian and American Whites. Bosnians are the most robust, while American Whites the least robust. American Whites show the most AP expansion. A high midshaft ratio signifies resistance to AP bending (Cole, 1994). In Cole's (1994) study of Northern Plains Indians a higher AP elongation was expected among

hunter-gatherers due to the more strenuous activities associated with this subsistence mode than horticulturalists. However, the interpretation that cross-sectional shape is solely a result of type of mechanical use does not seem to effectively explicate the differences observed here. Lifestyles of modern Americans would logically produce a decrease rather than an increase in midshaft measures as a result of increased sedentism.

American Whites show a much higher cross-sectional area than either Bosnians or Croatians, suggesting that femur length is increasing more rapidly than cross-sectional area. According to Ruff (1984) a difference in cross-sectional area is indicative of differences in mechanical loadings (types and levels of activities). Proportionally, longer femora should have a smaller cross-sectional area than shorter femora. These results reflect a decline in mechanical loading for American Whites compared to Eastern Europeans. Thus, some of the differences observed between Americans and Eastern Europeans can be explained by differential biomechanical and nutritional factors. Conversely, the variation observed between Bosnians and Croatians can probably be attributed to the same force responsible for craniometric differentiation between these two groups, genetic drift imposed by religious segregation.

In conclusion, the results of this investigation show considerable morphological variation among populations of European ancestry. To

exclusively attribute the vast range of variability observed among local as well as geographic populations to environmental adaptations would seem a gross oversimplification. It is evident that the evolutionary and environmental forces that have shaped contemporary population structures are in part influenced by their unique historical circumstances.

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