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Secular Change and Allometry in the Long Limb Bones of Americans from the Mid 1700s through the 1970s

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To the Graduate Council:

I am submitting herewith a dissertation written by Lee Meadows Jantz entitled "Secular Change and Allometry in the Long Limb Bones of Americans from the Mid 1700s through the 1970s." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

Lyle W. Konigsberg, William M. Bass, Major Professor

We have read this dissertation and recommend its acceptance:

William E. Harrison, Walter E. Klippel, Murray K. Marks

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Lyle W. Konigsberg
Lyle W. Konigsberg, Co-Chairperson

William M. Bass
William M. Bass, Co-Chairperson

We have read this dissertation
and recommend its acceptance:

Walter E Klippel

Murray K. Marks

Accepted for the Council:

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Associate Vice Chancellor and
Dean of The Graduate School

SECULAR CHANGE AND ALLOMETRY IN THE LONG LIMB BONES OF AMERICANS FROM THE MID 1700s THROUGH THE 1970s

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Lee Meadows Jantz

December 1996

ABSTRACT

Secular change has long been of interest to researchers in fields ranging from human growth to human identification. In addition to changes in size, changes in limb bone proportions may also have occurred.

Secular change in size and limb bone length proportion was investigated in five U.S. skeletal samples (Total N=2700) with dates of birth ranging from mid 1700 to 1970s. The six long bones are measured for maximum lengths, and stature is known for a approximately 2000 individuals. The goals of this study include 1) examining any changes in the long bones and stature of white and black males and females, and 2) examining the allometric relationships of the six long bones for these sex/race groups across time, and 3) examining any geographical differences in size and shape in a subsample.

In order to test for secular change in stature and bone lengths, regression is employed with each of the variables regressed onto year of birth. The second analysis involves the examination of allometric secular change. Size (geometric mean) and shape (X/size) were employed in a principal components analysis. The principal components of shape were then regressed onto year of birth for each sex/race group. Using Trotter's WWII sample, geographic differences are examined by using size and shape in principal components analysis and multivariate analysis of variance.

Results indicate that white males exhibit secular change in stature, all long bones, and most of their proportional relationships. Black males exhibit change in stature and all long bones except the humerus. Both male groups exhibit change in the proportional relationship of arm to leg bones with legs getting longer while arms get shorter. White females show the same secular change in size and bone lengths as black males, while black females only exhibit change in stature.

Results of the geographical analysis indicate that white males vary significantly by region in both size and shape, but black males do not. Of the five regions employed and examined, the Northeast yields the smallest males while the West has the largest.

Environmental improvements in the U.S. have lead to secular increases in size and bone lengths. Males exhibit a greater plastic response to these environmental changes, whereas females are more stable. Whites exhibit greater response than do blacks possibly due to harsher environmental conditions endured by blacks historically.

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CHAPTER I

INTRODUCTION AND STATEMENT OF PURPOSE

Secular change has long been of interest to researchers in fields ranging from human growth to human identification. Almost every living thing can exhibit change over time, but the biological aspects of change in human populations are of particular interest and probably the most complex. Factors that affect biological change may be genetic or environmental, and the two are extremely difficult to tease apart.

Secular change is any change occurring over time, and secular change in growth may ultimately result in secular change in adult size. Changes in growth are important to recognize for medical, pharmaceutical, and other clinical purposes. While these are important for clinical applications, secular changes in growth and adult size may also be important as indicators of other types of change. Environmental changes that might result in plastic biological responses include improvement or degeneration of things such as sanitation, immunization, diet or nutrition, the economy, or any combination of these.

Allometric relationships of anatomical structures may also reflect secular change. Allometry is the approach for examining proportional relationships of anatomical structures. If secular change occurs in body size, relationships among different structures may change as well. If allometric secular change occurs, it suggests that various parts of the body respond differently or at different rates to changes in the environment or reach their genetic potential at different rates. Consequences of this might include necessary re-evaluations of skeletal biological methods developed using older samples such as stature estimation formulae or revision of current standards for any anthropometrically based structures, clothing, and others. These consequences as well as the need to examine the underlying causes of these possible allometric secular changes have stimulated the present study.

While secular changes in a populations do not necessarily reflect changes in allele frequency in that population, it does suggest that some sort of selective pressure is in operation. If phenotypic changes in size are due to improvements or alterations in the environment, then this may drive the enhanced expression of the genetic potential present in a population. Phenotypic changes in shape may be reflecting changes in function. If allometric secular changes have occurred in the long bones of the population, what is driving these changes? Will these forces that may be causing size and functional changes ultimately lead to changes in the genetic structure? Do different race or sex groups respond differently to these potential forces?

In order to more closely examine the possibility of allometric secular change in the United States, five different skeletal samples with dates of birth ranging from the mid 1700s up to 1970s were included for a total sample size of approximately 2700 individuals. The six long limb bones of the postcranial skeleton are measured for maximum lengths. A large subsample derived from World War II casualties from the Pacific Theater were examined for size and allometric differences between geographical regions. These data are used for the following specific goals of this research:

1. To examine the changes, if any, in the long bones of white and black males and females that have occurred over the last two centuries.
2. To determine the rates of change, if any, in the long bones of white and black males and females.
3. To examine the allometric relationships of the six long limb bones for these sex/race groups across time using size and shape of the bones.
4. To examine any geographical differences in size and allometry in a subsample in order to narrow regional environmental influences.
5. To propose a model explaining secular change and allometric secular change (if any) in the postcranial skeleton of these populations.

Before presenting the analyses conducted in this project, a review of the literature is necessary. The bodies of literature are threefold; growth, secular change, and allometry. Because secular change in adult size is tested, examination of growth and secular changes in growth allows a basis for understanding how humans reach adult size and shape. Growth factors will obviously have strong correlations to adult size; "the ultimate size and shape that a child attains as an adult is the result of a continuous interaction between genetical and environmental influences during the whole period of growth" (Eveleth and Tanner,1990:176). Another body of literature to be reviewed is that concerning secular changes in heights and weights of different populations. Finally, the pertinent allometry literature is reviewed.

This study is unique in that skeletal samples of recent historic and modern populations are examined. The secular change literature is vast and encompasses a majority of the populations across the globe; however, these studies are mostly concerned with living people or samples. These studies typically concern stature and/or weight as well as other body composition components such as fat. This study deals with limb bones and examines each bone and its relationship to the others across time. Proportional changes will be examined and illustrated.

One of the advantages (or disadvantage) of this study is that the samples derive from across the United States and possibly across socioeconomic boundries. Environmental influences must by definition be broad based. Because the United States is the "melting pot", the genetic influences are across the spectrum. As Eveleth and Tanner (1990) note "Statements about the relative contributions of heredity and environment to adult size and shape must...always specify the circumstances with some exactness" (Eveleth and Tanner, 1990:176). Due to the nature of the sample, this cannot be done.

Thus, in this research, a large sample of postcranial long bone skeletal metrics spanning two centuries allows for the examination of secular change in size and allometric secular change in white and black males and females from across the United States as well as examination of regional allometric differences in a sub sample of males. Based on the results of these analyses, possible explanations are presented for these temporal changes.

CHAPTER II

REVIEW OF THE LITERATURE

Secular change in the adult postcranial skeleton is the result of change through historical time in growth and maturation. The purpose of this study is to examine these changes as well as examine the allometric relationships within the long limb bones for temporal change. For these reasons, three main bodies of literature will be reviewed: growth, secular change or trend, and allometry.

a. The Growth Literature

Human growth is an area of great interest. Many longitudinal as well as cross-sectional studies have been conducted for the purpose of developing growth standards by which to compare individual children for normal development (Chinn, 1988; Goldstein, 1986; Hauspie et al., 1980; Billewicz et al., 1983). If a child falls below the accepted standard, then the child may be treated for failure to thrive or delayed development. Some of the problems with the use of growth standards include the often ignored roles of population specificity, environmental differences, secular change, and feeding patterns. It has been shown that different populations have different growth rates (Ulijaszek, 1994; Eveleth and Tanner, 1990). Eveleth and Tanner (1990) devoted an entire volume, *Worldwide Variation in Human Growth,* to this very topic. More recently Frongilio and Hanson (1995) found significant variability among nations compared to variability within nations. One of their points was that as policy decisions and programs concerning malnutrition are considered, "the implications of cross-national variability in growth may assume greater importance" (Frongilio and Hanson, 1995:395).

Hauspie et al. (1980) examined middle class Indian children from Calcutta, and the data revealed that the mean heights of these children were below the 10th centile of British standards beginning at a very early age. Billewicz and McGregor (1982) illustrated that Gambian children have growth deficit patterns when compared to British children. This also may result from poorer nutrition and environmental conditions. Kim (1982) compared Korean and Japanese children's growth patterns and found differences between these two nationalities. Eveleth and Tanner stated the problem quite eloquently, "It simply will not do to use an American or British standard to judge the growth of Japanese or Hong Kong infants and children...both the size and tempo are different" (Eveleth and Tanner, 1990:15). Another study by Brown and Townsend (1982) compared Australian Aboriginal adolescent growth to British children and found that few differences between the Aboriginals and British children exist in the ages of peak height velocity or in adolescent gain. However, the Aboriginals were shorter when these growth periods occurred. Karlberg et al. (1988) discussed the application of a Swedish growth standard to a Pakistani population of children. They found that the Pakistani children are considerably smaller or slower in their linear growth and suggested this was due to Pakistan being an industrializing country. Populations differ in adult size and shape as a result of children differing in their growth and development.

Racial differences within the same geographic region are also apparent in growth. Owen and Lubin (1973) compared growth between black and white preschool children. They found that black children are smaller at birth, but gradually reach and then surpass white children in both height and weight during the preschool ages. While they discussed these differences, they concluded that different growth charts are not necessary (Owen and Lubin (1973). Garn and associates also examined growth differences between black and white children and found similar results. They pointed out that the growth differences are opposite of the socioeconomic positions of the two groups (Garn et al., 1973). Wingerd et al. (1974) investigated race differences in hand-wrist maturity by comparing radiographs of white, black, and Asian samples. They found that blacks mature at a much faster rate than the other groups, specifically blacks vary in the differential development of different growth centers in the hand and wrist (Wingerd et al., 1974). A black population from Lagos (Africa), has skeletal development ahead of British norms (Rea, 1971). Eveleth and colleagues (1979) observed secular change in growth of urban black children. They found evidence of accelerated skeletal maturation in these children from Philadelphia. A majority of the research into racial differences in growth and maturation concludes that blacks mature earlier or faster than many other groups.

While populations exhibit variation, even different surveys within the same population can yield different results. A comparison of four growth studies in the

United States is presented by Thissen and colleagues (1976) to investigate whether patterns of growth within the same population might differ. Their investigation revealed that individual growth parameters among the samples were statistically significantly different if only by a little, but no differences were found in the timing of the adolescent component.

Environmental conditions can also affect growth. Eveleth (1986) found that population differences are most likely the result of the interaction of genetics and environmental factors. Some of these environmental factors include nutrition, disease, urbanization, and socioeconomic status. Socioeconomic status has been shown to correlate with growth and development (Olivier, 1979). Brinkman et al. allowed that

> "by now, it is a generally accepted fact that patterns of human growth (average height at a given age, rate of change in height during the growth years, the age at which the growth of stature ends, average height at maturity, etc.) are strongly influenced by environmental factors, or, more specifically, material conditions. Since Villerme in 1829 posed the thesis that there is a close relation between human height and material circumstances, this subject has yielded an awe-inspiring spate of scientific publications." (1988:227)

Tanner (1986) discussed growth as a mirror of the condition of society. He believed that the growth of contemporary children accurately reflects the material condition of society, among other things. Numerous studies support this position. Buschang et al. (1986) examined linear growth of undernourished Zapotec children of Mexico and compared them to well nourished North American children. The results of their study showed that the Zapotec children were significantly shorter. While these are different populations, it was shown that the difference results from diminished growth in leg length in the Zapotec children. A study of Korean children raised in Japan illustrated how differing environments influence growth. Kim (1982) compared Korean children raised in Japan to Japanese children in Japan and Korean children in Korea. The Korean children raised in Japan experienced a better environment and thus grew taller and heavier than those children raised in Korea.

Lasker and Mascie-Taylor (1989) conducted a longitudinal follow-up study on British children where they examined the "well-known association" of social status and child size. In this study, they found that social mobility of the family does not affect children's growth after age 7 years. This suggests that patterns of growth are established prior to this age. Billewicz et al. (1983) also found social class differences that are established by the early age of five years in their investigation of English children.

In an earlier study by Rea (1971), social and economic influences on growth are examined in a population of preschool children from Lagos. Poor children and well-off children up to two years of age are compared. It is shown that in the poor children growth slowed greatly after 6 months of age until about 18 months when they exhibited catch-up growth. The well-off children's growth seemed to slow but at a more gradual pace. Further research comparing an affluent society to poorer societies is presented by Harrison and Schmitt (1989). They found that the poorer societies are systematically smaller than the affluent society. Hackett and colleagues reported on a two-year longitudinal study of English children focussing on dietary intake and growth in height and weight. Their results indicated that the

> usual differences in height, weight and growth increments between social classes were found [yet] ...no significant differences in nutrient intake between social classes [were discovered] (Hackett et al., 1984:545).

They concluded that a more rigid control of the dietary record would likely result in differences between the classes.

Economic historians have also related growth or statures to socioeconomics. Fogel (1986a) discussed the use of physical growth as a measure of economic well-being during the eighteenth and nineteenth centuries. He utilized heights and weights during growth to reflect the changes occurring in the economy. Komlos (1989) also discussed the use of stature as an indicator of economic conditions. He linked the two by explaining that stature can be used as a proxy for nutritional status as nutrition has an immediate impact on height. If individuals have access to adequate or better nutrition, this reflects stable or improving economics and well-being in the population. Susanne (1980) supported this link by stating that one major factor resulting in differences in growth is that of standard of living which is directly related to socioeconomic status.

An examination of genetic contributions, growth rates and patterns is needed at this point. Mueller (1986) discussed how heredity and environment interact to affect the growth of children. He pointed out certain critical areas in which this interaction is most likely to be understood including basic quantitative genetic theory with special reference to environmental covariation, the genetics of growth in size and shape, heritability estimates and estimates of ecosensitivity. While we know that genetics and environmental factors work in tandem, Eveleth (1986) suggested that genetic factors may predispose some individuals to have a greater ecosensitivity than others. According to Garn and Rohmann (1966), growth from infancy through adolescence may be seen as the interaction of nutrition and genetic contribution. Johnston et al. (1976) attempted to separate heredity and environmental influences by examining children of Guatemalan and European ancestry from a sample of children living in Guatemala. All children under investigation attended a private school and thus shared a similar environment, while their genetic backgrounds were different. Results showed that prior to adolescence, environmental influences appear to control growth as the two groups did not differ. During adolescence, however, the children of European ancestry grew the same amount as a control sample from Berkeley, California, segregating them from the Guatemalan sample.

Rates of growth differ between individuals as well as between populations. While "two individuals may reach the identical ultimate height, [this may occur by] one with a tempo of growth...which is slow, another with a tempo which is rapid" (Eveleth and Tanner, 1990:145). The tempo of growth begins before birth. Karlberg and colleagues suggested that the infancy component of the Infancy, Childhood, Puberty (ICP) model of growth begins in mid-gestation (Karlberg et al., 1987). Lampl et al. (1992) and Lampl (1993, 1996) have shown that growth in infancy does not proceed in a steady, continuous tempo. Instead, growth in length during infancy occurs by saltatory spurts. Adult size is the result of a number of discrete events of growth, and the association between these growth events and illness "suggests variability in saltatory growth patterns is a biological strategy in the attainment of adulthood for population-specific ecology" (Lampl, 1996:145).

The three different stages of growth include infancy, childhood, and puberty. These periods of growth proceed at different paces with infancy exhibiting a very rapid growth rate until about 6 months, followed by a fairly steady deceleration and climb in childhood, and finally, the adolescent growth spurt occurs during puberty (Yun et al.,1995). Several studies have shown that seasonal variation occurs in patterns of growth (see Billewicz and McGregor, 1982; Marshall, 1975; and Henneberg and Louw, 1990). While patterns are present in growth, variation is also present as to the rates at which individuals mature, with early maturers doing so at a faster rate and late maturers growing at a slower rate. Zacharias and Rand (1983) investigated adolescent growth in contemporary American females, and they found that a portion of their sample (about 20%) was different from the rest of the sample. This small group of the females lacked a clear growth spurt when compared to the remaining individuals, yet their adult stature was greater than the majority of the sample.

Environmental influences may result in differences in patterns of growth. Stunting is a phenomenon seen in early childhood (Martorell et al., 1994), and it may be reversed in what is called catch-up growth. Steckel (1987) delved into the historical record of African-American slaves to examine this phenomenon. His findings showed that the American slaves were undernourished as small children and experienced growth depression. After these individuals reached adolescence, if they survived, they experienced remarkable recovery in growth. Steckel concluded this growth depression resulted from poor pre- and postnatal care, poor nutrition in early childhood, and heavy disease load. Once children began to reach adolescence, they were able to join the work force which increased their value and qualified these individuals for better food intake. From this look into one historical sample, Steckel (1987) illustrated the human capacity for catch-up growth.

Stunting, as previously mentioned, results from under- or malnutrition, but this phenomenon may also result from a disease process such as inflammatory bowel disease. Golden (1994) investigated the possibility of complete catch-up growth in stunted children. This study revealed that most children who exhibit stunting also exhibit retarded bone maturity. If these individuals are treated for their malnutrition and/or their disease(s), then complete catch-up may occur. Golden stated that "the most obvious reason why catch-up is not seen regularly is that an appropriate diet is not available over a sufficient period of time" (Golden, 1994:S58). Research by Brown and Townsend (1982) suggested that Australian Aboriginals experience "catch-up" growth as seen in peak height velocity in their adolescent growth spurt following early childhood retardation in growth.

Changes in growth patterns have been documented for a large number of first world countries. These secular changes are most likely due to improvements in the environments. Further discussion of these changes will continue in the literature review concerning secular change.

b. The Secular Change Literature

Secular trends or changes are changes in something over a period of time. van Wieringen (1986) uses the term "secular change" instead of "secular trend" because the changes are not always in one direction or the other. Secular changes may be positive or negative. These do not connote bad or good, but rather refer to becoming larger or smaller, or occurring later or earlier. This literature review will focus on secular changes in growth and maturation and in adult height. Another whole body of literature addresses secular changes in sexual maturation which will not be dealt with here.

This section will provide some discussion of secular changes in growth. A monograph edited by Roche (1979) with papers by Roche, Himes and Malina provides a thorough review of the secular change literature. Roche's contribution concerns secular change in stature, weight and maturation (Roche, 1979). Another review is presented by van Wieringen (1986), and Eveleth and Tanner (1990) give a brief discussion of secular change in growth.

One of the most common links found among the numerous studies is defining the causes of secular change in linear dimensions. Malina (1979) specifically addressed this in his contribution to the previously mentioned Roche edited monograph entitled *Secular Changes in Size and Maturity: Causes and Effects*. Apparently, no single cause explains secular changes. Malina suggested that a most important cause of secular change "is the improved health status reflected in the marked reduction of infant and childhood mortality and morbidity during the nineteenth and twentieth centuries" (Malina, 1979:88). This implies that primarily secular change is a result of environmental influences. These influences must be growth inhibiting. However, if environmental influences improve, maybe these simply allow for a greater opportunity to reach the genetic growth potential. As Ulizza and Terrenato (1982) stated,

> It is widely accepted that the secular trend is associated with an increasing expression of the genetic capacities for stature, since the environmental factors affecting human growth are getting more favorable. (1982:715)

Eveleth (1986) suggested that population differences in growth were mostly the result of genetic and environmental interactions. In his survey, van Wieringen discussed several features of interest. He stated that "the start of the positive trend in the nineteenth century coincides with the moment that industrialization began to improve soci-economic conditions" (1986:313). In Europe, the secular increase was interrupted by World War II. Fogel (1986) and Meadows and Jantz (1995) found another interruption of the secular increase in America in the middle of the nineteenth century.

As mentioned previously, secular changes in growth are found most often to have occurred in developed or first world countries. A few of these studies are referenced in Table 2.1. All of these investigations show positive secular changes in growth of children. These populations are reaching larger sizes earlier and reaching maturity earlier. An early study by Bakwin (1964) reflected children growing taller and heavier, adolescence beginning earlier, and maturity being reached earlier. He suggested that "earlier maturation poses many problems in management especially as

Table 2.1. A brief survey of published studies illustrating positive secular growth changes in children.

Author(s) & Date	Population
Ljung et al. (1974)	
Lindgren and Hauspie (1989)	Swedish
Blanksby et al. (1974)	Australian
Blanksby (1995)	
Gray (1927)	American
Meredith (1963)	
Dreizen et al. (1967)	
Moore (1970)	
Eveleth et al. (1979)	
Lasker and Mascie-Taylor (1989)	English
Chinn et al. (1989)	
Chinn and Rona (1984)	
Himes (1984)	
Billewicz et al. (1983)	
Goldstein (1971)	
Clements (1953)	
Roberts (1994)	
Zellner et al. (1996)	German
Welon et al.(1981)	Polish
Dubrova et al. (1995)	Russian
Ji et al. (1995)	Chinese
Huang and Malina (1995)	Taiwanese
Matsumoto (1982)	Japanese
Tanner et al. (1982)	
Greulich (1976)	

psychological conflicts between parent and child appear earlier and last longer" (Bakwin, 1964:88). Most researchers believe these positive growth increases are due to improvement in the environmental factors. An argument posed by Ziegler (1967) suggested that there is a correlation between in increase in growth acceleration and an increase in sugar consumption.

Populations from developing countries have also been studied for secular changes; however, the outcome is typically different from that seen in industrialized countires. McCullough and McCullough (1984) compared samples of children from industrialized countries to samples of children from nonindustrialized countries and found that the nonindustrialized countries' inhabitants experienced irregular patterns and magnitudes of growth. The children from industrialized countries experienced a more stable environment which "leads to more stable patterns of growth and age-specific patterns of secular change" (McCullough and McCullough ,1984:169). Billewicz and McGregor (1982) found no evidence of secular change in heights of individuals from two Gambian villages in Africa, and they showed that in fact substantial deficits on height and weight appear early in life and continue when compared to British data. Investigations of secular change in Mexican-Americans revealed that this population has not experienced the same rate of change as others have in Texas (Malina et al., 1987; Malina and Zavaleta, 1980). Malina and Zavaleta suggested "that health and nutritional conditions for these children in Texas have not improved to the same degree as those for other American children" (1980:460). Aruba children have also experienced a slight secular increase in height. Comparing data on children from 1954 to data from 1974, van Wieringen (1981) found that a secular growth change has occurred, however, Aruban children still lag behind the Dutch standards. One study of San children compared anthropometric data of individuals existing on three different diets. Hausman and Wilmsen (1985) investigated the San as they were making a transition from hunting and gathering to pastoralism; while these subsistence changes were reflected biologically, their effect was minimal.

While most studies of secular change in growth focus on living populations, skeletal samples provide another source for investigation. Jantz and Owsley (1984a) investigated the long bone growth variation among historic Arikara skeletal populations and found secular changes. They suggested that the secular changes exhibited resulted from changes in health status and climatic conditions.

Secular changes in adults encompasses a tremendous amount of research. Only a brief survey of this literature will be presented here. Populations from all over the globe have been examined with regard to secular changes in height and weight. Just as seen in secular growth changes, differences are present between first and third world countries. Studies on adults from industrialized countries are given in Table 2.2. All of these studies indicate positive secular increase in heights and, in some cases, weight.

Developing or nonindustrialized countries do not reflect such positive secular increase in their populations. Prazuck et al. (1988) found a lack of change in adult males from Mali, Africa over the last century. Shatrugna and Rao (1987) also found

Table 2.2. A brief survey of published studies illustrating positive secular changes in adults.

Author(s) & Date	Population
Floud et al. (1990)	English
Schmidt et al. (1995)	European males
Bielicki and Waliszki (1991)	Polish males
Hermanussen et al. (1995)	German, Italian, & Dutch males
Sobral (1990)	Portugese males
Weber et al. (1995)	Austrian males
Deegan (1941) Borkan et al. (1983) Damon (1968)	American males
Damon (1974)	American females
Bock and Sykes (1989) Bakwin and McLaughlin (1964)	Americans
Holmgren (1952)	Swedish adults
Relethford (1995)	Irish adults
Facchini and Gualdi-Russo (1982) Terrenato and Ulizza (1983)	Italians
Olivier (1980)	French
Damon (1965)	Italian-Americans
Furushò (1973)	Japanese
Price et al. (1987)	African

no evidence of secular change in women of very poor socioeconomic groups from India.

In his investigation of secular change in adults of Papua New Guinea, Ulijaszek (1993) found that some groups exhibit a positive increase in heights and weights, while other groups show a decrease. Similar results are seen in adult Mayan males (McCullough, 1982). No significant changes have occurred in these Mesoamerican groups with the exception of the Otomi. McCullough (1982) suggested this was because the recent economic development is too recent to have affected statures. Henneberg and Van den Berg (1990) compared various groups living in South Africa to test for biological reflections of socioeconomic differences. Their findings indicated that the trend among the native Southern Africans was erratic, but overall positive, while the Africans of European descent exhibited a rate of increase much lower than seen in their European origins (Henneberg and Van den Berg, 1990). Tobias (1962) conducted an earlier study of secular change among an African population, the Kalahari Bushmen. Just as Hausman and Wilmsen (1985) suggested, Tobias concluded that a change in the Bushmen's subsistence patterns the caused a positive secular change.

Several studies have focused on historical records for examination of presence or absence of secular change in statures in Native Americans during the historical period to modern time. Stivers (1990) investigated secular change in stature among the Eastern band of the Cherokee. The historical data were derived from the Franz Boas anthropometric data collection. These anthropometric data were collected on over 15,000 Native American in preparation for a large exhibit held in the 1892 World's Exposition (Jantz, 1995). Modern data were collected by Stivers on Cherokee living in North Carolina. Stivers found a strong increase in heights since the turn of the century that follows a decline in stature during the nineteenth century. Stivers suggested this earlier negative trend was due to stress resulting from attempted removal of the tribe. The Eastern band successful evaded the removal of the Cherokee that became known as the Trail of Tears. The improvements in living conditions as well as health care are suggested as reasons for the positive increase in this century.

In another study of the Cherokee, Moon (1995) compared the secular changes in the Eastern and the Western bands of the Cherokee using the anthropometric data from Boas' collection. These groups both experienced a negative trend in heights which Moon attributed to the influences of environmental stresses prior to and during the removal and attempted removal of the Cherokee.

Prince (1995) utilized the Boas data to examine secular trends in stature of nineteenth century Sioux and suggested that the Sioux were able to maintain high statures due to particular factors despite living under adverse conditions. Prince employed not only data from Boas, but also data from Walker. These two samples differed in that only the Walker data indicated secular increase in height (Prince, 1995). Jantz et al. (1995), in their investigation of secular change among historic equestrian Plains Indians, did find a significant secular increase in stature for the Sioux. These workers also employed the Boas data for their study. The Sioux were the only tribe to reflect a constant positive change in height, while the other tribes (Arapaho, Assiniboin, Comanche, Crow, and Kiowa) all exhibit first a negative change in height until about 1850 when a positive increase reverses the downward trend. Jantz et al. (1995) attributed the negative trend and reversal to long term effects of a devastating disease episode occurring in the late 1700s. Of interest, the change/increase in stature for these groups was due to an increase in sitting height as opposed to leg length which is typically expected (Eveleth and Tanner, 1990).

A study of secular change among recent Native American was presented by Miller (1969, 1970) on the Western Apache. Miller found that heights and weights have increased in his sample comparing fathers measured in 1940 to sons in 1967.

As environmental conditions of health and nutrition improve, greater genetic potential is being reflected in these secular changes. A few researchers have suggested that this genetic potential has almost been met in some populations and a cessation of secular changes has or will soon occur. Damon (1968) examined four generations of 12 families that had sons attend Harvard University. He concluded: "these findings confirm other indications that the secular increase in height has ended among economically favored Americans" (Damon, 1968:45). Another study by Damon (1974) of females from "upper crust" families in America also lead Damon to believe that the secular increase has stabilized. Chinn and Rona (1984) speculated whether the lack of a positive trend in the latest birth cohorts in their study might be due to a cessation of that trend. Schmidt et al. (1995) suggested that in Scandinavia and The Netherlands height increases have levelled off due to a decrease in post neonatal mortality, and they expected to see a continuation of this levelling affect in other countries as mortality levels reach the critical decrease. This correlation between mortality in the first year of life and secular change is a very interesting one, and this will be discussed again later.

While some researchers believe that secular change is coming to an end, others do not. Bock and Sykes (1989) presented evidence for continuing secular increase in their study of families participating in the Fels Longitudinal study. They did, however, recommend a study of the third generation before a cessation of the secular increase might be seen (Bock and Sykes, 1989). Olivier did not feel that the end of the trend can predicted as "we do not know why children grow quicker or reach a final height higher than in the past" (Olivier, 1980:649).

This section has provided only a brief survey of the secular change literature. More detailed and in depth reviews may be found in Roche's edited monograph (1979) or van Wieringen (1986). The following section discusses secular change in proportions in humans. A brief examination of the allometry literature is needed first.

c. The Allometry Literature

Allometry is the study of proportional relationships of size and shape within biological organisms. Huxley (1932) devoted his work, *Problems of Relative Growth*, to growth patterns in relation to ratios and gradients within organisms. Allometry has been applied to humans and their ancestors as well as most living creatures in many studies during the last fifty years or so. Reitz et al. (1987) proposed the use of allometry in zooarchaeology as very often body weights are estimated via bone weights or size.

Allometric relationships in growth of children are of particular interest. As the long bones grow, do they grow at the same rate or allometrically? Jantz and Owsley (1984b) and Jungers et al. (1988) focused on historic Arikara subadult growth. Jantz and Owsley's focus was limb proportionality in children from skeletal material. The temporal period represented by these data ranges from about 1600 to 1830, derived from ten different archaeological sites. As mentioned previously, Jantz and Owsley found that the lower limb bones are longer proportionally when compared to the upper limb bones lengths equal to those from early temporal periods, and the proximal bones are proportionally longer than the distal bones (1984b). Jungers et al. (1988) found similar results as well as finding that along with size differences being primarily age-related, shape differences may also be age-related.

In his study of middle class white children, Buschang (1982) investigated allometric changes between the ages of two months to eleven years. His results indicated that positive allometric change (meaning bone lengths are increasing faster than height increases) occurs by reflecting shape changes in the long bones during growth. He also found the disto-proximal gradient as well as the lower limb positive to the upper limb (Buschang, 1982). Watkins and German (1992) examined ontogenetic allometry in fetal bones and determined growth rates from least squares regression of bone length on body mass. Their findings were slightly different between the fetal growth period and later growth periods. While after birth the distal bones grow slower than the proximal bones, during fetal growth they seem to grow at the same rate. The lower limb grows faster than the upper limb as seen in postnatal growth (Watkins and German, 1992).

Himes (1979) noted that "little attention has been given to the question of possible concomitant secular changes in body proportions or composition" (1979:28). His study examined published data concerning body proportions and composition in populations that have also been noted to have experienced secular change in size. Himes investigates various ratios such as weight to stature and sitting height to stature. He found that compared to statures, weights have increased relatively more for some populations. However, Himes does not see this as a secular change in the stature-weight relationship. Instead, he suggested that this reflects faster growth and earlier maturation. While some populations have seen an increase in the weight for stature, other populations have exhibited the reverse, a reduction in weight for stature. Himes states, "If these qualitatively different secular changes in stature-weight relationships are real and not artificial, the causes of such different responses are difficult to explain" (1979:37).

In investigating the stature-sitting height relationship, Himes found some interesting results. For U.S. and Japanese children, sitting height has declined in relation to stature indicating an increase in leg length in the last 90 years. He pointed out that a decline in relative sitting height is expected during growth and maturation, and the results may again be reflecting earlier maturation (Himes, 1979). Due to the nature of his data, Himes did not find very conclusive results. He argued that due to the kinds of measurements that are employed, the measurement error is probably too great to accurately reflect much information. He did agree that "nevertheless, analyzing reliable data for these differences can give insight into the nature of tissue-specific responses to factors influencing growth" (Himes, 1979:58).

Meadows and Jantz (1995) found allometric changes in the long bones of white and black males spanning a temporal period from the mid 1800s to 1970. Results indicated that the lower limb bones are positively allometric with stature, meaning that these bones become longer proportional to stature as stature increases, and the upper limb bones are isometric, meaning that these bones do not change in their proportions to stature as stature increases (Meadows and Jantz, 1995). This research is the impetus for this dissertation.

CHAPTER III

MATERIALS

The five skeletal samples examined in this study derive from North America, primarily the United States. Dates of birth range from approximately the mid 1700s to 1970s, covering a time span of about 200 years. Maximum lengths of the long bones (the humerus, radius, ulna, femur, tibia, and fibula), both left and right sides, and stature, if available, were obtained for white and black males and females. The First African Baptist Church data were collected by Mr. Thomas A.J. Crist, of John Milner Associates, Philadelphia, Pennsylvania. The Huntington data were collected by me, while the World War II and Terry data were collected by Mildred Trotter. The Forensic Data Bank data were collected and submitted by many different observers. Descriptions of the samples follow.

a. Samples

First African Baptist Church

The First African Baptist Church (FABC) sample derives from the skeletal remains of 89 black individuals excavated from the cemetery used by the First African Baptist Church congregation. This congregation was the earliest free black Baptist congregation in Philadelphia. Two separate archaeological excavations and

Table 3.1. First African Baptist Church sample by decade of birth.

Decade of Birth	Females	Males
1740 - 1749	1	-
1750 - 1759	4	3
1760 - 1769	1	1
1770 - 1779	4	1
1780 - 1789	6	-
1790 - 1799	1	1
Totals	17	6

analyses of this site, one focusing on the later period of use and one focusing on the earliest period of use, have been conducted. This sample derives from the early period of use between 1810 and 1822 (Crist et al., 1995). This cemetery yielded 56 adults and 33 infants and children. Of this cemetery sample, 17 females and 6 males had sufficient long bone lengths to include in the study (Table 3.1). Dates of birth of these individuals have been estimated from skeletal age estimations (see Crist et al., 1995). Each individual has an estimated age with a five year range, and age was taken as the midpoint of this range. Since the cemetery had a short 12 year period of use by the church, the midpoint of this period, 1816, was used as the estimated year of death. The estimated age was then subtracted from 1816 to obtain a year of birth.

Huntington Collection

The Huntington Anatomical Collection, housed at the National Museum of Natural History, Smithsonian Institution in Washington, D.C., consists of over 3600 individuals collected and macerated from the 1880's to 1920's. These individuals lived in the New York City area and were primarily European immigrants (Hunt, 1995: personal communication). Documentation includes the country of origin such as Ireland, Germany, or Greece, as well as some information concerning sex, age, and date and cause of death. Table 3.2 provides more details of the sample makeup. A total of 166 males and females was used in this study with dates of birth ranging from 1805 to 1877 with a mean age at death of 47 years. Stature was not available for this sample.

Table 3.2. Huntington Collection sample by decade of birth.

	Females		Males	
Decade of Birth	White	Black	White	Black
1800 - 1809	4	-	-	-
1810 - 1819	6	-	1	-
1820 - 1829	8	-	7	1
1930 - 1839	13	-	8	-
1840 - 1849	7	-	16	-
1850 - 1859	15	-	28	2
1860 - 1869	9	-	30	-
1870 - /1877	5	1	6	1
Totals	67	1	96	4

Terry Collection

The Terry Anatomical Collection, housed at the National Museum of Natural History, Smithsonian Institution in Washington, D.C., consists of 1732 specimens of known sex, age, ethnic origin, and cause of death that were collected and macerated in the early 20th century in St. Louis, Missouri (Terry, 1940; Hunt, 1995:pers.comm.). The portion of the Terry Collection used in this study (N = 851) have dates of birth from ranging from 1841 to 1921 with the mean age at death of 53 years. Sample size by decade of birth for each sex race group is given in Table 3.3.

The Terry Collection was initiated by Robert Terry with Mildred Trotter continuing the collection after his death. Trotter donated much of her research estate to the Archives at the School of Medicine at Washington University in St. Louis, Missouri, after her retirement in 1967. The Terry data were obtained through the Bernard Becker Medical Library Archives, Washington University School of Medicine, St. Louis, Missouri, in the form of 80 column computer punch cards. The computer punch cards were read into the University of Tennessee VAX computer through a still working card reader and downloaded onto a personal computer. Key punching protocols were also available so that variables could be identified.

These Terry data comprise the same sample that Trotter and Gleser specifically employed in their age related stature loss, secular trend and stature studies (1951a, 1951b, 1952). Included in this data set are the identification numbers, sex, race, age, stature, weight, and averaged left and right long bone lengths. The weight information was not employed in this research. Birthdate was also obtained for use in

Table 3.3. Terry Collection sample by decade of birth.

	Females		Males	
Decade of Birth	White	Black	White	Black
1840 - 1849	-	4	9	4
1850 - 1859	18	10	33	12
1860 - 1869	20	8	56	43
1870 - 1879	9	30	93	67
1880 - 1889	6	19	43	72
1890 - 1899	5	38	14	73
1900 - 1909	5	47	2	64
1910 - 1919	-	19	3	23
1920 - /	-	2	-	-
Totals	63	177	253	358

this study. During the organization of these data, it was noticed that several errors were present in this data set. An individual identified as "1294", a black male, had incorrect femur measurements. Apparently, a punching error occurred and instead of having femur measurements of 495 and 496 millimeters as measured by Dr. David R. Hunt, of the Smithsonian Institution, the measurements on the punch card were 295 and 296. Another error occurs in the form of a duplicated individual, identified as "719", a black male. It seems that both errors were incorporated into Trotter's and Gleser's analyses. Trotter and Gleser (1977) discuss an error in the radii for the black females. This error was pointed out to them by Drs. T.D. Stewart and L.E. St Hoyme (Trotter and Gleser, 1977). They discovered that an individual had the radius measurements of 337 and 335 mm, while in fact these radii were 237 and 235 respectively (1977). This again appears to be a punching error. These errors have now been corrected.

Data for places of birth are not available for this sample. It is assumed that these individuals lived in the surrounding area of St. Louis, Missouri. Terry (1940) reminds us

> ...the material of the dissecting laboratory can hardly be taken as a sample of the living population from which it has been derived...[considering] the generally high old age incidence, these bodies commonly bear the marks of undernourishment and in many cases of the wasting effects of a chronic ailment that brought death. Whereas these conditions scarcely effect at all the longitudinal measurements they render some of the transverse and circumferential measurements of questionable value (1940:435).

Terry (1940) suggests that the statures are tenable even though the individuals were not in states of good health.

World War II Casualties (WWII)

During her tenure with the Central Identification Laboratory, Mildred Trotter collected metric and demographic data on over 1200 casualties of the WWII Pacific theater. These remains were processed through the identification lab prior to repatriation and burial after the war (Stewart, 1979). Metric data include stature taken at induction and long bone measurements taken after death. Some of the demographic data include age, sex, ethnic origin, birthplace, and place of enlistment. This study employs a sample of 1213 individuals containing only white and black males. The dates of birth range from 1891 to 1927 with a mean age at death of 24.63 (ranging from 17-50). Table 3.4 gives the sample size by decade of birth.

The WWII data were also obtained through the Bernard Becker Medical Library Archives, Washington University School of Medicine, St. Louis, Missouri, in the form of computer punch cards and 5x8" data cards onto which Trotter had written the data. These computer punch cards were read at the same time as the Terry Collection cards were read and downloaded onto a personal computer. This punch card data set included the same WWII sample of complete white (N = 545) males that Trotter and Gleser employ in their stature estimation research (1952). Trotter and Gleser (1952) include a small number of incomplete individuals (N = 165) and black males, but the punch cards do not include these individuals. Information on these cards includes identification number, race (white only), age at enlistment in half years, half years of service, weight, height in millimeters, lengths of bones from both sides of the body as well as "maxfem" and "maxtib", and the total of these lengths.

Table 3.4. World War II Casualty sample by decade of birth.*

Decade of Birth	Whites	Blacks
1890 - 1899	3	-
1900 - 1909	36	8
1910 - 1919	454	40
1920 - /1927	634	38
Totals	1127	86

*Includes males only.

Data on 1239 individuals were presented on data cards, called "Locator" cards (Figure 3.1 illustrates an example of the cards[1]), but only 1213 individuals (white and black males) were employed in the present study. Information provided on the front side of these data cards includes identification number, (if present, if not, then a number was assigned by me), name, race, military rank, branch of the military, serial number, cemetery or location of the remains, place of birth, date of birth, place of enlistment, enlistment date, date of death, age in years, date the card was written (?), and stature in inches. The back side of the cards included metric data in centimeters. These data, with the exception of the long bone data on the punch cards, were all entered on computer files by me. Other data provided on a small portion of the cards includes hair color and eye color.

Approximately 790 individuals from the WWII sample were employed by Trotter and Gleser (1952). These individuals had either complete sets of long bones, or they were nearly complete. The present study incorporates these same individuals as well as approximately 423 additional individuals that were collected but not used by Trotter.

Places of birth for the individuals that comprise this sample represent almost the entire country. The only state not represented is Nevada, while six individuals were born outside the United States. In order to facilitate comparisons, the state of birth for each individual was assigned a geographic region following Karpinos (1958)

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[1] All figures may be found in Appendix 5.

(see Table 3.5). The regions include the Northeast, Southeast, South Central, North Central, and West.

Forensic Data Bank

The Forensic Data Bank (FDB) is a computerized data base housed in the Forensic Anthropology Center, Department of Anthropology, University of Tennessee, Knoxville. This collection includes data collected from forensic cases, anatomical specimens, and donated skeletal materials. The Forensic Data Bank comprises materials that have been reported from 59 different forensic laboratories or research institutions and over 60 observers across the nation. Jantz and Ousley (1996) stated that the majority of these cases had been measured by only 10 or so observers. A total of 432 individuals (white and black males and females) is included from this collection of data (Table 3.6). Dates of birth range from 1892 through 1975, and the mean age at death is 40.79, ranging from 16-86.

The criteria for inclusion in the sample were race and sex certainty as either positive or tentative. This means that the individual had to have been positively identified or the presence of soft tissue allowed the determination of sex and race (Moore-Jansen et al., 1994). If the individual was positively identified, then a date of birth or age and date of death must be available. If the identification was tentative, then the date of death and the estimated age range was used. The age range had to be within a ten year interval. Another criterion for inclusion was the presence of at least three long bones. Based on the previously mentioned criteria, the sample includes

Table 3.5. Geographic regions as designated by Karpinos (1958) and the WWII sample sizes for each.

Region (N)	States Included
Northeast (N = 344)	Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont
Southeast (N = 226)	Alabama, District of Columbia, Florida, Georgia, Kentucky, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia
South Central (N = 155)	Arkansas, Louisiana, New Mexico, Oklahoma, Texas
North Central (N = 371)	Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, Wyoming
West (N = 111)	Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, Washington

Table 3.6. Forensic Data Bank sample by decade of birth.

	Females		Males	
Decade of Birth	White	Black	White	Black
1890 - 1899	2	2	3	-
1900 - 1909	8	8	12	11
1910 - 1919	16	6	15	13
1920 - 1929	12	3	23	11
1930 - 1939	11	4	45	11
1940 - 1949	18	7	33	11
1950 - 1959	24	10	39	4
1960 - 1969	25	2	18	7
1970 - /1975	6	4	6	2
Totals	122	46	194	70

336 positively identified individuals and 96 tentatively identified individuals. Demographic data on this sample is not as complete as for the other samples. Places of birth are available for only 55 individuals (about 13% of the sample), too few for further geographic analysis.

CHAPTER IV

METHODS

a. Long Bone Measurements

The maximum lengths of the humerus, radius, ulna, femur, tibia, and fibula utilized in this study are defined in Martin (1957), Bass (1987), and Moore-Jansen et al. (1994) and are presented in Table 4.1. The Huntington sample was measured by me following these definitions. Long bone measurements from the Terry and WWII samples were taken by Mildred Trotter. In the Trotter data sets, the femur and tibia include measurements called Maxfem, Fem, Maxtib, and Tib. In their 1952 paper, Trotter and Gleser define these measurements as maximum length of the femur, bicondylar length of the femur, maximum length of the tibia, and ordinary length of the tibia. Only the maximum lengths are utilized in this study.

Jantz et al. (1994, 1995) illustrate that Trotter mismeasured the tibia in the WWII sample as well as the Terry sample. Trotter defines the maximum length of the tibia as

> End of malleolus against the vertical wall of the osteometric board, bone resting on its dorsal surface with its long axis parallel with the long axis of the board, block applied to the most prominent part of lateral half of lateral condyle (Trotter and Gleser, 1952:473)

However, Trotter did not measure the tibia in this manner. It has been shown by Jantz et al. (1994; 1995) that Trotter did not include the medial malleolus in the

Table 4.1. Long bone measurement definitions.*

Measurement	Description
Maximum length of the Humerus:	The direct distance from the most superior point on the head of the humerus to the most inferior point on the trochlea. (Martin, 1957:532 #1)
Maximum length of the Radius:	The distance from the most proximally positioned point on the head of the radius to the tip of the styloid process without regard to the long axis of the bone. (Martin, 1957:535-536 #1)
Maximum length of the Ulna:	The distance between the most proximal point on the olecranon and the most distal point on the styloid process. (Martin, 1957:539 #1)
Maximum length of the Femur:	The distance from the most superior point on the head of the femur to the most inferior point on the distal condyles. (Martin, 1957:561 #1)
Maximum length of the Tibia: (Length of the Tibia)	The distance from the superior surface of the lateral condyle of the tibia to the tip of the medial malleolus. (Martin, 1957:572 #1)
Maximum length of the Fibula:	The maximum distance between the most superior point on the head of the fibula and the most inferior point on the lateral malleolus. (Martin, 1957:576 #1)

* Martin's (1957) definitions translated in Moore-Jansen et al. (1994).

maximum length of the tibia. In their study, Jantz et al. compare measurements taken by Trotter of a subset of the Terry sample to measurements taken by one of the authors (Hunt) (1994; 1995). The results indicate that the tibial measurements by Trotter were significantly shorter than those taken by Hunt. Only the Terry sample could be tested as the WWII remains have been returned to families and buried. Due to this error, the tibiae in these two samples have been adjusted by adding a constant equal to the mean difference (rounded to the nearest millimeter) between Trotter's measure of maximum length of the tibia and Hunt's measure (Table 4.2; also found in Table 1 in Jantz et al., 1995) for appropriate sex/race groups.

While the data included in the FDB sample are derived from approximately 40 different laboratories and over 40 different observers, only about 10 observers contribute a majority. The FDB provides a manual of data collection procedures that are to be followed in an attempt to control the potential interobserver error. This is error that must be accepted if the sample is to be included. After checking the data, gross errors are either corrected or the individual is removed from the sample.

Table 4.2. Adjustment for the tibiae of the Terry and WWII samples.*

Group	Difference between Trotter's measure and Hunt's measure of the tibia.
White males	-10.18
White females	-10.84
Black males	-12.83
Black females	-11.28

* from Jantz et al. (1995)

b. Stature Measurements

Stature is available for three of the five samples, these being the Terry, World War II and Forensic Data Bank. Specific comments are necessary for each collection as follows.

Terry Collection

The Terry sample statures were measured in a rather unique manner. R.J. Terry (1940) describes the problems and methods used in measuring the cadaver. The problem of acquiring a measurement of stature from a cadaver that is comparable to that of the living is discussed. Terry points out that the "curves of the movable part of the vertebral column are somewhat flattened, and the feet are flexed plantarward, conditions not present when the body is standing erect" (Terry, 1940:436). In order to correct this difference, Terry devised a measuring board in which the cadaver is secured in a vertical position with feet flat against the board (1940). This allowed the body to presumably stand and assume the natural angles that occur while standing. The cadavers were photographed in this position while at the same time measurements were made with an anthropometer (Terry, 1940).

Trotter and Gleser (1951a) employ the Terry Collection in their study on the effects of ageing on stature. In their methods, they state that 11% of their sample needed to be adjusted for stature because the photographs of the cadavers reveal that these individuals did not have the soles of their feet planted flat on the board (Trotter and Gleser, 1951a). It is assumed that the Terry sample in the present study incorporates any of these corrections.

WWII

The WWII sample statures were all measured at induction in a standard format, however this results in numerous different locations and observers. Trotter and Gleser (1952) make the assumption that the stature was taken after the shoes were removed. The directions for taking stature by the military are cited in Trotter and Gleser (1952) and Karpinos (1958). These directions came from the War Department in the Mobilization Regulations dated October, 1942, which read as follows:

> Use a board at least 2 inches wide by 80 inches long, placed vertically and carefully graduated to 1/4 inch between 58 inches from the floor and the top end. Obtain the height by placing vertically, in firm contact with the top of the head, against the measuring rod an accurately square board of about 6 by 6, best permanently attached to graduated board by a long cord. The individual should stand erect with back to the graduated board, eyes straight to the front (Mobilization Regulations, 1942 as cited in Trotter and Gleser, 1952 and Karpinos, 1958).

Forensic Data Bank

Stature data are available for 225 individuals from the larger sample of 432. The FDB data collection procedure guide (Moore-Jansen et al., 1994) discusses the stature information that the observer may provide. If the individual is positively identified and height is available, then the source of the height is requested. Height comes from various sources, most commonly police records, driver's licenses, or even reported statures, all of which are termed "forensic stature", and cadaver stature (Moore-Jansen et al., 1994).

c. Adjustments of Stature

Statures must also be adjusted for several reasons including cadaver stature and age related stature loss. Cadaver stature has been considered to be approximately 2.5 centimeters (cm) greater than living stature (Trotter and Gleser, 1952; Genoves, 1967). The Terry Collection and FDB cadaver statures are corrected by subtracting 2.5 cm.

Age related stature loss has been reported by several researchers (see Trotter and Gleser (1951a or b); Galloway (1989); Cline et al. (1989); and Giles (1991)). The formulae presented by Cline et al. (1989) are employed in this study for adjusted stature due to age effects. These formulae consider sex and the nonlinearity effects of aging, and the study is based on a large longitudinal sample. The following formulae have been applied to males 40 years and older and females 43 years and older in all samples:

$$\textbf{Males: Max. Stat.} = \textbf{Stat.} + 3.27651 - 0.16541(\text{age}) + 0.00209(\text{age})^2$$

$$\textbf{Females: Max. Stat.} = \textbf{Stat.} + 5.13708 - 0.23776(\text{age}) + 0.00276(\text{age})^2$$

As stated previously, the dates of birth or year of birth are either known or are calculated by subtracting the known age from the known date of death. These then are grouped by decades of birth beginning in 1800 through 1970.

d. Statistical Analyses

Two main types of analyses are conducted to examine secular change in bone lengths as well as to examine possible allometric secular change. One side for each element is used for analysis. The FABC, Huntington, WWII, and FDB data sets are incomplete. If one side is missing, then the side that is present is substituted. From this more complete data set, one side is randomly chosen for analysis in order to avoid some systematic bias. If an individual is missing both sides, then that individual is eliminated from any analysis for that element. Because of this, each elemental analysis has slightly varying data sets. The Terry data set includes the average of both sides representing the elements.

Summary descriptive statistics including sample size, mean, standard deviation, minimum value, and maximum value for each of the variables are calculated for each of the sex/race groups by decade of birth. These data are presented in Appendix 1-4.

Secular Change in Bone Length

Because of the nature of the study, i.e. secular change over time, the data must be examined for autocorrelation which may occur in time series data and may require specialized time series analysis (McCleary and Hay, 1980). When regression is used on this type of data, the errors are often correlated (SAS II, 1990). If no autocorrelation exists in the data, then simple regression may be employed; however, if the data are autocorrelated, then time series analysis must be employed. The

Durbin-Watson *d* statistic is employed to test for autocorrelation (SAS II, 1990) as suggested by Wonnacott and Wonnacott (1977, 1981), Manly (1992), and Neter et al. (1990). If no autocorrelation is found further regression analyses may be conducted.

In order to examine secular change of the bone lengths, regression analysis is used. The hypothesis being tested is that year of birth has no affect on the bone lengths. Each of the variables (long bone lengths and stature) given as "Y" is regressed on year of birth (YOB) using the following model:

$$Y = b_0 + b_1(\mathrm{YOB}) + b_2(\mathrm{YOB})^2$$

This polynomial regression is accomplished using the SAS procedure REG (SAS II, 1990). If the polynomial is not significant, then it is removed, and the regression is as follows:

$$Y = b_0 + b_1(\mathrm{YOB})$$

This regression model in SAS (SAS II, 1990) uses the method of "least squares to produce estimates that are the best linear unbiased estimates (BLUE) under classical statistical assumptions" (SAS II, 1990:1354). The results are then plotted by bone for each sex/race group.

Allometric Analysis

The second analysis involves the examination of allometric secular change. Size and shape relationships in groups or populations is of interest to many researchers (see Humphries et al., 1981; Smith, 1980; Shea, 1985; Falsetti, 1989; Jungers et al., 1995; and others). While the interest here is in allometric relationships, the growing debate concerning the methodology cannot be ignored. This debate centers around how to make adjustments or corrections in size in order to compare groups or whether size corrections need to be made at all. Rohlf and Bookstein (1987) discussed several methods of size correction such as shearing and Burnaby's. The shearing method defines size "as the first factor of the observed pooled within-group covariance matrix" (Rohlf and Bookstein, 1987:358). These authors described Burnaby's method as

> sweeping the effect of one or more extraneous variables from the data and then carrying out principal components analysis...The resulting axes, clusters. etc. are then based on variation that is orthogonal to the vectors corresponding to the variables being held constant (1987:360-361).

A recent paper by Jungers et al.(1995) presented a comparison of ratio methods and residuals methods. The ratio methods, particularly the Mosimann family of shape variables, were favored in this review article. The authors designed their study so that the ratio approach satisfied their criteria, and thus their comparisons of other methods do not operate as appropriately or satisfyingly as the Mosimann methods. While Jungers et al. (1995) do not convincingly argue that the Mosimann family of shape analysis is by far the best, the paper does serve to compare the various ratio and residual methods.

The Mosimann family of shape analysis is presented in several papers (Mosimann, 1970; Mosimann and James, 1979; Darroch and Mosimann, 1985). This approach does not remove size from the comparison, yet defines size as the geometric mean $(\Pi_{i=1}X_i)^{1/n}$ which is calculated by taking the nth root of the product of n variables as follows:

$$(HUM*RAD*ULNA*FEM*TIB*FIB)^{1/6}$$

Arguments are made that size may not be independent of shape, and that the critical aspect is the choice of the size variable (Mosimann and James, 1979). The method then defines shape as the proportion of the variable to the geometric mean. Rohlf and Bookstein (1987) recommend this procedure for samples that do not differ much in size.

The Mosimann and James (1979) and Darroch and Mosimann (1985) method of defining size and shape is employed in the current study for several reasons. Height may be used as the size variable in other methods. If height were used as the size variable in this study, then sample sizes would decrease unsatisfactorily. With the Mosimann method, size is defined as the geometric mean of the variables. Shape variables are derived by calculating the geometric mean followed by division of the raw variables of bone lengths by the geometric mean. These shape variables are then employed in a principal components analysis using the SAS (SAS II, 1990) procedure PRINCOMP. This allows the examination of the shape differences among the bones. While Mosimann and James (1979) and Darroch and Mosimann (1985) log transform their data, the data are not log transformed here as Smith (1980) suggests that untransformed data often work as well.

Prior to testing for secular change in size and allometry, another test for autocorrelation is needed. The same methods previously mentioned are employed using the Durbin-Watson *d* statistic. If no autocorrelation exists in these data, then regression analysis can again be used where principal components are regressed onto year of birth, YOB, using the following model with "Y" equal to the principal component for each sex race group:

$$Y = b_0 + b_1(YOB)$$

The same regression analysis is employed where size is regressed onto year of birth.

Geographic Analysis

Geographic differences in the long bone lengths are tested using the WWII sample. The data set includes place of birth for each of the individuals, and as previously mentioned, each has been assigned to one of 5 geographic regions as described by Karpinos (1958). The SAS (SAS II, 1990) procedures GLM and MANOVA are employed to perform the multivariate analysis of variance. The hypothesis being tested is that region of birthplace has no affect on any of the long bone lengths.

If it is shown that a regional effect is present, then pairwise comparisons are made of the regions to examine more specifically which regions differ from each other for each element. The pairwise comparisons include Fisher's least significant difference (LSD) and the Tukey-Kramer statistical tests. The LSD test controls the experimentwise error rate, and the Tukey-Kramer test allows for a more rigid test by controlling the maximum experimentwise error rate under the null hypothesis (SAS II, 1990). This test also accounts for unequal samples sizes.

Further geographic analysis involves tests of allometry. The previous statistical tests of allometry are applied with this sub sample.

CHAPTER V

RESULTS

a. Secular Change

Summary descriptive statistics including sample size, mean, standard deviation, minimum value, and maximum value for each of the variables by decade of birth for each sex race group are presented in Appendices 1-4.

The results of the test for autocorrelation of these data with years of birth, the Durbin-Watson *d* statistic are presented in Table 5.1. As indicated in Neter et al. (1990), and Wonnacott and Wonnacott (1977, 1981), if the D is greater than the upper bounds, the null hypothesis of no autocorrelation must be accepted. The upper bounds for these samples at alpha = 0.05 is 1.78. All of these exceed the upper bounds indicating no autocorrelation in these data.

The first tests for secular change in the long bones and stature are regressions of maximum height and bone lengths on year of birth. The polynomial in the first regressions yielded no significant results. The polynomial was removed, and the regressions yielded more significant results. Figures 5.1-5.28 illustrate the plots of these regressions, and Tables 5.2-5.5 give the regression results by variable starting with maximum height and proceeding through the long bones for each sex/race groups. It can be seen that for white females the only variable not significant for change over time is the humerus ($p = 0.3778$). The element with the greatest level

Table 5.1. Results of the Durbin-Watson *d* statistic test for autocorrelation between the bone length and year of birth.

	D-W *d* (n)			
	Females		Males	
Variable	White	Black	White	Black
Maxht	2.097 (121)	1.997 (201)	2.023 (1492)	2.016 (474)
Humerus	2.279 (217)	2.131 (232)	1.993 (1592)	2.020 (518)
Radius	1.994 (192)	2.261 (230)	1.966 (1558)	2.007 (514)
Ulna	2.063 (197)	2.286 (225)	1.995 (1525)	1.992 (506)
Femur	2.353 (225)	2.201 (235)	1.962 (1614)	2.015 (518)
Tibia	2.107 (222)	2.126 (227)	1.921 (1630)	2.001 (516)
Fibula	2.033 (186)	2.165 (225)	1.973 (1453)	1.999 (501)

If the D > upper bounds, H_0 must be accepted. The upper bounds for these sample sizes at significant level of alpha = .05 is 1.78 (Neter et al., 1990; Wonnacott and Wonnacott, 1977,1981; and Manly, 1992). All of these exceed the upper bounds, so no autocorrelation is present.

Table 5.2. Results of regressions of bone lengths onto year of birth for white females.

Variable	N	b_1	Intercept	Model Mean Square	Error Mean Square	F value
MaxHeight	121	0.050383	66.117331	565.94811	51.90640	10.903**
Humerus	217	0.019856	267.872429	180.86974	231.60238	0.781
Radius	192	0.060042	111.180453	1338.32039	169.04478	7.717**
Ulna	197	0.054533	138.395844	1197.68911	196.39503	6.098**
Femur	225	0.100769	240.814727	4895.23639	518.44289	9.442**
Tibia	222	0.104173	154.830105	5131.19820	429.16894	11.956**
Fibula	186	0.110059	136.660461	4213.82560	416.97009	10.106**

**Significant at alpa = 0.05

Table 5.3. Results of regressions of bone lengths onto year of birth for black females.

Variable	N	b_1	Intercept	Model Mean Square	Error Mean Square	F value
MaxHeight	201	0.039755	84.052515	194.58087	45.73044	4.255**
Humerus	232	0.001065	306.615853	0.36608	247.52067	0.001
Radius	230	0.019334	199.331171	104.66384	167.26284	0.626
Ulna	225	-0.019706	291.614438	103.90778	180.39352	0.576
Femur	235	0.075050	297.124016	1840.49813	639.73250	2.877
Tibia	227	0.033930	301.777822	317.28381	482.38533	0.658
Fibula	225	0.037720	285.314478	356.30385	454.88226	0.783

**Significant at alpa = 0.05

Table 5.4. Results of regressions of bone lengths onto year of birth for white males.

Variable	N	$\mathbf{b_1}$	Intercept	Model Mean Square	Error Mean Square	F value
MaxHeight	1491	0.094114	-6.543608	5845.78817	43.95472	132.966**
Humerus	1592	0.108128	127.964112	10684.53508	281.50835	37.955**
Radius	1558	0.141293	-20.099090	16771.77330	165.42390	101.387**
Ulna	1525	0.145188	-9.078315	17589.72226	170.65324	103.073**
Femur	1613	0.281831	-68.993940	75041.84675	567.29857	132.279**
Tibia	1630	0.281648	-153.036659	78675.88212	470.28401	167.294**
Fibula	1453	0.287446	-170.692411	66189.60349	434.79068	152.233**

**Significant at alpa = 0.05

Table 5.5. Results of regressions of bone lengths onto year of birth for black males.

Variable	N	b_1	Intercept	Model Mean Square	Error Mean Square	F value
MaxHeight	474	0.059838	58.233453	803.46073	57.31726	14.018**
Humerus	518	0.056871	230.897695	1158.25646	339.36441	3.413
Radius	514	0.056971	156.063553	1161.27991	237.26423	4.894**
Ulna	506	0.057390	173.793719	1143.84069	252.81397	4.524**
Femur	518	0.172209	150.471762	10323.36553	734.87749	14.048**
Tibia	516	0.163318	92.592156	9140.62284	623.96353	14.649**
Fibula	501	0.187398	36.564471	10681.27662	583.09766	18.318**

**Significant at alpa = 0.05

of significance is the tibia ($p = 0.0007$). Rates of secular change are given at as the slope, $\mathbf{b_1}$, in Table 5.2. Maximum height has changes at a rate of 0.05 cm per year indicating a difference of approximately 8.5 cm since 1800. The radius has increased by 0.06 mm per year, while the ulna has increased by 0.05 mm per year. Change in the femur has occurred at 0.10 mm per year. The tibia and fibula rates of change are 0.10 and 0.11 mm per year respectively. These varying rates of change over the last 170 years indicates proportional changes as well. Table 5.2 shows that the increases of long bones of white females over time range between 0.05 and 0.11 mm per year.

Black females reflect no significant change through time in any of the long bones, but show significant change in stature over time ($p = 0.0404$) (Table 5.3). This suggests that secular change in stature of black females is resulting from change in either trunk height or cranial height rather than leg length. Height is changing at a rate of 0.04 cm per year as indicated by the slope for an increase of almost 9 cm over the past 220 years. The femur changes at a rate of 0.075 mm per year, yet it is not significant at alpha of 0.05 ($p = 0.09$). It is indicated that changes in the radius and ulna are occurring in opposite directions as the ulna has a negative slope and the radius has a positive slope.

White males show very high levels of significance ($p = 0.0001$) for all of the variables for change over time (Table 5.4). Rates of change are quite high for this group ranging from 0.11 to 0.29 mm per year for the long bones. Stature has increased 0.09 cm per year, an incredible increase of 15.3 cm. The humerus has increased at about 0.1 mm per year, while the radius and ulna have increased about 0.14 mm per year. The lower limb reflects greater rates of secular change. The femur and tibia have increased at a rate of 0.28 mm per year, and the fibula has increased 0.29 mm per year. The proportional changes are clearly exhibited in this groups of males.

Results for black males are similar to the results seen in white females with regard to which bones exhibit significant change. With the exception of the humerus, all of the variables are significant for change over time. The lower limb has higher levels of significance (p = 0.0002 and 0.0001) than does the upper limb (p values range from 0.0274 to 0.0361). Stature has increased in black males at a rate of 0.06 cm per year for a change of 13 cm over the past 220 years. The upper limb bones all exhibit similar rates of change at about 0.06 mm per year. The lower limb shows slightly more proportional differences in rates of change ranging from 0.16 to 0.19 mm per year.

b. Analysis of Proportional Variation

The allometric analysis begins with deriving the variable "size" as the geometric mean of the bone lengths. Summary descriptive statistics of size by decade of birth for each sex/race group are given in Appendices 1-4. Shape variables are derived once size is calculated, and these summary descriptive statistics for each sex race group are also given in Appendices 1-4. Table 5.6 gives the simple statistics for

Table 5.6. Simple statistics of shape variables in four group analysis.

	SHUM	SRAD	SULNA	SFEM	STIB	SFIB
Mean	0.9780262070	0.7388306612	0.7933504471	1.376412983	1.137930609	1.115246017
StD	0.0255717203	0.0154052461	0.0173302925	0.031165703	0.020680125	0.019039475

the shape variables SHUM, SRAD, SULNA, SFEM, STIB, and SFIB which correspond to the long bones respectively.

Principal component analysis of these six variables employed 2185 observations from the total sample. The covariance matrix and its eigenvalues are presented in Tables 5.7 and 5.8. The proportion of the variance for each of the principal components, PRIN1 through PRIN6 are also provided in Table 5.8. The first three components account for 93.3% of the variance, while PRIN4 and PRIN5 essentially account for the remaining variability. PRIN6 contributes only 0.000105 of the variance.

Table 5.9 provides the eigenvectors for the principle component analysis. The weights are given by variable for each component PRIN1 through PRIN6. High positive weights are compared to high negative weights indicating the variables are allometrically different. As can be seen in the table, the first principal component reflects the femur against the radius and ulna. For individuals that have high scores on this component, the femur is larger proportionally and the radius and ulna are small. For individuals with low scores, the femur is not as large proportionately when compared to the larger radius and ulna.

PRIN2 is reflecting longer lower limb to shorter upper limb, with the emphasis here being the humerus against the tibia and fibula. High scores on this component indicate proportionally shorter humerus to longer tibia and fibula. PRIN3 contrasts the femur and the humerus. Individuals with high scores on this third component

Table 5.7. Covariance matrix for shape variables in four group analysis.

	SHUM	SRAD	SULNA	SFEM	STIB	SFIB
SHUM	0.0006539129	-.0001357680	-.0001528481	0.0001138096	-.0002486177	0.0001927940
SRAD	-.0001357680	0.0002373216	0.0001935355	-.0002824339	-.0001149676	-.0001269979
SULNA	-.0001528481	0.0001935355	0.0003003390	-.0003143329	-.0001424737	-.0001395900
SFEM	0.0001138096	-.0002824339	-.0003143329	0.0009713010	-.0000304952	-.0000174827
STIB	-.0002486177	-.0001149676	-.0001424737	-.0000304952	0.0004276676	0.0002673709
SFIB	-.0001927940	-.0001269979	-.0001395900	-.0000174827	0.0002673709	0.0003625016

Total Variance = 0.0029530437

Table 5.8. Eigenvalues of the covariance matrix of shape for four groups.

	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	0.001274	0.000344	0.444012	0.44401
PRIN2	0.000931	0.000463	0.324255	0.76827
PRIN3	0.000467	0.000341	0.162760	0.93103
PRIN4	0.000126	0.000054	0.043799	0.97483
PRIN5	0.000072	0.000072	0.025070	0.99990
PRIN6	0.000001	.	0.000105	1.00000

Table 5.9. Principal component analysis for four groups analysis.

	Eigenvectors					
	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6
SHUM	0.278920	-.544755	0.678375	-.050978	0.042593	0.401049
SRAD	-.333317	-.157445	-.261787	-.101457	-.714797	0.523785
SULNA	-.378381	-.186496	-.320997	0.101911	0.682104	0.493311
SFEM	0.816293	0.000849	-.503141	0.001550	0.010985	0.283535
STIB	0.014002	0.604718	0.218125	-.672406	0.127663	0.343676
SFIB	0.037434	0.527246	0.259820	0.724285	-.074610	0.350639

have longer humeri when compared to femora, proportionally, and conversely, low scores reflect as the humerus is shorter, the femur is proportionally longer.

The fourth and fifth principal components each contrast distal bones. PRIN4 reflects differences between the tibia and fibula, while PRIN5 contrasts the radius and ulna. PRIN4 indicates that the tibia is proportionally shorter than the fibula for individuals that have high scores, while low scores indicate proportionally longer tibia compared to the fibula. High scores on PRIN5 indicate these individuals have relatively longer ulnae compared to the radius, and low scores indicate a reversal of this with relatively longer radii for these individuals.

The last principal component reveals all positive eigenvectors for the shape variables ranging from .283535 up to .523785. As this last component contributes virtually nothing to the variation, it does not seem relevant.

c. Secular Change in Long Bone Proportions

The results for the test for autocorrelation of these data are presented in Table 5.10. As indicated earlier, if the *d* is greater than the upper bounds, the null hypothesis of no autocorrelation must be accepted (Neter et al., 1990; and Wonnacott and Wonnacott ,1977 and 1981). The upper bounds for these samples at alpha = 0.05 is 1.78. All of these exceed the upper bounds indicating no autocorrelation in these data, the only exception is for black females for PRIN3 (*d* = 1.677). As this component is not significant in the model, it can be disregarded.

Table 5.10. Results of the Durbin-Watson *d* statistic test for autocorrelation between the principal components and year of birth.

	D-W *d*			
	Females		Males	
Variable	White (n=152)	Black (n=215)	White (n=1334)	Black (n=484)
PRIN1	2.012	2.204	1.958	1.960
PRIN2	1.983	1.905	2.056	1.994
PRIN3	2.044	1.677	2.063	2.015
PRIN4	1.852	2.058	1.914	2.090
PRIN5	1.795	2.118	2.053	1.970

Linear regression is employed to examine the relationship of dependent variables "size" (as previously defined) and the first five principal components and the independent variable year of birth for each sex/race group. Tables 5.11-5.14 show the results of these regression analyses. Size changes significantly over time for white females, white males and black males. Black females are the only group to not show a significant change in size. For white females, the only principal component to change significantly over time is PRIN5. This suggests that the relative lengths of the radius and ulna have changed over time. PRIN2 is close to significance ($p = 0.0947$) for change over time in this group. None of the other principal components reveal any change over time.

Interestingly, black females also show a high level of significance ($p = 0.0001$) for the fifth principal component, PRIN5 and year of birth. This again reflects a strong proportional change between the radius and ulna over time. While this proportional relationship is significant for change over time, neither of the bone lengths were significant for secular change in this group. The ANOVA of PRIN1 on year of birth is also close to the alpha level of significance ($p = 0.0644$). This reflects change in the femur and radius/ulna proportions over time. None of the other principal components is significant for change through time.

White males do not exhibit change over time in the first principal component, PRIN1, but they do exhibit significant change through time for the remaining components, PRIN2, PRIN3, PRIN4, and PRIN5. So even as white males show

Table 5.11. Results of linear regressions of principal components onto year of birth for white females.

Component	b_1	Intercept	Model Mean Square	Error Mean Square	F Value
PRIN1	0.000008827	0.010785	0.00002	0.00102	0.019
PRIN2	0.000102000	-0.191958	0.00262	0.00092	2.828
PRIN3	-0.000035604	0.070708	0.00032	0.00063	0.503
PRIN4	0.000020332	-0.040210	0.00010	0.00013	0.772
PRIN5	-0.000052471	0.101279	0.00007	0.00069	10.488**

** indicates siginificant at alpha = 0.05

Table 5.12. Results of linear regressions of principal components onto year of birth for black females.

Component	b_1	Intercept	Model Mean Square	Error Mean Square	F Value
PRIN1	0.000153000	-0.296500	0.00408	0.00118	3.456
PRIN2	0.000023021	-0.031738	0.00009	0.00095	0.098
PRIN3	-0.000005138	0.003820	0.00001	0.00054	0.008
PRIN4	0.000033339	-0.067047	0.00019	0.00009	2.050
PRIN5	-0.000081544	0.156930	0.00116	0.00005	21.331**

** indicates siginificant at alpha = 0.05

Table 5.13. Results of linear regressions of principal components onto year of birth for white males.

Component	**b_1**	Intercept	Model Mean Square	Error Mean Square	F Value
PRIN1	-0.000029077	0.063911	0.00057	0.00094	0.601
PRIN2	0.000330000	-0.636296	0.07326	0.00083	88.075**
PRIN3	-0.000120000	0.232962	0.00971	0.00041	23.767**
PRIN4	0.000025291	-0.045908	0.00043	0.00012	3.661**
PRIN5	-0.000022861	0.043742	0.00035	0.00007	4.932**

** indicates siginificant at alpha = 0.05

Table 5.14 Results of linear regressions of principal components onto year of birth for black males.

Component	b_1	Intercept	Model Mean Square	Error Mean Square	F Value
PRIN1	0.000055008	-0.132939	0.00082	0.00104	0.793
PRIN2	0.000206000	-0.384333	0.01153	0.00087	13.312**
PRIN3	-0.000063865	0.114663	0.00111	0.00045	2.485
PRIN4	0.000008869	-0.021381	0.00002	0.00012	0.185
PRIN5	-0.000020064	0.036481	0.00011	0.00007	1.463

** indicates siginificant at alpha = 0.05

significant secular change in the bone lengths, they are also exhibiting secular allometric change as well.

Black males exhibit secular change in only the second principal component, PRIN2 ($p = 0.0003$). This reflects the changing proportional relationship between the humerus and the tibia/fibula.

d. World War II Geographic Analysis

The data employed for this regional analysis are from Trotter's data set of WWII Pacific Theater casualties. These data represent individuals born during a short period of time so geography and secular change are unlikely to be compounded in this analysis. Summary statistics (n, mean, standard deviation, minimum, and maximum) for the geographic regions are presented in Tables 5.15 and 5.16. The white sample is much larger than the black sample as can be seen from the tables.

The first phase of the geographic analysis tests the hypothesis that geographic region of birth has no effect on bone length. Results of these ANOVAs of bone length onto region are presented in Tables 5.17 and 5.18, the results of the MANOVA are presented in Table 5.19. For white males, Wilk's Lambda is significant indicating that the null hypothesis that region has no effect is soundly rejected, while for black males the Wilk's Lambda is not significant indication that the null hypothesis cannot be rejected.

Further post hoc statistical tests, *t*-test (LSD) and Tukey-Kramer, take the analysis further by yielding results by specifically examining pairwise differences

Table 5.15. Summary statistics for the World War II geographic white male sample.

Variable	N	Mean	Std Dev	Minimum	Maximum
North Central					
DOB	367	1915.53	5.5494276	1890.00	1920.00
YOB	367	1919.56	4.8221384	1895.00	1927.00
MAXHT	367	174.8574347	6.1767761	160.0200000	189.2300000
HUM	365	337.9232877	15.7202407	298.0000000	384.0000000
RAD	357	253.0672269	12.4823906	216.0000000	300.0000000
ULNA	344	271.8633721	12.3786917	238.0000000	308.0000000
FEM	367	476.0136240	22.5009369	418.0000000	556.0000000
TIB	366	391.1557377	20.6902878	339.0000000	459.0000000
FIB	327	384.3730887	20.2887502	330.0000000	450.0000000
SIZE	310	344.0019987	15.6232030	303.0557116	384.4199287
SHUM	310	0.9815099	0.0202865	0.9135339	1.0441719
SRAD	310	0.7354822	0.0123672	0.7048018	0.7705496
SULNA	310	0.7903806	0.0142350	0.7290710	0.8297751
SFEM	310	1.3823475	0.0278431	1.2989059	1.4539332
STIB	310	1.1360153	0.0190502	1.0807115	1.1917177
SFIB	310	1.1171826	0.0179114	1.0609259	1.1716679

Table 5.15. (continued)

Variable	N	Mean	Std Dev	Minimum	Maximum
			Northeast		
DOB	338	1914.29	6.3712042	1890.00	1920.00
YOB	338	1918.42	5.3484462	1895.00	1927.00
MAXHT	337	173.0790826	6.5485175	156.2100000	189.2300000
HUM	333	334.0360360	16.7755889	293.0000000	381.0000000
RAD	325	248.1169231	12.9913975	215.0000000	295.0000000
ULNA	316	266.2784810	13.1336831	231.0000000	315.0000000
FEM	335	469.0746269	24.7492294	411.0000000	534.0000000
TIB	334	384.0239521	22.5502980	315.0000000	452.0000000
FIB	298	377.2617450	20.6260259	328.0000000	432.0000000
SIZE	275	338.0368500	16.3061765	297.7893623	378.1929012
SHUM	275	0.9878607	0.0201441	0.9404092	1.0421707
SRAD	275	0.7334388	0.0137764	0.6954589	0.7703689
SULNA	275	0.7869511	0.0157777	0.7426603	0.8430299
SFEM	275	1.3860500	0.0296846	1.2911205	1.4719346
STIB	275	1.1353077	0.0181397	1.0850918	1.1954487
SFIB	275	1.1157388	0.0177233	1.0665539	1.1704457

Table 5.15. (continued)

Variable	N	Mean	Std Dev	Minimum	Maximum
			South Central		
DOB	140	1916.00	5.0607816	1900.00	1920.00
YOB	140	1920.26	3.7905804	1909.00	1926.00
MAXHT	140	174.4753214	6.0403024	156.2100000	190.5000000
HUM	139	335.1798561	16.1327158	286.0000000	381.0000000
RAD	138	253.1521739	12.2628763	219.0000000	285.0000000
ULNA	133	272.7368421	12.1230401	231.0000000	300.0000000
FEM	139	473.3812950	22.1965514	409.0000000	537.0000000
TIB	137	389.0072993	19.3491512	334.0000000	443.0000000
FIB	123	381.2032520	19.3746325	319.0000000	435.0000000
SIZE	115	341.6550106	15.6519602	295.9995972	385.0762277
SHUM	115	0.9783467	0.0183173	0.9232906	1.0207153
SRAD	115	0.7382611	0.0131724	0.6861929	0.7722882
SULNA	115	0.7957572	0.0150096	0.7628481	0.8358510
SFEM	115	1.3776584	0.0275848	1.3103935	1.4562611
STIB	115	1.1349800	0.0183116	1.0961423	1.1773876
SFIB	115	1.1138078	0.0185747	1.0761531	1.1688541

Table 5.15. (continued)

Variable	N	Mean	Std Dev	Minimum	Maximum
Southeast					
DOB	165	1915.27	5.4731759	1900.00	1920.00
YOB	165	1919.59	4.1230877	1907.00	1926.00
MAXHT	165	174.4903030	6.2168761	157.4800000	189.2300000
HUM	164	338.1707317	15.8948268	296.0000000	380.0000000
RAD	165	253.4787879	12.0155326	216.0000000	284.0000000
ULNA	160	272.0125000	11.9079211	239.0000000	301.0000000
FEM	165	475.1636364	24.0244517	408.0000000	537.0000000
TIB	164	392.2012195	21.7941231	342.0000000	454.0000000
FIB	146	384.8493151	20.6612556	333.0000000	435.0000000
SIZE	143	344.4213207	15.7931436	305.8760440	382.7087704
SHUM	143	0.9815156	0.0204256	0.9272337	1.0772378
SRAD	143	0.7362375	0.0131206	0.6999748	0.7728941
SULNA	143	0.7907120	0.0160321	0.7356502	0.8346700
SFEM	143	1.3786746	0.0289658	1.3021611	1.4697495
STIB	143	1.1372035	0.0195641	1.0957069	1.1898585
SFIB	143	1.1174774	0.0191163	1.0672884	1.1760709

Table 5.15. (continued)

Variable	N	Mean	Std Dev	Minimum	Maximum
			West		
DOB	111	1916.13	5.2520422	1900.00	1920.00
YOB	111	1920.80	3.9904883	1905.00	1927.00
MAXHT	111	174.4590991	5.7741604	162.5600000	190.5000000
HUM	109	335.2018349	15.5615741	304.0000000	377.0000000
RAD	107	251.3457944	13.1242989	225.0000000	287.0000000
ULNA	104	269.8173077	13.6707216	240.0000000	305.0000000
FEM	111	474.4504505	22.9076163	427.0000000	534.0000000
TIB	111	388.8198198	21.2047157	338.0000000	434.0000000
FIB	98	380.9897959	20.8699927	331.0000000	430.0000000
SIZE	89	341.3450061	16.3275443	307.3891549	378.9527636
SHUM	89	0.9805165	0.0246836	0.8669103	1.0329877
SRAD	89	0.7339884	0.0122466	0.6919352	0.7612046
SULNA	89	0.7875357	0.0151310	0.7487850	0.8247513
SFEM	89	1.3901150	0.0261841	1.3194213	1.4711145
STIB	89	1.1368797	0.0202627	1.0963553	1.1945737
SFIB	89	1.1176580	0.0196949	1.0768109	1.1773078

Table 5.16. Summary statistics for the World War II geographic black male sample.

Variable	N	Mean	Std Dev	Minimum	Maximum
			North Central		
DOB	4	1917.50	5.0000000	1910.00	1920.00
YOB	4	1920.75	6.6520673	1911.00	1926.00
MAXHT	4	174.9425000	2.8160418	171.4500000	177.8000000
HUM	4	338.5000000	7.9372539	328.0000000	346.0000000
RAD	4	264.5000000	5.4467115	257.0000000	270.0000000
ULNA	4	281.7500000	14.4539499	263.0000000	295.0000000
FEM	4	489.7500000	14.7958327	474.0000000	506.0000000
TIB	4	413.7500000	17.3084758	402.0000000	439.0000000
FIB	4	403.7500000	15.5857841	391.0000000	424.0000000
SIZE	4	356.7506717	10.0691737	347.3774680	367.2747419
SHUM	4	0.9492623	0.0291684	0.9175692	0.9873985
SRAD	4	0.7415931	0.0123421	0.7319413	0.7594573
SULNA	4	0.7894693	0.0231247	0.7571015	0.8117394
SFEM	4	1.3728398	0.0183810	1.3559332	1.3923395
STIB	4	1.1596065	0.0267859	1.1309319	1.1952905
SFIB	4	1.1315316	0.0153277	1.1226769	1.1544491

Table 5.16. (continued)

Variable	N	Mean	Std Dev	Minimum	Maximum
			<u>Northeast</u>		
DOB	6	1916.67	5.1639778	1910.00	1920.00
YOB	6	1920.33	6.3140056	1912.00	1926.00
MAXHT	6	171.6616667	6.2043974	163.8300000	179.7050000
HUM	6	338.6666667	15.8071714	312.0000000	357.0000000
RAD	6	263.5000000	12.7867119	249.0000000	280.0000000
ULNA	3	283.3333333	19.5533458	267.0000000	305.0000000
FEM	6	477.8333333	28.0029760	437.0000000	513.0000000
TIB	6	408.8333333	27.7158198	376.0000000	442.0000000
FIB	4	410.0000000	16.3503313	394.0000000	429.0000000
SIZE	1	374.7215852	.	374.7215852	374.7215852
SHUM	1	0.9180149	.	0.9180149	0.9180149
SRAD	1	0.7472214	.	0.7472214	0.7472214
SULNA	1	0.8139376	.	0.8139376	0.8139376
SFEM	1	1.3263180	.	1.3263180	1.3263180
STIB	1	1.1795424	.	1.1795424	1.1795424
SFIB	1	1.1448500	.	1.1448500	1.1448500

Table 5.16. (continued)

Variable	N	Mean	Std Dev	Minimum	Maximum
			South Central		
DOB	15	1913.33	7.2374686	1900.00	1920.00
YOB	15	1917.60	5.8773172	1906.00	1924.00
MAXHT	15	174.0746667	5.9173720	162.5600000	184.1500000
HUM	15	335.9333333	13.7605371	308.0000000	365.0000000
RAD	15	267.9333333	10.7135873	251.0000000	291.0000000
ULNA	14	287.2857143	13.4360512	263.0000000	309.0000000
FEM	15	486.0666667	24.6966356	441.0000000	524.0000000
TIB	15	409.4666667	19.2608658	376.0000000	444.0000000
FIB	14	399.6428571	20.5860563	360.0000000	434.0000000
SIZE	13	356.7864874	15.2019057	328.4446260	381.7287866
SHUM	13	0.9429266	0.0265410	0.8985437	0.9988062
SRAD	13	0.7515772	0.0174770	0.7205967	0.7792922
SULNA	13	0.8063706	0.0195962	0.7785757	0.8459232
SFEM	13	1.3573590	0.0348991	1.2775757	1.4038016
STIB	13	1.1511116	0.0198518	1.1110009	1.1844291
SFIB	13	1.1216438	0.0217254	1.0863728	1.1623418

Table 5.16. (continued)

SouthEast

Variable	N	Mean	Std Dev	Minimum	Maximum
DOB	61	1912.95	6.4146349	1900.00	1920.00
YOB	61	1917.54	4.9651243	1907.00	1925.00
MAXHT	61	171.6269672	6.5542861	160.0200000	187.9600000
HUM	61	338.0327869	15.3187981	302.0000000	367.0000000
RAD	61	264.3114754	13.8197214	231.0000000	291.0000000
ULNA	61	283.6393443	13.7404910	251.0000000	312.0000000
FEM	61	481.1147541	23.3524434	436.0000000	533.0000000
TIB	61	405.9836066	24.5869151	364.0000000	451.0000000
FIB	57	395.7894737	23.4640583	356.0000000	440.0000000
SIZE	57	354.1061705	16.8671575	319.4647962	387.5949602
SHUM	57	0.9555165	0.0215697	0.9080564	1.0017490
SRAD	57	0.7478706	0.0143275	0.7135801	0.7745452
SULNA	57	0.8026777	0.0170271	0.7672225	0.8423113
SFEM	57	1.3613500	0.0314963	1.2581085	1.4315258
STIB	57	1.1477387	0.0223566	1.1048230	1.1861197
SFIB	57	1.1172365	0.0221790	1.0729447	1.1680043

Table 5.17. Results of ANOVAs testing long bone length variation among region of birth for white males (N = 932).

Variable	Model Mean Square	Error Mean Square	F Value
Max Height	125.8287	39.9361	3.15**
Humerus	763.7378	256.8736	2.97**
Radius	1225.3156	145.6932	7.92**
Ulna	1691.7571	156.6152	10.80**
Femur	2124.6135	539.4011	3.94**
Tibia	2244.1649	447.2412	5.02**
Fibula	2282.1664	414.2397	5.51**

** significance of alpha = .05

Table 5.18. Results of ANOVAs testing long bone length variation among region of birth for black males (N = 74).

Variable	Model Mean Square	Error Mean Square	F Value
Max Height	48.8094	40.2301	1.21
Humerus	11.5771	209.3627	0.06
Radius	105.0668	169.4464	0.62
Ulna	181.4639	190.5666	0.95
Femur	240.6364	518.7210	0.46
Tibia	534.3754	555.8930	0.96
Fibula	487.4210	527.3451	0.92

** significance of alpha = .05

Table 5.19. Manova Test Criteria and F Approximations for the hypothesis of no overall REGION effect.

Whites

H = Type III SS&CP Matrix for REGION E = Error SS&CP Matrix

S=4 M=1.5 N=459

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.90627457	2.8688	32	3394.388	0.0001

Blacks

S=3 M=2 N=30.5

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.79273231	0.6369	24	183.3204	0.9038

region by region for the five regions. The results of the *t*-tests are presented in Tables 5.20-5.26, and the results of the Tukey-Kramer tests are present in Tables 5.27-5.33. As none of the variables for black males show any significant differences by region of birth, only the tests for white males are presented.

The *t*-tests for maximum height (Table 5.20) indicate that significant differences are present between the Northeast sample and the North Central, West and Southeast samples. For the humerus, the Southeast, Northeast, and North Central regions are all significantly different from each other (5.21). The radius exhibits a slightly different pattern still with the North East region differing significantly from the Southeast, North Central, and South Central regions (Table 5.22). Comparisons of the regions for the ulna yield yet again different results than previously noted. With the ulna, the Southeast and the North Central differ from the West and Northeast regions, and the Northeast differs further with the South Central region (Table 5.23). The regions exhibiting significant differences for the femur are the Northeast from the North Central, Southeast and the West, and the South Central differs from the North Central(Table 5.24). The tibia and fibula are found to be different in the Northeast when compared to the Southeast and the North Central (Tables 5.25 and 5.26).

The results for the Tukey-Kramer pairwise comparisons are generally more conservative than the *t*-test results. The only regional differences found in maximum height are from the North Central and the Northeast (Table 5.27), and the humerus exhibits no regional differences (Table 5.28). The Northeast region differs

Table 5.20. T tests (LSD) for maximum height in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
NC - WE	-1.3831	0.1084	1.5998	
NC - SE	-0.9454	0.3083	1.5620	
NC - SC	-0.4942	0.8557	2.2055	
NC - NE	0.7111	1.7395	2.7679	***
WE - NC	-1.5998	-0.1084	1.3831	
WE - SE	-1.4745	0.2000	1.8745	
WE - SC	-1.0003	0.7473	2.4949	
WE - NE	0.1180	1.6311	3.1443	***
SE - NC	-1.5620	-0.3083	0.9454	
SE - WE	-1.8745	-0.2000	1.4745	
SE - SC	-1.0024	0.5473	2.0970	
SE - NE	0.1517	1.4312	2.7106	***
SC - NC	-2.2055	-0.8557	0.4942	
SC - WE	-2.4949	-0.7473	1.0003	
SC - SE	-2.0970	-0.5473	1.0024	
SC - NE	-0.4900	0.8838	2.2576	
NE - NC	-2.7679	-1.7395	-0.7111	***
NE - WE	-3.1443	-1.6311	-0.1180	***
NE - SE	-2.7106	-1.4312	-0.1517	***
NE - SC	-2.2576	-0.8838	0.4900	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 39.93609
Critical Value of T = 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.21. T tests (LSD) for the humerus in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
SE - NC	-2.777	0.403	3.582	
SE - WE	-0.827	3.420	7.667	
SE - SC	-0.058	3.872	7.803	
SE - NE	0.777	4.022	7.267	***
NC - SE	-3.582	-0.403	2.777	
NC - WE	-0.765	3.017	6.800	
NC - SC	0.046	3.470	6.893	***
NC - NE	1.011	3.620	6.228	***
WE - SE	-7.667	-3.420	0.827	
WE - NC	-6.800	-3.017	0.765	
WE - SC	-3.980	0.452	4.885	
WE - NE	-3.235	0.602	4.440	
SC - SE	-7.803	-3.872	0.058	
SC - NC	-6.893	-3.470	-0.046	***
SC - WE	-4.885	-0.452	3.980	
SC - NE	-3.334	0.150	3.634	
NE - SE	-7.267	-4.022	-0.777	***
NE - NC	-6.228	-3.620	-1.011	***
NE - WE	-4.440	-0.602	3.235	
NE - SC	-3.634	-0.150	3.334	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 256.8736
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.22. T tests (LSD) for the radius in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
SE - NC	-1.9107	0.5568	3.0242	
SE - SC	-1.8629	1.1871	4.2372	
SE - WE	-0.2909	3.0046	6.3002	
SE - NE	3.0994	5.6175	8.1356	***
NC - SE	-3.0242	-0.5568	1.9107	
NC - SC	-2.0264	0.6304	3.2871	
NC - WE	-0.4875	2.4479	5.3832	
NC - NE	3.0368	5.0608	7.0847	***
SC - SE	-4.2372	-1.1871	1.8629	
SC - NC	-3.2871	-0.6304	2.0264	
SC - WE	-1.6221	1.8175	5.2571	
SC - NE	1.7266	4.4304	7.1342	***
WE - SE	-6.3002	-3.0046	0.2909	
WE - NC	-5.3832	-2.4479	0.4875	
WE - SC	-5.2571	-1.8175	1.6221	
WE - NE	-0.3652	2.6129	5.5910	
NE - SE	-8.1356	-5.6175	-3.0994	***
NE - NC	-7.0847	-5.0608	-3.0368	***
NE - SC	-7.1342	-4.4304	-1.7266	***
NE - WE	-5.5910	-2.6129	0.3652	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 154.6932
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.23. T tests (LSD) for the ulna in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
SE - SC	-2.810	0.259	3.328	
SE - NC	-2.079	0.404	2.887	
SE - WE	0.145	3.461	6.777	***
SE - NE	3.725	6.259	8.792	***
SC - SE	-3.328	-0.259	2.810	
SC - NC	-2.528	0.145	2.818	
SC - WE	-0.259	3.202	6.663	
SC - NE	3.279	6.000	8.721	***
NC - SE	-2.887	-0.404	2.079	
NC - SC	-2.818	-0.145	2.528	
NC - WE	0.104	3.057	6.011	***
NC - NE	3.818	5.855	7.891	***
WE - SE	-6.777	-3.461	-0.145	***
WE - SC	-6.663	-3.202	0.259	
WE - NC	-6.011	-3.057	-0.104	***
WE - NE	-0.199	2.798	5.794	
NE - SE	-8.792	-6.259	-3.725	***
NE - SC	-8.721	-6.000	-3.279	***
NE - NC	-7.891	-5.855	-3.818	***
NE - WE	-5.794	-2.798	0.199	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 156.6152
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.24. T tests (LSD) for the femur in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
NC - SE	-3.972	0.636	5.243	
NC - WE	-4.452	1.030	6.511	
NC - SC	0.145	5.106	10.067	***
NC - NE	3.075	6.855	10.634	***
SE - NC	-5.243	-0.636	3.972	
SE - WE	-5.760	0.394	6.548	
SE - SC	-1.225	4.470	10.165	
SE - NE	1.517	6.219	10.921	***
WE - NC	-6.511	-1.030	4.452	
WE - SE	-6.548	-0.394	5.760	
WE - SC	-2.347	4.076	10.499	
WE - NE	0.264	5.825	11.386	***
SC - NC	-10.067	-5.106	-0.145	***
SC - SE	-10.165	-4.470	1.225	
SC - WE	-10.499	-4.076	2.347	
SC - NE	-3.300	1.749	6.798	
NE - NC	-10.634	-6.855	-3.075	***
NE - SE	-10.921	-6.219	-1.517	***
NE - WE	-11.386	-5.825	-0.264	***
NE - SC	-6.798	-1.749	3.300	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 539.4011
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.25. T tests (LSD) for the tibia in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
SE - NC	-3.289	0.906	5.102	
SE - WE	-1.982	3.622	9.225	
SE - SC	-1.258	3.928	9.114	
SE - NE	3.541	7.823	12.105	***
NC - SE	-5.102	-0.906	3.289	
NC - WE	-2.276	2.715	7.706	
NC - SC	-1.496	3.022	7.539	
NC - NE	3.475	6.917	10.358	***
WE - SE	-9.225	-3.622	1.982	
WE - NC	-7.706	-2.715	2.276	
WE - SC	-5.542	0.306	6.155	
WE - NE	-0.862	4.201	9.265	
SC - SE	-9.114	-3.928	1.258	
SC - NC	-7.539	-3.022	1.496	
SC - WE	-6.155	-0.306	5.542	
SC - NE	-0.703	3.895	8.492	
NE - SE	-12.105	-7.823	-3.541	***
NE - NC	-10.358	-6.917	-3.475	***
NE - WE	-9.265	-4.201	0.862	
NE - SC	-8.492	-3.895	0.703	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 447.2411
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.26. T tests (LSD) for the fibula in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
SE - NC	-3.439	0.598	4.636	
SE - WE	-2.021	3.372	8.765	
SE - SC	-0.702	4.289	9.280	
SE - NE	3.534	7.654	11.775	***
NC - SE	-4.636	-0.598	3.439	
NC - WE	-2.030	2.774	7.577	
NC - SC	-0.656	3.691	8.038	
NC - NE	3.744	7.056	10.368	***
WE - SE	-8.765	-3.372	2.021	
WE - NC	-7.577	-2.774	2.030	
WE - SC	-4.711	0.917	6.546	
WE - NE	-0.591	4.282	9.155	
SC - SE	-9.280	-4.289	0.702	
SC - NC	-8.038	-3.691	0.656	
SC - WE	-6.546	-0.917	4.711	
SC - NE	-1.060	3.365	7.789	
NE - SE	-11.775	-7.654	-3.534	***
NE - NC	-10.368	-7.056	-3.744	***
NE - WE	-9.155	-4.282	0.591	
NE - SC	-7.789	-3.365	1.060	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 414.2397
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.27. Tukey's Studentized Range (HSD) Test for maximum height.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
NC - WE	-1.9688	0.1084	2.1855	
NC - SE	-1.4377	0.3083	2.0544	
NC - SC	-1.0243	0.8557	2.7356	
NC - NE	0.3073	1.7395	3.1717	***
WE - NC	-2.1855	-0.1084	1.9688	
WE - SE	-2.1320	0.2000	2.5320	
WE - SC	-1.6866	0.7473	3.1812	
WE - NE	-0.4762	1.6311	3.7385	
SE - NC	-2.0544	-0.3083	1.4377	
SE - WE	-2.5320	-0.2000	2.1320	
SE - SC	-1.6109	0.5473	2.7056	
SE - NE	-0.3507	1.4312	3.2130	
SC - NC	-2.7356	-0.8557	1.0243	
SC - WE	-3.1812	-0.7473	1.6866	
SC - SE	-2.7056	-0.5473	1.6109	
SC - NE	-1.0295	0.8838	2.7971	
NE - NC	-3.1717	-1.7395	-0.3073	***
NE - WE	-3.7385	-1.6311	0.4762	
NE - SE	-3.2130	-1.4312	0.3507	
NE - SC	-2.7971	-0.8838	1.0295	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 39.93609
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.28. Tukey's Studentized Range (HSD) Test for the humerus.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
SE - NC	-4.026	0.403	4.831
SE - WE	-2.494	3.420	9.334
SE - SC	-1.601	3.872	9.346
SE - NE	-0.497	4.022	8.541
NC - SE	-4.831	-0.403	4.026
NC - WE	-2.251	3.017	8.285
NC - SC	-1.298	3.470	8.237
NC - NE	-0.013	3.620	7.252
WE - SE	-9.334	-3.420	2.494
WE - NC	-8.285	-3.017	2.251
WE - SC	-5.720	0.452	6.625
WE - NE	-4.742	0.602	5.947
SC - SE	-9.346	-3.872	1.601
SC - NC	-8.237	-3.470	1.298
SC - WE	-6.625	-0.452	5.720
SC - NE	-4.703	0.150	5.002
NE - SE	-8.541	-4.022	0.497
NE - NC	-7.252	-3.620	0.013
NE - WE	-5.947	-0.602	4.742
NE - SC	-5.002	-0.150	4.703

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 256.8736
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.29. Tukey's Studentized Range (HSD) Test for the radius.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
SE - NC	-2.8797	0.5568	3.9932	
SE - SC	-3.0606	1.1871	5.4349	
SE - WE	-1.5851	3.0046	7.5943	
SE - NE	2.1106	5.6175	9.1245	***
NC - SE	-3.9932	-0.5568	2.8797	
NC - SC	-3.0696	0.6304	4.3303	
NC - WE	-1.6402	2.4479	6.5359	
NC - NE	2.2420	5.0608	7.8795	***
SC - SE	-5.4349	-1.1871	3.0606	
SC - NC	-4.3303	-0.6304	3.0696	
SC - WE	-2.9727	1.8175	6.6078	
SC - NE	0.6648	4.4304	8.1960	***
WE - SE	-7.5943	-3.0046	1.5851	
WE - NC	-6.5359	-2.4479	1.6402	
WE - SC	-6.6078	-1.8175	2.9727	
WE - NE	-1.5346	2.6129	6.7604	
NE - SE	-9.1245	-5.6175	-2.1106	***
NE - NC	-7.8795	-5.0608	-2.2420	***
NE - SC	-8.1960	-4.4304	-0.6648	***
NE - WE	-6.7604	-2.6129	1.5346	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 154.6932
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.30. Tukey's Studentized Range (HSD) Test for the ulna.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
SE - NC	-2.8797	0.5568	3.9932	
SE - SC	-4.015	0.259	4.533	
SE - NC	-3.054	0.404	3.862	
SE - WE	-1.157	3.461	8.079	
SE - NE	2.730	6.259	9.787	***
SC - SE	-4.533	-0.259	4.015	
SC - NC	-3.578	0.145	3.868	
SC - WE	-1.618	3.202	8.022	
SC - NE	2.211	6.000	9.789	***
NC - SE	-3.862	-0.404	3.054	
NC - SC	-3.868	-0.145	3.578	
NC - WE	-1.056	3.057	7.170	
NC - NE	3.019	5.855	8.691	***
WE - SE	-8.079	-3.461	1.157	
WE - SC	-8.022	-3.202	1.618	
WE - NC	-7.170	-3.057	1.056	
WE - NE	-1.375	2.798	6.971	
NE - SE	-9.787	-6.259	-2.730	***
NE - SC	-9.789	-6.000	-2.211	***
NE - NC	-8.691	-5.855	-3.019	***
NE - WE	-6.971	-2.798	1.375	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 156.6152
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.31. Tukey's Studentized Range (HSD) Test for the femur.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
NC - SE	-5.781	0.636	7.052	
NC - WE	-6.604	1.030	8.663	
NC - SC	-1.803	5.106	12.015	
NC - NE	1.591	6.855	12.118	***
SE - NC	-7.052	-0.636	5.781	
SE - WE	-8.177	0.394	8.964	
SE - SC	-3.462	4.470	12.402	
SE - NE	-0.330	6.219	12.768	
WE - NC	-8.663	-1.030	6.604	
WE - SE	-8.964	-0.394	8.177	
WE - SC	-4.869	4.076	13.021	
WE - NE	-1.920	5.825	13.570	
SC - NC	-12.015	-5.106	1.803	
SC - SE	-12.402	-4.470	3.462	
SC - WE	-13.021	-4.076	4.869	
SC - NE	-5.283	1.749	8.781	
NE - NC	-12.118	-6.855	-1.591	***
NE - SE	-12.768	-6.219	0.330	
NE - WE	-13.570	-5.825	1.920	
NE - SC	-8.781	-1.749	5.283	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 539.4011
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.32. Tukey's Studentized Range (HSD) Test for the tibia.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
SE - NC	-4.937	0.906	6.749	
SE - WE	-4.182	3.622	11.426	
SE - SC	-3.294	3.928	11.151	
SE - NE	1.860	7.823	13.786	***
NC - SE	-6.749	-0.906	4.937	
NC - WE	-4.236	2.715	9.666	
NC - SC	-3.269	3.022	9.313	
NC - NE	2.124	6.917	11.710	***
WE - SE	-11.426	-3.622	4.182	
WE - NC	-9.666	-2.715	4.236	
WE - SC	-7.839	0.306	8.452	
WE - NE	-2.851	4.201	11.254	
SC - SE	-11.151	-3.928	3.294	
SC - NC	-9.313	-3.022	3.269	
SC - WE	-8.452	-0.306	7.839	
SC - NE	-2.508	3.895	10.298	
NE - SE	-13.786	-7.823	-1.860	***
NE - NC	-11.710	-6.917	-2.124	***
NE - WE	-11.254	-4.201	2.851	
NE - SC	-10.298	-3.895	2.508	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 447.2411
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.33. Tukey's Studentized Range (HSD) Test for the fibula.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
SE - NC	-5.025	0.598	6.222	
SE - WE	-4.138	3.372	10.883	
SE - SC	-2.662	4.289	11.240	
SE - NE	1.915	7.654	13.393	***
NC - SE	-6.222	-0.598	5.025	
NC - WE	-3.916	2.774	9.464	
NC - SC	-2.364	3.691	9.746	
NC - NE	2.443	7.056	11.668	***
WE - SE	-10.883	-3.372	4.138	
WE - NC	-9.464	-2.774	3.916	
WE - SC	-6.922	0.917	8.756	
WE - NE	-2.505	4.282	11.069	
SC - SE	-11.240	-4.289	2.662	
SC - NC	-9.746	-3.691	2.364	
SC - WE	-8.756	-0.917	6.922	
SC - NE	-2.797	3.365	9.527	
NE - SE	-13.393	-7.654	-1.915	***
NE - NC	-11.668	-7.056	-2.443	***
NE - WE	-11.069	-4.282	2.505	
NE - SC	-9.527	-3.365	2.797	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 414.2397
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

significantly from the Southeast, North Central and the South Central for the radius and ulna (Tables 5.29 and 5.30). Regional differences in the femur are present between the Northeast and the North Central (Table 5.31), while for the tibia and fibula, the Northeast differs from the Southeast and the North Central (Tables 5.32 and 5.33).

In summary, the regional differences are most commonly seen as the Northeast being different from most other regions. The Tukey-Kramer test yielded fewer significant pairwise differences than did the *t*-test. The upper distal bones exhibit the most variation regionally, and the lower distal bones are the next most variable. Both the humerus and the femur exhibit the least amount of variation from region to region. An examination of the means table (Table 5.15) shows the reason the Northeast region is different from the others is due to shorter stature and shorter bones. Mean maximum height for the Northeast is at least 1.5 centimeters less than any other region. The North Central group is the largest in height, but as the tests indicate, not significantly different from any other group except the Northeast. No consistent pattern is present other than the shorter, smaller Northeast group.

e. Geographical Variation in Long Bone Proportions

White Sample

Summary statistics are presented by region in Tables 5.15 for size and the shape variables SHUM, SRAD, SULNA, SFEM, STIB, and SFIB, each representing the respective bones. Table 5.34 gives the simple statistics for the shape variables,

Table 5.34. Simple statistics for the shape variables for white males in the geographic allometry analysis (n=939).

	SHUM	SRAD	SULNA	SFEM	STIB	SFIB
Mean	0.9828500826	0.7352179445	0.7898756845	1.383007111	1.135898032	1.116442086
StD	0.0208424596	0.0131095086	0.0154530567	0.028741083	0.018897887	0.018310968

the covariance matrix is presented in Table 5.35, and Table 5.36 presents the eigenvalues of the covariance matrix, all of which are derived in the principal component analysis. The principal component analysis is presented in Table 5.37. Individuals with high scores on the first component, PRIN1, exhibit proportionally longer femora to shorter radius and ulna. The second component contrasts shorter humeri to longer tibiae and fibulae, while the third component, PRIN3 contrasts relatively liner humeri to shorter ulna and femora. Individuals with high scores on the fourth component have proportionally contrasting tibia and fibula, while the fifth component contrasts the radius and ulna. These results are similar to the principal component analysis for the four groups temporal study. The sixth component only accounts for 0.000057 proportion of the variation, and thus will not be considered.

The next phase of analysis concerns the regional effect on allometry. The results of the ANOVAs testing for regional effect are presented in Table 5.38 and reveal that regional variation is not limited to size. Size is shown to be significant for a regional effect as are PRIN1 and PRIN3 ($p = 0.0001$). The other principal components are not significantly different by region. Again the *t*-test and Tukey-Kramer pairwise comparisons are employed for a closer examination of which regions are different from others. These test results are presented in Tables 5.39-5.44. Size is found to be significant between the Northeast and the Southeast, North Central, and the South Central (Table 5.39). In the *t*-test pairwise comparison for PRIN1, the West and Northeast regions exhibit significant differences from the North Central, Southeast and the South Central, and the North Central is different from the South

Table 5.35. Covariance Matrix of shape variables for whites in geographic analysis.

	SHUM	SRAD	SULNA	SFEM	STIB	SFIB
SHUM	0.0004344081	-.0000510989	-.0000714274	0.0000353940	-.0001800042	-.0001683572
SRAD	-.0000510989	0.0001718592	0.0001266159	-.0002002639	-.0001115795	-.0001106390
SULNA	-.0000714274	0.0001266159	0.0002387970	-.0002384387	-.0001404057	-.0001185234
SFEM	0.0000353940	-.0002002639	-.0002384387	0.0008260499	-.0000170604	-.0000490304
STIB	-.0001800042	-.0001115795	-.0001404057	-.0000170604	0.0003571301	0.0002369838
SFIB	-.0001683572	-.0001106390	-.0001185234	-.0000490304	0.0002369838	0.0003352915

Table 5.36. Eigenvalues of the covariance matrix for whites in the geographic analysis.

	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	0.000992	0.000185	0.419624	0.41962
PRIN2	0.000807	0.000425	0.341305	0.76093
PRIN3	0.000382	0.000271	0.161495	0.92242
PRIN4	0.000111	0.000038	0.046835	0.96926
PRIN5	0.000073	0.000072	0.030683	0.99994
PRIN6	0.000000	.	0.000057	1.00000

Total Variance = 0.0023635359

Table 5.37. Principal component analysis of whites in the geographic analysis.

	Eigenvectors					
	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6
SHUM	0.066882	-.512381	0.755486	-.005646	0.064860	0.397485
SRAD	-.299327	-.126586	-.278801	-.196101	-.705605	0.529448
SULNA	-.365920	-.143691	-.379902	0.166588	0.655365	0.493837
SFEM	0.866845	-.197137	-.359400	0.032853	0.011854	0.281653
STIB	0.120469	0.586294	0.183438	-.667190	0.213654	0.342501
SFIB	0.078102	0.564085	0.210636	0.698240	-.150409	0.348108

Table 5.38. Results of ANOVAs testing shape variation among region of birth for white males (N = 933).

Variable	Model Mean Square	Error Mean Square	F Value
Size	1561.3929520	253.22544200	6.17**
PRIN1	0.0058177	0.00097421	5.97**
PRIN2	0.0011542	0.00080095	1.44
PRIN3	0.0022476	0.00037495	5.99**
PRIN4	0.0000477	0.00011129	0.43
PRIN5	0.0000865	0.00007276	1.19

** significance of alpha = .05

Table 5.39 T tests (LSD) for SIZE in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
SE - NC	-2.738	0.419	3.576	
SE - SC	-1.166	2.736	6.638	
SE - WE	-1.140	3.076	7.293	
SE - NE	3.094	6.316	9.538	***
NC - SE	-3.576	-0.419	2.738	
NC - SC	-1.083	2.317	5.716	
NC - WE	-1.099	2.657	6.413	
NC - NE	3.307	5.897	8.486	***
SC - SE	-6.638	-2.736	1.166	
SC - NC	-5.716	-2.317	1.083	
SC - WE	-4.060	0.340	4.741	
SC - NE	0.121	3.580	7.039	***
WE - SE	-7.293	-3.076	1.140	
WE - NC	-6.413	-2.657	1.099	
WE - SC	-4.741	-0.340	4.060	
WE - NE	-0.571	3.240	7.050	
NE - SE	-9.538	-6.316	-3.094	***
NE - NC	-8.486	-5.897	-3.307	***
NE - SC	-7.039	-3.580	-0.121	***
NE - WE	-7.050	-3.240	0.571	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 253.2254
Critical Value of T= 1.96253
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.40. T tests (LSD) for PRIN1 in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
WE - NE	-0.004477	0.002993	0.010464	
WE - NC	0.000930	0.008296	0.015663	***
WE - SE	0.003390	0.011661	0.019931	***
WE - SC	0.008157	0.016788	0.025420	***
NE - WE	-0.010464	-0.002993	0.004477	
NE - NC	0.000229	0.005303	0.010377	***
NE - SE	0.002352	0.008667	0.014983	***
NE - SC	0.007013	0.013795	0.020576	***
NC - WE	-0.015663	-0.008296	-0.000930	***
NC - NE	-0.010377	-0.005303	-0.000229	***
NC - SE	-0.002828	0.003365	0.009557	
NC - SC	0.001825	0.008492	0.015159	***
SE - WE	-0.019931	-0.011661	-0.003390	***
SE - NE	-0.014983	-0.008667	-0.002352	***
SE - NC	-0.009557	-0.003365	0.002828	
SE - SC	-0.002527	0.005127	0.012782	
SC - WE	-0.025420	-0.016788	-0.008157	***
SC - NE	-0.020576	-0.013795	-0.007013	***
SC - NC	-0.015159	-0.008492	-0.001825	***
SC - SE	-0.012782	-0.005127	0.002527	

Alpha= 0.05 Confidence= 0.95 df= 928 MSE= 0.000974
Critical Value of T= 1.96252
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.41. T tests (LSD) for PRIN3 in the geographical analysis.

REGION Comparison	Lower Confidence Limit	Difference Between Means	Upper Confidence Limit	
NE - SE	-0.000280	0.003638	0.007556	
NE - NC	0.001758	0.004906	0.008054	***
NE - WE	0.002058	0.006692	0.011326	***
NE - SC	0.005420	0.009627	0.013834	***
SE - NE	-0.007556	-0.003638	0.000280	
SE - NC	-0.002574	0.001268	0.005109	
SE - WE	-0.002077	0.003054	0.008185	
SE - SC	0.001241	0.005989	0.010737	***
NC - NE	-0.008054	-0.004906	-0.001758	***
NC - SE	-0.005109	-0.001268	0.002574	
NC - WE	-0.002784	0.001786	0.006356	
NC - SC	0.000585	0.004721	0.008857	***
WE - NE	-0.011326	-0.006692	-0.002058	***
WE - SE	-0.008185	-0.003054	0.002077	
WE - NC	-0.006356	-0.001786	0.002784	
WE - SC	-0.002420	0.002935	0.008290	
SC - NE	-0.013834	-0.009627	-0.005420	***
SC - SE	-0.010737	-0.005989	-0.001241	***
SC - NC	-0.008857	-0.004721	-0.000585	***
SC - WE	-0.008290	-0.002935	0.002420	

Alpha= 0.05 Confidence= 0.95 df= 928 MSE= 0.000375
Critical Value of T= 1.96252
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.42. Tukey's Studentized Range (HSD) Test for SIZE in the geographic analysis.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
SE - NC	-3.977	0.419	4.816	
SE - SC	-2.699	2.736	8.171	
SE - WE	-2.796	3.076	8.949	
SE - NE	1.829	6.316	10.803	***
NC - SE	-4.816	-0.419	3.977	
NC - SC	-2.417	2.317	7.050	
NC - WE	-2.573	2.657	7.887	
NC - NE	2.290	5.897	9.503	***
SC - SE	-8.171	-2.736	2.699	
SC - NC	-7.050	-2.317	2.417	
SC - WE	-5.788	0.340	6.469	
SC - NE	-1.238	3.580	8.398	
WE - SE	-8.949	-3.076	2.796	
WE - NC	-7.887	-2.657	2.573	
WE - SC	-6.469	-0.340	5.788	
WE - NE	-2.067	3.240	8.546	
NE - SE	-10.803	-6.316	-1.829	***
NE - NC	-9.503	-5.897	-2.290	***
NE - SC	-8.398	-3.580	1.238	
NE - WE	-8.546	-3.240	2.067	

Alpha= 0.05 Confidence= 0.95 df= 927 MSE= 253.2254
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.43. Tukey's Studentized Range (HSD) Test for PRIN1 in the geographical analysis.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
WE - NE	-0.007410	0.002993	0.013397	
WE - NC	-0.001963	0.008296	0.018555	
WE - SE	0.000143	0.011661	0.023179	***
WE - SC	0.004767	0.016788	0.028809	***
NE - WE	-0.013397	-0.002993	0.007410	
NE - NC	-0.001764	0.005303	0.012370	
NE - SE	-0.000128	0.008667	0.017463	
NE - SC	0.004350	0.013795	0.023240	***
NC - WE	-0.018555	-0.008296	0.001963	
NC - NE	-0.012370	-0.005303	0.001764	
NC - SE	-0.005259	0.003365	0.011988	
NC - SC	-0.000793	0.008492	0.017777	
SE - WE	-0.023179	-0.011661	-0.000143	***
SE - NE	-0.017463	-0.008667	0.000128	
SE - NC	-0.011988	-0.003365	0.005259	
SE - SC	-0.005532	0.005127	0.015787	
SC - WE	-0.028809	-0.016788	-0.004767	***
SC - NE	-0.023240	-0.013795	-0.004350	***
SC - NC	-0.017777	-0.008492	0.000793	
SC - SE	-0.015787	-0.005127	0.005532	

Alpha= 0.05 Confidence= 0.95 df= 928 MSE= 0.000974
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Table 5.44. Tukey's Studentized Range (HSD) Test for PRIN3 in the geographical analysis.

REGION Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
NE - SE	-0.001818	0.003638	0.009094	
NE - NC	0.000522	0.004906	0.009290	***
NE - WE	0.000238	0.006692	0.013146	***
NE - SC	0.003768	0.009627	0.015486	***
SE - NE	-0.009094	-0.003638	0.001818	
SE - NC	-0.004082	0.001268	0.006618	
SE - WE	-0.004091	0.003054	0.010200	
SE - SC	-0.000624	0.005989	0.012602	
NC - NE	-0.009290	-0.004906	-0.000522	***
NC - SE	-0.006618	-0.001268	0.004082	
NC - WE	-0.004578	0.001786	0.008151	
NC - SC	-0.001039	0.004721	0.010481	
WE - NE	-0.013146	-0.006692	-0.000238	***
WE - SE	-0.010200	-0.003054	0.004091	
WE - NC	-0.008151	-0.001786	0.004578	
WE - SC	-0.004523	0.002935	0.010393	
SC - NE	-0.015486	-0.009627	-0.003768	***
SC - SE	-0.012602	-0.005989	0.000624	
SC - NC	-0.010481	-0.004721	0.001039	
SC - WE	-0.010393	-0.002935	0.004523	

Alpha= 0.05 Confidence= 0.95 df= 928 MSE= 0.000375
Critical Value of Studentized Range= 3.865
Comparisons significant at the 0.05 level are indicated by '***'.

Central (Table 5.40). In the *t*-test for PRIN3, the Northeast exhibits significant differences from the North Central, West, and South Central regions, while the South Central differs from the Southeast and North Central as well (Table 5.41).

The results from the Tukey-Kramer test once again yield more conservative results (Tables 5.42-5.44). Size differs between the Northeast and Southeast and North Central regions (Table 5.42). For the first component, the West differs from the Southeast and South Central regions, and the Northeast differs from the South Central (Table 5.43). Regional differences found to be significant for PRIN3 are the Northeast from the North Central, West and South Central (Table 5.44). This test has resulted in a more conservative view of regional differences in allometry for white males.

In summary, the Northeast differs from the others in size and shape as was seen in the bone length analysis. This is due to smaller bone lengths in this group. The shape variables are also smaller in the Northeast. The first principal component reflects the proportional contrast of the relatively longer femur to shorter radius and ulna. As previously mentioned, the West group differs from the Southeast and South Central regions in this component, PRIN1. This can be seen in Table 5.15 as the West has larger values for SFEM and smaller values for SRAD and SULNA when compared to the two southern groups. The regional differences expressed in the third principal component can also be seen Table 5.15. PRIN3 contrasts the humerus to the radius, ulna, and femur. The Northeast group exhibits this very trend and thus has high scores for this component, whereas the North Central, West, and South Central have lower scores.

Black Sample

Summary statistics are presented by region in Table 5.16 for size and the shape variables SHUM, SRAD, SULNA, SFEM, STIB, and SFIB, each representing the respective bones. Table 5.45 gives the simple statistics for the shape variables, the covariance matrix is presented in Table 5.46, and Table 5.47 presents the eigenvalues of the covariance matrix, all of which are derived in the principal component analysis. The principal component analysis is presented in Table 5.48.

The components for this sample are somewhat different from the previous sample. PRIN1 contrasts relatively longer tibia and fibula with relatively shorter humerus and femur, while PRIN2 contrasts longer femur to shorter radius and ulna. This component is reflecting lower versus upper limb allometry. Individuals with high scores on the third component exhibit relatively longer humeri compared to relatively shorter radii. The fourth and fifth components exhibit the same pattern as in the white sample and in the four group analysis with the distal bones contrasting. The sixth component only accounts for 0.000033 of the variance so it will not be discussed.

Table 5.45. Simple statistics of shape variables for blacks in the geographic analysis (n = 74).

	SHUM	SRAD	SULNA	SFEM	STIB	SFIB
Mean	0.9529622085	0.7477490117	0.8021802308	1.361928590	1.149527121	1.118908177
StD	0.0230599612	0.0143183589	0.0171860936	0.030091475	0.022290879	0.021959881

Table 5.46. Covariance matrix of the shape variables for blacks in the geographic analysis.

	SHUM	SRAD	SULNA	SFEM	STIB	SFIB
SHUM	0.0005317618	-.0000345077	-.0000900405	0.0000445085	-.0002310004	-.0002603820
SRAD	-.0000345077	0.0002050154	0.0001304495	-.0001985135	-.0001439726	-.0001431734
SULNA	-.0000900405	0.0001304495	0.0002953618	-.0001990750	-.0001838198	-.0001565687
SFEM	0.0000445085	-.0001985135	-.0001990750	0.0009054969	-.0001182187	-.0001100107
STIB	-.0002310004	-.0001439726	-.0001838198	-.0001182187	0.0004968833	0.0003560001
SFIB	-.0002603820	-.0001431734	-.0001565687	-.0001100107	0.0003560001	0.0004822364

Table 5.47. Eigenvalues of the covariance matrix for blacks in geographic analysis.

	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	0.001173	0.000158	0.402153	0.40215
PRIN2	0.001015	0.000527	0.347881	0.75003
PRIN3	0.000488	0.000354	0.167331	0.91736
PRIN4	0.000134	0.000028	0.046078	0.96344
PRIN5	0.000107	0.000106	0.036524	0.99997
PRIN6	0.000000	.	0.000033	1.00000

Total Variance = 0.0029167556

Table 5.48. Principal component analysis for blacks in the geographic analysis.

Eigenvectors

	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6
SHUM	-.438028	-.067564	0.783478	0.099484	0.103113	0.411339
SRAD	-.071215	-.335437	-.216563	-.270740	-.699516	0.522387
SULNA	-.082436	-.381842	-.438829	0.178025	0.621709	0.486431
SFEM	-.430330	0.793389	-.318254	-.029317	-.011526	0.288223
STIB	0.553267	0.235141	0.195974	-.640021	0.272594	0.340975
SFIB	0.552246	0.228815	0.083672	0.688929	-.197694	0.349229

The results of the ANOVAs examining possible regional effects are presented in Table 5.49. As no regional effects are found to be significant for allometry, no further results are presented.

Table 5.49. Results of ANOVAs testing shape variation among region of birth for black males (N = 74).

Variable	Model Mean Square	Error Mean Square	F Value
Size	178.8852262	269.4797974	0.66
PRIN1	0.0016281	0.0011534	1.41
PRIN2	0.0076561	0.0010254	0.75
PRIN3	0.0003092	0.0004957	0.62
PRIN4	0.0000157	0.0001395	0.11
PRIN5	0.0000445	0.0001092	0.41

** significance of alpha = .05

CHAPTER VI

DISCUSSION

a. Secular Change in Height

Secular change has been shown to have occurred in stature and in the six long bones of American whites and blacks over the last two centuries. While white males exhibit the most dramatic changes in all of the long bones, black males and white females exhibit change in all but the humerus. Interestingly, black females exhibit no significant change in any of the long bones, yet this group has experienced a positive increase in stature over time.

A brief discussion is needed to uphold the validity of a portion of my data, the statures from the Forensic Data Bank. Previous studies have reported on the inaccuracy of self-reporting of statures (Boldsen et al., 1986; Giles and Hutchinson, 1991; and Willey and Falsetti, 1991). The statures obtained from the FDB are either living or cadaver statures which include about two thirds "forensic" statures as defined in Moore-Jansen et al. (1994). It might be argued that the positive secular trend in statures is due to over reporting of statures in the FDB sample. A comparison of the means and standard deviations of the FDB statures with published means of American males and females illustrates that the FDB statures are comparable to other stature data reported in the literature, and this supports the integrity of the FDB statures (see Table 6.1).

Another portion of this data set that bears some discussion is the WWII sample. This data set only includes those individuals that were accepted for military service and

Table 6.1. Means and standard deviations of stature (cm) for males and females.

	Females			Males		
Population	N	Mean	S.D.	N	Mean	S.D.
U.S. Army[1]	2208	162.94	6.36	1774	175.58	6.68
U.T. Students[2]	244	163.79	5.84	268	178.25	6.78
FDB[3]	82	163.88	7.98	143	176.43	8.31

[1] Gordon et al. (1988)

[2] Willey and Falsetti (1991)

[3] Current study

does not represent the individuals that were disqualified for duty for unknown reasons. In a study by Karpinos (1958a), weight and height standards based on WWII registrants were examined. Karpinos employed data from 237,372 inducted men and 148,565 disqualified men. While not directly comparing those individuals that qualified for duty to those that were disqualified, this study presented data concerning these groups. The mean height for those that served in the military was 68.1 inches, and the mean height for those individuals disqualified was 67.84 inches (Karpinos, 1958a). This difference of 0.26 of an inch is unlikely bias the secular change analysis.

Secular changes in stature occur in all of the sex/race groups. In order to compare these results to other reports of this phenomenon, white males, possessing more extensive information, are examined more closely. Economic historians have amassed huge amounts of height data. Primarily, this data derives from military conscripts. Fogel (1986b) presents a section on secular trends in heights of white males in the United States from 1700 to 1930. He found a sharp decline in stature beginning in cohorts born about 1830 and continuing until about 1880. In a closer examination of the white males from my investigation (Figure 6.1) which includes height data beginning about the 1840s, a similar decline is reflected. This decline is followed by a sharp increase that continues throughout the 1970s. The deviation seen between 1940 and 1950 is presumably the result of sampling. Komlos (1992) discusses the trends in stature for African-Americans during the late eighteenth and early nineteenth centuries. Black males and females experience a similar decline in height in the 1820s and 1830s as do the white males discussed previously.

Other economic historians have used height data to examine historical standards of living (see Komlos, 1989, 1990, and 1994; Floud et al., 1990; Steckel, 1987, 1995; and others). The basic argument is that about three quarters of income is spent on food. So if nutritional standards are improving as reflected in increasing heights, then that reflects an improvement in economic conditions. Fogel (1986b) found that heights and life expectancy are highly correlated. This is reflecting again the positive correlation between environmental conditions and growth and development. Schmidt et al. explored the hypothesis that "adult height is influenced by environmental factors during early life (1995:58). They showed that a strong inverse correlation exists between postneonatal mortality rate (mortality rate from 28 days to 1 year) and stature in Europe. As mortality rate decreases, stature increase at a similar rate (Schmidt et al., 1995). Sobral (1990) also noticed this association between infant mortality and adult height in Portugal.

An examination of the vital statistics for the United States (U.S. Bureau of the Census, 1960: Series B 143-154) reveals that a sharp and steady decline has occurred in the mortality of infants under one year since 1900. Data prior to 1900 was not available except for a single state. Males have decreased from a rate of 179.1 deaths per 1000 in 1900 to 33.6 deaths in 1956, while females have decreased from 145.4 deaths per 1000 in 1900 to 25.5 deaths in 1956. Comparing these data with increases in statures for America males and females reveals a similar inverse relationship. AS mortality declines, statures increase. Or as Fogel (1986b) stated, a correlation between increased stature and increased life expectancy exists.

Schmidt et al. argued that

> adverse conditions during infancy have a long-term influence on linear growth...Furthermore, there is increasing evidence that infancy is a sensitive period during which factors with a negative influence on growth might also influence development, morbidity and mortality later in life (1995:65).

This increase in height in the population during better environmental conditions is reflected in this study. Perhaps individuals that might not survive during times of harsh environmental conditions but do survive during better times may in fact be taller than those individuals that survived under harsh environments. Not only do they survive, but greater genetic potential is met due to improved nutrition, hygiene, and health care, essentially an improved environment during the critical period of growth and development. It might be argued that the taller individuals are the ones that would survive, but they do not have the resources to invest in their height during stressful environmental conditions, and the shorter individuals do not have the resources to divert for survival. While this might account for a portion of the secular increase, it does not explain the full extent of it. The major decrease in postneonatal mortality means that a much larger proportion of the population is surviving the critical first year of life. This allows for a greater expression of the genetic potential for height as well as alteration of the gene pool. As the environment improves, the population increases, and growth and development are improved so that the mean heights of the population increase over time as seen in this study.

Males exhibit greater secular change in stature than females. This reflects the differences between males and females in sensitivity to environmental changes (Wolanski and Kasprzak, 1976; Siniarska, 1996; and Stinson, 1985). Wolanski and Kasprzak (1976) point out that the female body is more resistant to change, while males respond to the slightest change. Greulich (1976) phrases it in terms of "biological superiority of the human female as compared with the male" (1976:553). Stinson (1985) reviews the literature to test her "hypothesis that males are less buffered than females against the environment during growth and development" (1985:123). She concludes that males seem to have greater environmental sensitivity.

b. Secular Change in Bone Lengths

Secular change in bone lengths is somewhat more difficult to explain. The results of this study indicate that white males exhibit significant change in all of the long bones, while black males and white females exhibit change in all bones except the humerus. The difference in these two groups is that for white females the humerus does not come remotely close to the level of significance of alpha = 0.05, while for black males the humerus has a level of significance close to alpha of 0.05.

The results reveal a pattern of change that first reflects sex differences, males responding more to environmental changes than females, and secondly, racial differences in response to environmental change. Whites exhibit more change than blacks in both sexes indicating greater stability or buffering in blacks. Black females exhibit this inherent stability by lack of significant secular change in their bone lengths, while white males appear to have responded strongly to fluctuations in the environment as seen in their large increases in the long bone lengths.

c. Proportional Variation and Secular Change

Not only has secular change occurred in bone lengths, secular change in proportions of the long bones has also occurred. Generally, lower limb bones exhibit rates of change greater than the upper limb bones. In the upper limb, distal bones change at a faster rate than the proximal bone. The parallel distal bones of the arm and leg show differing patterns of change. AN interesting pattern seen in black females is in the radius and ulna. The radius exhibits a positive slope or change, and the ulna has a negative change. While changes in the lengths of the bones are not statistically significant over time, this proportional relationship exhibits significant secular change. Humans have two sets of parallel bones, 1) the radius and ulna and 2) the tibia and fibula. Parallel bones are articulated proximally and distally, the exception being the distal tibia and fibula. Forces directed on one of the parallel bones must also impact the other. Yet, the data indicate that these bones are changing at different rates. The females exhibit greater discrepancies between these parallel bones than do males. The inverse relationship of the radius and ulna is seen dramatically in the black females with positive and negative slopes of change, but this relationship changes over time in white males and females as well. This is seen in the proportional variation analysis using principal components. These three groups exhibit significant secular change in the component illustrating this inverse relationship. Black males do not exhibit any temporal change in this relationship.

The parallel bones of the leg, the tibia and fibula, also appear to be changing at differing rates for each of the sex/race groups. In all four groups, the fibula exhibits a greater rate of change than the tibia. Black males have the largest difference (0.03 mm per year) between these bones, and white males have the smallest (0.005 mm per year). These patterns are very interesting as they indicate changes in development and possibly function.

In a study based on middle-class white children, Buschang found that "sex differences in allometric growth are small but consistently higher in boys" (1982:295). This pattern is seen to continue into adulthood and holds true for white males and females as well as black males and females. Buschang concludes that "patterns of differential growth maintained postnatally are established prior to two months of age" (1982:295).

Similar findings between Buschang's study and this one include the greater differences that are seen in the lower limb (see also Jantz and Owsley, 1984b). AS mentioned previously, the present study shows that the lower limb bones change at a faster rate than do the upper limb bones. Thus, this allometric relationship is reflected after growth stops. The explanation offered by Buschang follows Moss et al. (1955) that the lower limb bones grow proportionally faster than the upper limbs. They attribute this to the specialization in bipedal locomotion as the opposite is seen in brachiating gibbons and orangutans. No strong pattern of sex or race differences is present in the proportional secular changes. Secular change in "size" is exhibited in white females and both white and black males. Black females are shown to be rather stable in this dimension as was seen in all of the long bone lengths. White males exhibit secular change in all but one of the proportional relationships described in the principal component analysis, while black males exhibit secular change in only one of the proportional relationships, that of the humerus to the tibia/fibula. Black and white females change significantly over time in the radius/ulna relationship. The radius is getting larger faster than the ulna in bathe female samples as well as in white males. None of the groups change through time in the femur to radius/ulna relationship.

As patterns of growth and development have been shown to be well established at an early age, it seems less likely that changes in function are totally responsible for secular changes in proportional relationships. Some force must be altering the development of these bones to the extent that proportional relationships are changing, yet it is not clear how this force affects race/sex groups. It would be very interesting to examine this phenomenon in other populations.

d. WWII Geographical Variation

The data collected by Trotter on the World War II casualties is an exceptional source of information. This study provides a limited analysis of regional variation in long bone lengths and proportions for black and white males of the United States. Individuals from this sample were born over a forty year period (1890-1927), but over 96% were born within a time span of 17 years (see Table 3.4). This reduces any possible confounding effects of secular change in a regional analysis.

The five geographic regions, Northeast, Southeast, South Central, North Central, and West, were chosen in order to facilitate a comparison with other published WWII data. Results of the regional variation in bone length analysis indicate significant differences are present between these regions. This could be reflecting variation in immigration patterns from European countries. Individuals that were born in the Northeast region are generally smaller than the other regions possibly indicating a more southern European origin. While regional variation is present in the WWII sample, it is only exhibited in the white sample. The black sample does not reflect any regional variation. This may be the result of smaller sample size (N = 86) and one less region for examination.

Geographic variation in long bone proportions was also illustrated in the white sample from this study. The black sample again did not exhibit any significant regional variation. The Northeast region varies from three other groups in size (as defined earlier) and the femur and ulna proportional relationship to the humerus, while no other groups vary with each other in these. This is again reflecting the generally smaller size of this Northeast sample. Other regional variation is exhibited in the proportional differences of the tibia and fibula with the humerus and femur. Individuals from the West region differ from the two southern regions in these proportional relationships.

An earlier study by Karpinos (1958b) focuses on the height and weight of men that were examined for military service during WWII. Beginning in January 1943 through January 1944, over 5.5 million men were examined by the U.S. Army and Navy (Karpinos, 1958b). Of these men, about 465,000 were included in the study by Karpinos. A comparison of these individuals with the much smaller sample from this study is shown in Table 6.2. Similar patterns of height variation are found between these two WWII samples. Karpinos (1958b) does not give sample sizes by region so no

Table 6.2. Means and standard deviations of heights by geographic region*.

	Trotter's Sample		Karpinos' Sample[1]	
Region	Mean	S.D.	Mean	S.D
Whites				
North Central	174.86	6.18	173.10	6.45
North East	173.08	6.55	171.30	6.78
South Central	174.48	6.04	173.99	6.86
South East	174.49	6.22	173.25	6.38
West	174.46	5.77	174.47	6.86
Blacks				
North Central	174.94	2.82	172.06	6.63
North East	171.66	6.20	170.89	6.86
South Central	174.07	5.92	173.13	6.65
South East	171.63	6.55	171.98	6.99

* Sample sizes are not available for Karpinos' regions.

[1] Karpinos (1958)

significance tests are applied to this comparison. It is clear that samples from the Karpinos study are much larger than this study as seen in the total number of subjects in his study (465,000), and thus would tend to yield significant results based on samples size differences.

Another study of geographic variation was reported by Wissler (1924). Data on U.S. military males from World War I were employed to examine the geographic distribution of height and two other measurements. The method of sectioning the country was "somewhat arbitrary" (Wissler, 1924:130) resulting in many different sections. While not easily comparable, a general impression of the similarity of Wissler's results with those of this study is possible. Wissler found that the shortest males in the population are mostly from the Northeast with a few scatters elsewhere of shorter means for sections. Texas, Oklahoma, Kansas, and part of Nebraska appear to have a taller portion of the population than the Southeast or the West, whereas in the present study the West yielded the tallest individuals. This may be due to the large clumping (only five sections) in this study as opposed to 156 sections in Wissler's study. Wissler (1924) explains the differences in regional height as

> Knowing the history of our population, the interpretation of this is obvious. It means that the older colonists were tall, whereas those arriving recently were short (1924:132).

A study by Newman and Munro (1955) examined the relationship of body size to climate. Again, U.S. military males were the sample employed. These military personnel were measured at induction in 1946, 1949, and 1953. Newman and Munro included stature and weight in their study, and the geographic regions were broken along state lines. A brief discussion on the possible source of error in using the places of birth is provided, and they concluded that only a small percentage made drastic migrations from their birthplace to place of induction. In their analysis, Newman and Munro (1955) found very low and insignificant correlations of stature with temperature. Weight was shown to be more strongly correlated with temperature than heights.

The studies by Wissler (1924) and Karpinos (1958b) both found similar results to the present study of geographic variation in height. From the study by Newman and Munro (1955), the argument can be made that stature is less likely to respond quickly to climate whereas weight does. Stature reflects more the ethnic and nutritional and disease load environment rather than the climatic environment. This is the first study to examine geographic variation in long bone lengths and proportions. From the present analysis, I have illustrated the regional variation exhibited in the white male sample from Trotter's data. The small sample size of black males may be responsible for the lack of geographic variation seen in this sample.

CHAPTER VII

CONCLUSIONS

While changes over time are significant in bone lengths and proportional relationships in all four groups, there only seems to be a sex and/or race pattern to the bone length changes. Can these changes be explained by genetic or environmental influences? Obviously, genetic potential can be obstructed by environmental conditions. If individuals experience poor or undernutrition and a heavy disease load during growth and development, any clear expression of the extent of genetic potential for larger statures may be prevented. If environmental conditions are ideal, then genetic potential may be met unheeded by obstacles during growth and development.

Tanner (1994) points out that when dealing with the means of heights (or any other element) of individuals from the same subpopulation over time, we are dealing with

> the variation between the means of groups of individuals [and this] reflects the cumulative nutritional, hygienic, disease, and stress experience of each of the groups (1994:1).

These environmental influences have their greatest impact from between the ages of six months and three years and possibly again during adolescence (Martorell et al., 1992; Tanner et al., 1956). Based on the results of this study, the "cumulative" environmental conditions that Americans were exposed to during the first three years of life have continued to improve over the past two centuries. The next question concerns if and when these secular changes will level off. Some researchers feel that this has already occurred (Damon, 1968, 1974; Bakwin and McLaughlin, 1964). However, other studies have shown that the genetic potential has not been completely reached for height (see Bock and Sykes, 1989). This study suggests that secular change is continuing with no strong indication of leveling in the near future.

While geographical variation is seen in the white male WWII sample, no such variation is present in black males. As previously mentioned, the Trotter data set of WWII casualties offers a tremendous resource of data. Future research with these data should examine and construct more precise regional or geographical divisions. The United States is large and might yield even more diversity than this study has shown. Also as birthplace is known for these individuals, spatial analysis is projected for future research. Analysis of rural versus urban might also be examined.

In summary, this dissertation has examined secular changes in the six long bones of American white and black females and males over the last two centuries. The allometric relationships of these long bones for these sex/race groups have been examined, and secular changes in these proportional relationships using size and shape have also been explored. Further, this study has established geographic variation in the long bone lengths and their proportional relationships of white males from Mildred Trotter's WWII data.

In the discussion a model was proposed to explain some of the secular changes exhibited in Americans over the last two centuries. While heterosis may account for a portion of the increase in size, ultimately the drastic improvements in our environment of nutrition, disease load, and hygiene have resulted in secular changes in size. Environmental improvements have resulted in a rapid decrease in postneonatal mortality allowing a larger portion of the population to reach maturity. These individuals are taller increasing mean statures over time. As seen in the mortality figures, males are more susceptible to harsh environmental conditions, and thus, females have lower mortality rates. This sex difference in environmental sensitivity is also exhibited in the differences in rates of secular change. Racial differences in environmental sensitivity are found to be secondary to sex differences. Blacks may be reflecting a harsher environment than that whites have endured. Larger samples of white females and black females and males would allow a closer examination of these varying levels of environmental sensitivity.

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APPENDICES

Appendix 1. Summary statistics for white females by decade of birth.

```
                           Decade of Birth = 1800

Variable       N         Mean       Std Dev       Minimum       Maximum
-------------------------------------------------------------------------
 YOB           4      1805.75     0.5000000       1805.00       1806.00
 MAXHT         0            .             .             .             .
 HUM           3  315.6666667     4.1633320   311.0000000   319.0000000
 RAD           2  241.0000000     2.8284271   239.0000000   243.0000000
 ULNA          2  258.0000000     8.4852814   252.0000000   264.0000000
 FEM           3  448.3333333    27.5378527   420.0000000   475.0000000
 TIB           1  396.0000000             .   396.0000000   396.0000000
 FIB           0            .             .             .             .
 SIZE          0            .             .             .             .
 SHUM          0            .             .             .             .
 SRAD          0            .             .             .             .
 SULNA         0            .             .             .             .
 SFEM          0            .             .             .             .
 STIB          0            .             .             .             .
 SFIB          0            .             .             .             .
 PRIN1         0            .             .             .             .
 PRIN2         0            .             .             .             .
 PRIN3         0            .             .             .             .
 PRIN4         0            .             .             .             .
 PRIN5         0            .             .             .             .
 PRIN6         0            .             .             .             .
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Appendix 1. (continued)

```
                        Decade of Birth = 1810

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           6       1816.83      1.4719601        1815.00        1819.00
MAXHT         0             .              .              .              .
HUM           3   297.6666667      9.7125349    287.0000000    306.0000000
RAD           1   226.0000000              .    226.0000000    226.0000000
ULNA          2   234.0000000     15.5563492    223.0000000    245.0000000
FEM           4   419.7500000     16.0286202    407.0000000    443.0000000
TIB           6   342.6666667     16.0457679    322.0000000    359.0000000
FIB           1   313.0000000              .    313.0000000    313.0000000
SIZE          0             .              .              .              .
SHUM          0             .              .              .              .
SRAD          0             .              .              .              .
SULNA         0             .              .              .              .
SFEM          0             .              .              .              .
STIB          0             .              .              .              .
SFIB          0             .              .              .              .
PRIN1         0             .              .              .              .
PRIN2         0             .              .              .              .
PRIN3         0             .              .              .              .
PRIN4         0             .              .              .              .
PRIN5         0             .              .              .              .
PRIN6         0             .              .              .              .
--------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                          Decade of Birth = 1820

Variable      N           Mean        Std Dev        Minimum        Maximum
----------------------------------------------------------------------------
YOB           8        1826.13      0.9910312        1825.00        1827.00
MAXHT         0              .              .              .              .
HUM           6    303.6666667     15.8577005    282.0000000    325.0000000
RAD           3    221.3333333      8.5049005    215.0000000    231.0000000
ULNA          4    238.0000000     14.3759058    217.0000000    249.0000000
FEM           6    416.5000000     23.9645572    379.0000000    438.0000000
TIB           5    361.2000000     22.3539706    334.0000000    394.0000000
FIB           4    356.2500000     34.5386257    316.0000000    399.0000000
SIZE          1    320.8412857              .    320.8412857    320.8412857
SHUM          1      1.0129619              .      1.0129619      1.0129619
SRAD          1      0.7199822              .      0.7199822      0.7199822
SULNA         1      0.7760847              .      0.7760847      0.7760847
SFEM          1      1.3651610              .      1.3651610      1.3651610
STIB          1      1.1438678              .      1.1438678      1.1438678
SFIB          1      1.1314005              .      1.1314005      1.1314005
PRIN1         1      0.0140347              .      0.0140347      0.0140347
PRIN2         1   -0.000567130              .   -0.000567130   -0.000567130
PRIN3         1      0.0451450              .      0.0451450      0.0451450
PRIN4         1      0.0060761              .      0.0060761      0.0060761
PRIN5         1      0.0026083              .      0.0026083      0.0026083
PRIN6         1    0.000154550              .    0.000154550    0.000154550
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Appendix 1. (continued)

```
                          Decade of Birth = 1830

Variable      N          Mean        Std Dev        Minimum        Maximum
----------------------------------------------------------------------------
YOB          13       1834.92      2.2898886        1830.00        1837.00
MAXHT         0             .              .              .              .
HUM           5   304.8000000     20.9809437    279.0000000    331.0000000
RAD           4   220.0000000     12.0554275    203.0000000    231.0000000
ULNA          7   231.7142857     15.6387796    212.0000000    251.0000000
FEM           9   424.4444444     23.8857233    387.0000000    456.0000000
TIB          11   335.1818182     19.7930199    311.0000000    372.0000000
FIB           5   335.4000000     15.9624560    315.0000000    353.0000000
SIZE          1   302.4436549              .    302.4436549    302.4436549
SHUM          1     1.0183715              .      1.0183715      1.0183715
SRAD          1     0.7307146              .      0.7307146      0.7307146
SULNA         1     0.7836170              .      0.7836170      0.7836170
SFEM          1     1.3853820              .      1.3853820      1.3853820
STIB          1     1.1175635              .      1.1175635      1.1175635
SFIB          1     1.1076443              .      1.1076443      1.1076443
PRIN1         1     0.0243648              .      0.0243648      0.0243648
PRIN2         1    -0.0350234              .     -0.0350234     -0.0350234
PRIN3         1     0.0215033              .      0.0215033      0.0215033
PRIN4         1     0.0059913              .      0.0059913      0.0059913
PRIN5         1    -0.0010584              .     -0.0010584     -0.0010584
PRIN6         1   0.000024760              .    0.000024760    0.000024760
----------------------------------------------------------------------------
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Appendix 1. (continued)

```
                         Decade of Birth = 1840

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           7       1844.00      2.8867513        1841.00        1848.00
MAXHT         0             .              .              .              .
HUM           5   304.0000000     21.3307290    271.0000000    323.0000000
RAD           1   195.0000000              .    195.0000000    195.0000000
ULNA          1   205.0000000              .    205.0000000    205.0000000
FEM           3   407.0000000     48.7749936    369.0000000    462.0000000
TIB           3   343.3333333     31.0053759    312.0000000    374.0000000
FIB           3   321.3333333     29.3655127    301.0000000    355.0000000
SIZE          0             .              .              .              .
SHUM          0             .              .              .              .
SRAD          0             .              .              .              .
SULNA         0             .              .              .              .
SFEM          0             .              .              .              .
STIB          0             .              .              .              .
SFIB          0             .              .              .              .
PRIN1         0             .              .              .              .
PRIN2         0             .              .              .              .
PRIN3         0             .              .              .              .
PRIN4         0             .              .              .              .
PRIN5         0             .              .              .              .
PRIN6         0             .              .              .              .
--------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                     Decade of Birth = 1850

Variable      N            Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB          33         1853.24       2.8176930         1850.00         1859.00
MAXHT        18     157.8944089       7.2681958     141.8424000     173.8262000
HUM          25     298.6800000      13.3345416     269.0000000     328.0000000
RAD          27     219.8148148      14.3125470     193.0000000     269.0000000
ULNA         26     239.1923077      14.7594559     208.0000000     284.0000000
FEM          28     420.4285714      20.3495902     378.0000000     474.0000000
TIB          29     342.3448276      18.6016049     299.0000000     386.0000000
FIB          24     336.7083333      18.4189863     295.0000000     374.0000000
SIZE         20     303.8946737      15.1982077     266.7225009     331.2568197
SHUM         20       0.9834264       0.0234234       0.9346106       1.0310709
SRAD         20       0.7315394       0.0332049       0.7006487       0.8639528
SULNA        20       0.7936008       0.0316469       0.7576772       0.9121286
SFEM         20       1.3891492       0.0304271       1.3392874       1.4362925
STIB         20       1.1358074       0.0353152       1.0084802       1.1791406
SFIB         20       1.1133513       0.0289110       1.0052685       1.1446245
PRIN1        20       0.0141096       0.0457976      -0.1350211       0.0718977
PRIN2        20      -0.0039342       0.0426554      -0.1543198       0.0455035
PRIN3        20      -0.0020565       0.0396913      -0.1386510       0.0464186
PRIN4        20     0.000578511       0.0075292      -0.0098902       0.0172687
PRIN5        20       0.0056182       0.0101909      -0.0190000       0.0264196
PRIN6        20     0.000706404       0.0029527    -0.000467401       0.0131611
-------------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                         Decade of Birth = 1860

Variable      N          Mean       Std Dev       Minimum       Maximum
-----------------------------------------------------------------------
YOB          29       1865.38     2.8210154       1861.00       1869.00
MAXHT        20   162.0353680     5.6499287   152.3720000   174.7254000
HUM          27   306.5555556    15.0315907   283.0000000   334.0000000
RAD          23   223.8260870    12.4559302   199.0000000   246.0000000
ULNA         23   241.4782609    12.8871662   219.0000000   262.0000000
FEM          24   434.0000000    23.3480285   386.0000000   469.0000000
TIB          27   351.2592593    20.7838558   317.0000000   391.0000000
FIB          22   345.7727273    18.9709849   319.0000000   383.0000000
SIZE         20   310.8722435    15.5011521   286.6959803   336.5903408
SHUM         20     0.9901416     0.0248473     0.9452944     1.0427944
SRAD         20     0.7244697     0.0144795     0.6872964     0.7438026
SULNA        20     0.7812718     0.0157203     0.7488937     0.8060745
SFEM         20     1.3963061     0.0270085     1.3353851     1.4263223
STIB         20     1.1448283     0.0217149     1.1184257     1.1838357
SFIB         20     1.1176221     0.0230964     1.0742018     1.1573812
PRIN1        20     0.0291324     0.0310142    -0.0395705     0.0817834
PRIN2        20     0.0035331     0.0360428    -0.0449341     0.0732532
PRIN3        20     0.0077837     0.0209966    -0.0273840     0.0448726
PRIN4        20    -0.0032643     0.0090428    -0.0181362     0.0131469
PRIN5        20     0.0034597     0.0049595    -0.0069395     0.0136628
PRIN6        20   0.000241491   0.000645280  -0.000423213     0.0022185
-----------------------------------------------------------------------
```

Appendix 1. (continued)

```
                         Decade of Birth = 1870

Variable     N          Mean       Std Dev       Minimum       Maximum
-----------------------------------------------------------------------
YOB         14       1872.14     2.1432234       1870.00       1877.00
MAXHT        9   157.7125867     8.8501868   140.3074800   168.3074800
HUM         13   306.0769231    21.4299694   271.0000000   346.0000000
RAD         11   223.1818182    13.9629380   200.0000000   239.0000000
 ULNA        11   239.9090909    14.3628308   214.0000000   257.0000000
FEM         14   431.2857143    21.8928459   390.0000000   471.0000000
TIB         13   350.1538462    19.3771608   317.0000000   380.0000000
FIB         12   339.5833333    20.0882523   301.0000000   368.0000000
SIZE        10   305.6415725    17.9080379   276.0394892   330.9144483
SHUM        10     0.9872818     0.0271197     0.9545357     1.0351412
SRAD        10     0.7252854     0.0106460     0.7062310     0.7426474
SULNA       10     0.7809926     0.0141276     0.7524603     0.8069594
SFEM        10     1.4051954     0.0165091     1.3808418     1.4290829
STIB        10     1.1443372     0.0173633     1.1211376     1.1794059
SFIB        10     1.1129254     0.0136431     1.0904237     1.1335008
PRIN1       10     0.0352421     0.0215852    -0.0044928     0.0688698
PRIN2       10     0.0022489     0.0274992    -0.0486676     0.0526914
PRIN3       10  -0.000080218     0.0189831    -0.0265942     0.0286911
PRIN4       10    -0.0062875     0.0115138    -0.0273603     0.0098111
PRIN5       10     0.0029497     0.0096619    -0.0124955     0.0157042
PRIN6       10   0.000088892   0.000411473  -0.000353153   0.000685788
-----------------------------------------------------------------------
```

Appendix 1. (continued)

```
                          Decade of Birth = 1880

Variable      N           Mean         Std Dev          Minimum          Maximum
---------------------------------------------------------------------------------
YOB           6        1887.00       1.8973666          1885.00          1889.00
MAXHT         6    160.7046733       7.8954520      151.5190000      171.5268800
HUM           6    309.3333333      18.0628532      284.0000000      332.0000000
RAD           6    223.5000000      13.7658999      203.0000000      238.0000000
ULNA          6    240.5000000      17.8745629      218.0000000      265.0000000
FEM           6    440.1666667      26.3622204      397.0000000      470.0000000
TIB           6    360.8333333      23.8697856      332.0000000      389.0000000
FIB           6    353.1666667      27.3599464      319.0000000      384.0000000
SIZE          6    312.5389351      20.1670452      284.3358961      335.3838837
SHUM          6      0.9901894       0.0168415        0.9644381        1.0147387
SRAD          6      0.7152551       0.0084454        0.7036115        0.7263117
SULNA         6      0.7692119       0.0156189        0.7491036        0.7901393
SFEM          6      1.4089261       0.0290761        1.3566543        1.4361418
STIB          6      1.1544943       0.0121616        1.1406335        1.1676331
SFIB          6      1.1292413       0.0171070        1.1090976        1.1494342
PRIN1         6      0.0476522       0.0295553     -0.000476257        0.0814301
PRIN2         6      0.0191890       0.0173413       -0.0073210        0.0425388
PRIN3         6      0.0128772       0.0215686       -0.0135722        0.0389964
PRIN4         6     -0.0016252       0.0127046       -0.0163506        0.0155160
PRIN5         6      0.0023279       0.0091499       -0.0057577        0.0195470
PRIN6         6    0.000459198     0.000556878     -0.000096997        0.0013297
---------------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                          Decade of Birth = 1890

Variable       N          Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB            7       1896.71       2.4299716         1892.00         1899.00
MAXHT          6   163.0372400       9.2746767     152.5000000     174.5836400
HUM            7   314.7142857      19.0588062     291.0000000     335.0000000
RAD            6   222.5000000      13.0038456     206.0000000     243.0000000
ULNA           6   239.8333333      17.7247473     214.0000000     263.0000000
FEM            7   434.4285714      32.4543636     386.0000000     470.0000000
TIB            7   355.0000000      28.2311884     315.0000000     393.0000000
FIB            7   346.8571429      28.4571524     305.0000000     387.0000000
SIZE           6   308.5783165      21.9886281     280.5105239     339.4699740
SHUM           6     1.0099613       0.0301469       0.9754030       1.0623487
SRAD           6     0.7216927       0.0154124       0.6935055       0.7343753
SULNA          6     0.7771651       0.0136018       0.7628947       0.7957267
SFEM           6     1.3926102       0.0217903       1.3742791       1.4269029
STIB           6     1.1404153       0.0197591       1.1225131       1.1660712
SFIB           6     1.1127625       0.0217205       1.0873032       1.1400125
PRIN1          6     0.0338795       0.0264166       0.0041366       0.0775965
PRIN2          6    -0.0112946       0.0370169      -0.0631658       0.0274872
PRIN3          6     0.0229085       0.0188220       0.0058901       0.0576093
PRIN4          6    -0.0049696       0.0104634      -0.0171046       0.0063151
PRIN5          6     0.0032462       0.0116608      -0.0138335       0.0176943
PRIN6          6   0.000441162     0.000773480    -0.000285667       0.0014339
-------------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                          Decade of Birth = 1900

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          13       1904.69      2.3232382        1901.00        1909.00
MAXHT         7   162.1541714      6.3488147    154.5000000    171.5792000
HUM          13   310.4615385     17.7229389    266.0000000    334.0000000
RAD          13   230.0769231     19.4098838    195.0000000    271.0000000
ULNA         13   246.3076923     19.3364277    214.0000000    287.0000000
FEM          13   441.7692308     22.7674982    394.0000000    481.0000000
TIB          13   358.2307692     22.9134380    313.0000000    396.0000000
FIB          12   350.5000000     23.4501405    304.0000000    392.0000000
SIZE         12   315.3715833     20.9198467    273.2377460    353.1457608
SHUM         12     0.9874282      0.0293222      0.9443284      1.0247547
SRAD         12     0.7308756      0.0186214      0.7136642      0.7673885
SULNA        12     0.7810581      0.0180540      0.7542905      0.8131717
SFEM         12     1.4035535      0.0279508      1.3552861      1.4419677
STIB         12     1.1387255      0.0158958      1.1182799      1.1653197
SFIB         12     1.1113906      0.0110741      1.0929727      1.1300333
PRIN1        12     0.0319185      0.0391353     -0.0430837      0.0781063
PRIN2        12    -0.0029273      0.0181894     -0.0290805      0.0218631
PRIN3        12    -0.0022621      0.0249398     -0.0334860      0.0288458
PRIN4        12    -0.0041963      0.0128917     -0.0294152      0.0109087
PRIN5        12    -0.0016152      0.0061881     -0.0104803      0.0127568
PRIN6        12   0.000175685    0.000379489   -0.000284516      0.0010476
--------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                       Decade of Birth = 1910

Variable      N          Mean         Std Dev         Minimum         Maximum
------------------------------------------------------------------------------
YOB          16       1914.63       3.1596413         1910.00         1919.00
MAXHT         5   165.4188280       5.4683676     158.1804200     172.8300800
HUM          16   308.1875000      14.1384523     278.0000000     330.0000000
RAD          15   229.8000000      11.3779235     211.0000000     247.0000000
ULNA         16   246.8750000      13.5984068     225.0000000     266.0000000
FEM          16   439.2500000      19.0735419     406.0000000     478.0000000
TIB          14   361.5000000      26.4014860     313.0000000     404.0000000
FIB          12   352.9166667      23.6622382     307.0000000     391.0000000
SIZE         10   310.8468853      16.7220294     283.6867492     342.5127319
SHUM         10     0.9778975       0.0117353       0.9533897       0.9917422
SRAD         10     0.7285220       0.0110987       0.7174984       0.7513468
SULNA        10     0.7790063       0.0142179       0.7580009       0.8081714
SFEM         10     1.4078326       0.0266720       1.3637892       1.4487811
STIB         10     1.1442306       0.0211666       1.1033296       1.1736790
SFIB         10     1.1194216       0.0195364       1.0821796       1.1378067
PRIN1        10     0.0346918       0.0269705      -0.0266664       0.0703112
PRIN2        10     0.0105848       0.0247913      -0.0399058       0.0469913
PRIN3        10    -0.0063183       0.0209884      -0.0526508       0.0144131
PRIN4        10    -0.0015590       0.0129013      -0.0199654       0.0238865
PRIN5        10    -0.0015878       0.0074229      -0.0092116       0.0120815
PRIN6        10   0.000029679     0.000261874    -0.000257655     0.000441878
------------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                          Decade of Birth = 1920

Variable     N            Mean         Std Dev          Minimum          Maximum
--------------------------------------------------------------------------------
YOB         12         1924.25       2.8001623          1920.00          1929.00
MAXHT        3     162.9658267       7.0051271      156.1126400      170.1136000
HUM         12     301.9166667      13.5476152      272.0000000      324.0000000
RAD         10     223.6000000      12.3396380      195.0000000      236.0000000
ULNA        10     239.1000000      12.7056418      214.0000000      254.0000000
FEM         12     430.5000000      24.1378616      385.0000000      463.0000000
TIB         12     349.5833333      15.3472434      312.0000000      368.0000000
FIB         12     339.3333333      13.9175059      310.0000000      361.0000000
SIZE        10     305.3960494      14.2463216      273.9464757      320.2137053
SHUM        10       0.9853676       0.0208916        0.9547834        1.0244101
SRAD        10       0.7319212       0.0105110        0.7118179        0.7536083
SULNA       10       0.7828191       0.0155496        0.7562759        0.8110869
SFEM        10       1.4044704       0.0258563        1.3692279        1.4459094
STIB        10       1.1395570       0.0115513        1.1240260        1.1646619
SFIB        10       1.1075401       0.0160494        1.0825137        1.1316079
PRIN1       10       0.0309449       0.0239645     -0.000951226        0.0777182
PRIN2       10      -0.0038244       0.0148093       -0.0234747        0.0211196
PRIN3       10      -0.0057794       0.0287639       -0.0530577        0.0457254
PRIN4       10      -0.0073644       0.0124492       -0.0275382        0.0119933
PRIN5       10    -0.000845712       0.0084983       -0.0171490        0.0108545
PRIN6       10    -0.000038808     0.000340271     -0.000421483      0.000589979
--------------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                            Decade of Birth = 1930

Variable      N          Mean         Std Dev         Minimum         Maximum
------------------------------------------------------------------------------
YOB          11       1934.45       2.5441555         1930.00         1939.00
MAXHT         5   168.1787640      12.5335377     155.1900800     189.0836400
HUM           9   309.3333333      11.8638105     293.0000000     333.0000000
RAD          11   229.6363636      10.6044588     212.0000000     256.0000000
ULNA          9   244.7777778       9.4044907     228.0000000     258.0000000
FEM          11   443.2727273      25.8537847     413.0000000     507.0000000
TIB          10   361.4000000      19.2134212     335.0000000     409.0000000
FIB          10   357.4000000      19.9064479     331.0000000     407.0000000
SIZE          8   313.0287501      10.0434127     294.2118743     328.6068373
SHUM          8     0.9914355       0.0169711       0.9627019       1.0133691
SRAD          8     0.7232410       0.0063685       0.7120972       0.7320343
SULNA         8     0.7801457       0.0117549       0.7618869       0.7983925
SFEM          8     1.3982706       0.0239767       1.3704690       1.4424532
STIB          8     1.1386219       0.0150730       1.1107499       1.1574197
SFIB          8     1.1234645       0.0184158       1.1016204       1.1603427
PRIN1         8     0.0320644       0.0260847      -0.0020633       0.0748675
PRIN2         8     0.0025606       0.0229302      -0.0368977       0.0428472
PRIN3         8     0.0085204       0.0117679      -0.0092692       0.0277221
PRIN4         8     0.0050875       0.0141153      -0.0207654       0.0272520
PRIN5         8     0.0024181       0.0079944      -0.0124300       0.0132766
PRIN6         8   0.000033903     0.000365037    -0.000455526     0.000742504
------------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                          Decade of Birth = 1940

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          18       1945.39      2.5927249        1941.00        1949.00
MAXHT         5   167.8080560      4.5502036    163.0000000    175.0000000
HUM          16   305.5625000     12.8684045    288.0000000    337.0000000
RAD          14   225.1428571     13.5695198    201.0000000    243.0000000
ULNA         14   242.3571429     12.6162724    219.0000000    258.0000000
FEM          18   432.7222222     18.5846412    405.0000000    472.0000000
TIB          18   352.3333333     20.3035784    321.0000000    383.0000000
FIB          13   349.6153846     18.9144498    316.0000000    379.0000000
SIZE         12   311.7237681     15.3596641    285.1266551    332.7630210
SHUM         12     0.9895516      0.0197472      0.9648045      1.0268972
SRAD         12     0.7282903      0.0182672      0.6972709      0.7532964
SULNA        12     0.7827006      0.0130162      0.7587045      0.7997962
SFEM         12     1.3937188      0.0257179      1.3391937      1.4245173
STIB         12     1.1390637      0.0163561      1.1134824      1.1764527
SFIB         12     1.1178152      0.0199601      1.0885439      1.1641660
PRIN1        12     0.0249683      0.0338343     -0.0386035      0.0662442
PRIN2        12  -0.000399830      0.0281297     -0.0404373      0.0629736
PRIN3        12     0.0060192      0.0103977     -0.0091427      0.0236990
PRIN4        12   0.000535681      0.0104738     -0.0187851      0.0153165
PRIN5        12   0.000899331      0.0081345     -0.0097125      0.0118217
PRIN6        12   0.000063836    0.000614362   -0.000502099      0.0014233
--------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                     Decade of Birth = 1950

Variable    N         Mean        Std Dev        Minimum        Maximum
------------------------------------------------------------------------
YOB        24      1955.63      2.8255434        1950.00        1959.00
MAXHT      15  163.1333333      6.5668721    155.0000000    178.0000000
HUM        23  304.7826087     13.8299955    278.0000000    336.0000000
RAD        21  229.2857143     10.9870053    209.0000000    249.0000000
ULNA       21  246.0476190     11.7152729    222.0000000    266.0000000
FEM        24  434.3333333     19.2662504    395.0000000    483.0000000
TIB        22  357.3181818     20.7877857    320.0000000    405.0000000
FIB        22  350.7727273     19.3635195    316.0000000    401.0000000
SIZE       18  312.4716275     14.8865253    285.7898439    342.5093301
SHUM       18    0.9776041      0.0280893      0.9109241      1.0287279
SRAD       18    0.7306737      0.0125203      0.7057327      0.7573907
SULNA      18    0.7811023      0.0167238      0.7517587      0.8086283
SFEM       18    1.3918020      0.0241157      1.3435275      1.4360125
STIB       18    1.1465183      0.0249036      1.1054681      1.1837611
SFIB       18    1.1246015      0.0204382      1.0969637      1.1707710
PRIN1      18    0.0202399      0.0267492     -0.0205995      0.0809941
PRIN2      18    0.0141158      0.0357342     -0.0392155      0.0984024
PRIN3      18    0.0021570      0.0249179     -0.0383011      0.0444372
PRIN4      18  0.000639834      0.0127991     -0.0244955      0.0183892
PRIN5      18   -0.0019791      0.0082154     -0.0133114      0.0183060
PRIN6      18  0.000130196    0.000520545   -0.000338820      0.0014662
------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                         Decade of Birth = 1960

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          25       1963.08      2.9427878        1960.00        1969.00
MAXHT        16   164.0000000      7.7974355    150.0000000    180.0000000
HUM          22   305.0000000     14.1084237    272.0000000    333.0000000
RAD          18   228.1111111     12.0190481    213.0000000    256.0000000
ULNA         20   243.7500000     13.2063581    226.0000000    278.0000000
FEM          22   435.6363636     23.2574524    390.0000000    475.0000000
TIB          21   359.1904762     16.0954001    331.0000000    391.0000000
FIB          17   350.7058824     17.6130800    318.0000000    381.0000000
SIZE         14   314.2864264     14.9341489    292.9628034    344.6836815
SHUM         14     0.9776416      0.0264266      0.9407901      1.0313366
SRAD         14     0.7291543      0.0141864      0.6984368      0.7495760
SULNA        14     0.7795229      0.0180499      0.7376015      0.8065366
SFEM         14     1.4016698      0.0285882      1.3551208      1.4553330
STIB         14     1.1436130      0.0135264      1.1247597      1.1683959
SFIB         14     1.1240073      0.0220280      1.0943525      1.1583902
PRIN1        14     0.0293465      0.0330034     -0.0145989      0.0911828
PRIN2        14     0.0125674      0.0262400     -0.0195687      0.0570440
PRIN3        14    -0.0026658      0.0256828     -0.0460613      0.0499352
PRIN4        14     0.0021696      0.0147598     -0.0173434      0.0339105
PRIN5        14    -0.0021870      0.0074255     -0.0152908      0.0128101
PRIN6        14   0.000161327    0.000733943   -0.000451055      0.0023008
--------------------------------------------------------------------------
```

Appendix 1. (continued)

```
                         Decade of Birth = 1970

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           6       1970.83      0.7527727        1970.00        1972.00
MAXHT         6   164.1666667      5.8793424    157.0000000    173.0000000
HUM           6   309.1666667     16.9872501    286.0000000    330.0000000
RAD           6   229.5000000      8.2643814    219.0000000    242.0000000
ULNA          6   246.8333333     12.5445871    232.0000000    265.0000000
FEM           5   444.6000000     19.6035711    419.0000000    473.0000000
TIB           4   361.7500000     14.4308697    346.0000000    380.0000000
FIB           4   352.5000000     13.5277493    336.0000000    365.0000000
SIZE          4   314.7881683      9.9784123    300.6852832    322.8133573
SHUM          4     0.9839009      0.0194726      0.9634050      1.0008184
SRAD          4     0.7276782      0.0103356      0.7170973      0.7416392
SULNA         4     0.7814470      0.0108676      0.7732180      0.7970366
SFEM          4     1.3899137      0.0128476      1.3723100      1.4030165
STIB          4     1.1490790      0.0204947      1.1304583      1.1771508
SFIB          4     1.1196650      0.0132084      1.1018793      1.1306843
PRIN1         4     0.0211739      0.0169965      0.0021007      0.0434099
PRIN2         4     0.0100371      0.0275210     -0.0218428      0.0440772
PRIN3         4     0.0073282      0.0095844     -0.0049152      0.0175416
PRIN4         4    -0.0046424      0.0099258     -0.0146319      0.0087054
PRIN5         4     0.0013399      0.0112675     -0.0132398      0.0142588
PRIN6         4  -0.000129676    0.000206185   -0.000382860    0.000111842
--------------------------------------------------------------------------
```

Appendix 2. Summary statistics for black females by decade of birth.

```
                         Decade of Birth = 1740

Variable     N          Mean        Std Dev        Minimum        Maximum
-------------------------------------------------------------------------
YOB          1       1749.00              .        1749.00        1749.00
MAXHT        0             .              .              .              .
HUM          1   333.0000000              .    333.0000000    333.0000000
RAD          0             .              .              .              .
ULNA         1   251.0000000              .    251.0000000    251.0000000
FEM          1   461.0000000              .    461.0000000    461.0000000
TIB          0             .              .              .              .
FIB          1   348.0000000              .    348.0000000    348.0000000
SIZE         0             .              .              .              .
SHUM         0             .              .              .              .
SRAD         0             .              .              .              .
SULNA        0             .              .              .              .
SFEM         0             .              .              .              .
STIB         0             .              .              .              .
SFIB         0             .              .              .              .
PRIN1        0             .              .              .              .
PRIN2        0             .              .              .              .
PRIN3        0             .              .              .              .
PRIN4        0             .              .              .              .
PRIN5        0             .              .              .              .
PRIN6        0             .              .              .              .
-------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                           Decade of Birth = 1750

Variable      N         Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           4      1755.25      2.5000000        1754.00        1759.00
MAXHT         0            .              .              .              .
HUM           3  297.6666667      8.6216781    290.0000000    307.0000000
RAD           1  224.0000000              .    224.0000000    224.0000000
ULNA          1  245.0000000              .    245.0000000    245.0000000
FEM           2  412.0000000      2.8284271    410.0000000    414.0000000
TIB           3  350.6666667     11.0604400    339.0000000    361.0000000
FIB           1  350.0000000              .    350.0000000    350.0000000
SIZE          0            .              .              .              .
SHUM          0            .              .              .              .
SRAD          0            .              .              .              .
SULNA         0            .              .              .              .
SFEM          0            .              .              .              .
STIB          0            .              .              .              .
SFIB          0            .              .              .              .
PRIN1         0            .              .              .              .
PRIN2         0            .              .              .              .
PRIN3         0            .              .              .              .
PRIN4         0            .              .              .              .
PRIN5         0            .              .              .              .
PRIN6         0            .              .              .              .
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                      Decade of Birth = 1760

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           1       1769.00              .        1769.00        1769.00
MAXHT         0             .              .              .              .
HUM           1   305.0000000              .    305.0000000    305.0000000
RAD           1   242.0000000              .    242.0000000    242.0000000
ULNA          1   264.0000000              .    264.0000000    264.0000000
FEM           1   438.0000000              .    438.0000000    438.0000000
TIB           1   377.0000000              .    377.0000000    377.0000000
FIB           1   364.0000000              .    364.0000000    364.0000000
SIZE          1   324.6678832              .    324.6678832    324.6678832
SHUM          1     0.9394215              .      0.9394215      0.9394215
SRAD          1     0.7453771              .      0.7453771      0.7453771
SULNA         1     0.8131386              .      0.8131386      0.8131386
SFEM          1     1.3490709              .      1.3490709      1.3490709
STIB          1     1.1611866              .      1.1611866      1.1611866
SFIB          1     1.1211457              .      1.1211457      1.1211457
PRIN1         1    -0.0422378              .     -0.0422378     -0.0422378
PRIN2         1     0.0336382              .      0.0336382      0.0336382
PRIN3         1    -0.0140764              .     -0.0140764     -0.0140764
PRIN4         1    -0.0080729              .     -0.0080729     -0.0080729
PRIN5         1     0.0093978              .      0.0093978      0.0093978
PRIN6         1   0.000036109              .    0.000036109    0.000036109
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                         Decade of Birth = 1770

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           4       1776.50      2.8867513        1774.00        1779.00
MAXHT         0             .              .              .              .
HUM           2   320.5000000     27.5771645    301.0000000    340.0000000
RAD           3   238.6666667     15.0443788    229.0000000    256.0000000
ULNA          3   261.0000000     15.7162336    250.0000000    279.0000000
FEM           3   445.6666667     40.5257120    406.0000000    487.0000000
TIB           3   370.3333333     39.5137107    335.0000000    413.0000000
FIB           2   373.0000000     35.3553391    348.0000000    398.0000000
SIZE          2   334.0850857     27.1401211    314.8941220    353.2760494
SHUM          2     0.9591485      0.0046268      0.9558768      0.9624202
SRAD          2     0.7291128      0.0063174      0.7246458      0.7335799
SULNA         2     0.7918342      0.0029465      0.7897507      0.7939176
SFEM          2     1.3942616      0.0222543      1.3785254      1.4099977
STIB          2     1.1609129      0.0115181      1.1527684      1.1690575
SFIB          2     1.1158656      0.0151776      1.1051334      1.1265977
PRIN1         2     0.0134341      0.0129255      0.0042944      0.0225738
PRIN2         2     0.0265147      0.0139723      0.0166348      0.0363946
PRIN3         2    -0.0137665      0.0233912     -0.0303066      0.0027736
PRIN4         2    -0.0131698      0.0033184     -0.0155163     -0.0108234
PRIN5         2     0.0081872      0.0027965      0.0062098      0.0101647
PRIN6         2  -0.000213453    0.000063585   -0.000258415   -0.000168492
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                           Decade of Birth = 1780

Variable      N          Mean          Std Dev          Minimum          Maximum
---------------------------------------------------------------------------------
YOB           6       1786.50        2.7386128          1784.00          1789.00
MAXHT         0             .                .                .                .
HUM           5   312.2000000        7.2249567      305.0000000      324.0000000
RAD           5   236.0000000       13.2098448      215.0000000      249.0000000
ULNA          3   262.6666667        8.0208063      255.0000000      271.0000000
FEM           4   444.7500000       30.1813960      405.0000000      474.0000000
TIB           2   383.5000000        4.9497475      380.0000000      387.0000000
FIB           3   364.0000000       17.3493516      345.0000000      379.0000000
SIZE          1   335.3994829                .      335.3994829      335.3994829
SHUM          1     0.9302340                .        0.9302340        0.9302340
SRAD          1     0.7423983                .        0.7423983        0.7423983
SULNA         1     0.8079917                .        0.8079917        0.8079917
SFEM          1     1.3744804                .        1.3744804        1.3744804
STIB          1     1.1538479                .        1.1538479        1.1538479
SFIB          1     1.1299958                .        1.1299958        1.1299958
PRIN1         1    -0.0208899                .       -0.0208899       -0.0208899
PRIN2         1     0.0403219                .        0.0403219        0.0403219
PRIN3         1    -0.0299629                .       -0.0299629       -0.0299629
PRIN4         1     0.0035571                .        0.0035571        0.0035571
PRIN5         1     0.0063069                .        0.0063069        0.0063069
PRIN6         1   0.000037690                .      0.000037690      0.000037690
---------------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                              Decade of Birth = 1790

Variable      N           Mean        Std Dev        Minimum        Maximum
---------------------------------------------------------------------------
YOB           1        1798.00              .        1798.00        1798.00
MAXHT         0              .              .              .              .
HUM           0              .              .              .              .
RAD           0              .              .              .              .
ULNA          0              .              .              .              .
FEM           1    441.0000000              .    441.0000000    441.0000000
TIB           0              .              .              .              .
FIB           0              .              .              .              .
SIZE          0              .              .              .              .
SHUM          0              .              .              .              .
SRAD          0              .              .              .              .
SULNA         0              .              .              .              .
SFEM          0              .              .              .              .
STIB          0              .              .              .              .
SFIB          0              .              .              .              .
PRIN1         0              .              .              .              .
PRIN2         0              .              .              .              .
PRIN3         0              .              .              .              .
PRIN4         0              .              .              .              .
PRIN5         0              .              .              .              .
PRIN6         0              .              .              .              .
---------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                         Decade of Birth = 1840

Variable     N          Mean       Std Dev       Minimum       Maximum
----------------------------------------------------------------------
YOB          4       1848.25     0.5000000       1848.00       1849.00
MAXHT        4   155.4904800     8.3478262   148.3684800   164.3684800
HUM          4   310.5000000    24.5017006   287.0000000   335.0000000
RAD          4   236.7500000    14.0801278   222.0000000   252.0000000
ULNA         4   257.5000000    15.3514386   238.0000000   274.0000000
FEM          4   423.7500000    27.8013789   402.0000000   461.0000000
TIB          4   362.5000000    28.7691965   335.0000000   397.0000000
FIB          4   352.0000000    28.6006993   325.0000000   386.0000000
SIZE         4   317.4264102    22.1085812   295.4659961   343.1988110
SHUM         4     0.9777568     0.0156498     0.9636395     0.9999301
SRAD         4     0.7462384     0.0083317     0.7342683     0.7524308
SULNA        4     0.8117336     0.0179572     0.7983711     0.8382343
SFEM         4     1.3354204     0.0238940     1.3078354     1.3639471
STIB         4     1.1414313     0.0113494     1.1319463     1.1567639
SFIB         4     1.1082605     0.0131493     1.0956449     1.1247125
PRIN1        4    -0.0432026     0.0221879    -0.0669923    -0.0214716
PRIN2        4    -0.0058704     0.0156473    -0.0164918     0.0173559
PRIN3        4     0.0113660     0.0262113    -0.0104976     0.0438818
PRIN4        4    -0.0063279     0.0013171    -0.0079945    -0.0047729
PRIN5        4     0.0077460     0.0091300  -0.000472825     0.0204287
PRIN6        4  -9.463103E-6   0.000410999  -0.000416368   0.000476621
----------------------------------------------------------------------
```

Appendix 2. (continued)

```
                      Decade of Birth = 1850

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          10       1855.80      3.3598942        1850.00        1859.00
MAXHT        10   156.9056960      5.2650124    147.2802800    163.2802800
HUM          10   305.6000000     18.7035350    273.0000000    329.0000000
RAD          10   234.0000000     11.8883697    212.0000000    252.0000000
ULNA         10   254.9000000     10.3864228    237.0000000    269.0000000
FEM          10   429.8000000     24.5528908    387.0000000    462.0000000
TIB          10   354.8000000     20.5577777    325.0000000    379.0000000
FIB          10   346.0000000     18.8325959    320.0000000    368.0000000
SIZE         10   314.0943725     15.1753046    287.8593751    333.9383024
SHUM         10     0.9726049      0.0247937      0.9185926      0.9985959
SRAD         10     0.7450718      0.0161378      0.7207695      0.7705411
SULNA        10     0.8121718      0.0263686      0.7731331      0.8647557
SFEM         10     1.3681460      0.0329930      1.3221992      1.4115095
STIB         10     1.1293201      0.0243872      1.1091434      1.1772494
SFIB         10     1.1014820      0.0225650      1.0754358      1.1461052
PRIN1        10    -0.0181262      0.0422275     -0.0935087      0.0329342
PRIN2        10    -0.0138319      0.0354931     -0.0534429      0.0563349
PRIN3        10    -0.0128327      0.0227664     -0.0560645      0.0145119
PRIN4        10    -0.0026174      0.0110304     -0.0210587      0.0195938
PRIN5        10     0.0079784      0.0089132     -0.0022745      0.0252673
PRIN6        10   0.000269259    0.000754312   -0.000318825      0.0022527
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                        Decade of Birth = 1860

Variable     N          Mean        Std Dev        Minimum        Maximum
----------------------------------------------------------------------------
YOB          8       1863.75      3.5355339        1861.00        1868.00
MAXHT        8   159.9205300      4.1338071    154.5090800    165.9886400
HUM          8   304.6250000     10.9796890    290.0000000    320.0000000
RAD          8   232.1250000     10.5212370    216.0000000    249.0000000
ULNA         8   250.6250000     11.5007764    236.0000000    270.0000000
FEM          8   427.8750000     13.8092878    413.0000000    453.0000000
TIB          8   361.5000000     14.9761715    342.0000000    385.0000000
FIB          8   351.3750000     14.4512728    333.0000000    372.0000000
SIZE         8   314.1967081     10.9574471    301.4842017    333.4232825
SHUM         8     0.9697437      0.0234400      0.9419047      1.0017109
SRAD         8     0.7386061      0.0122193      0.7161292      0.7542704
SULNA        8     0.7974470      0.0124993      0.7798295      0.8101423
SFEM         8     1.3625955      0.0463055      1.2943653      1.4488356
STIB         8     1.1503700      0.0136954      1.1343878      1.1805206
SFIB         8     1.1182119      0.0175048      1.0977727      1.1554031
PRIN1        8    -0.0148074      0.0438344     -0.0742224      0.0635700
PRIN2        8     0.0130362      0.0278023     -0.0192051      0.0667162
PRIN3        8     0.0033765      0.0265185     -0.0404439      0.0427205
PRIN4        8    -0.0053617      0.0067331     -0.0191358      0.0024302
PRIN5        8     0.0038125      0.0070746     -0.0088949      0.0144853
PRIN6        8  -2.030355E-6    0.000354008   -0.000333623    0.000509349
----------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                         Decade of Birth = 1870

Variable      N            Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB          31         1873.48       3.1184501         1870.00         1879.00
MAXHT        30     159.8752960       4.8317603     149.5178800     168.8436800
HUM          30     308.4333333      16.1686869     271.0000000     354.0000000
RAD          31     236.6774194      10.5083684     223.0000000     261.0000000
ULNA         31     256.2580645      12.0470404     240.0000000     284.0000000
FEM          31     438.8709677      22.3423991     405.0000000     485.0000000
TIB          30     368.1000000      21.1274458     331.0000000     408.0000000
FIB          31     356.7741935      19.3109808     325.0000000     395.0000000
SIZE         30     320.6134161      14.9419270     299.1041792     355.8307158
SHUM         30       0.9619954       0.0225386       0.9032052       0.9948551
SRAD         30       0.7398339       0.0132886       0.7079579       0.7680485
SULNA        30       0.8011841       0.0181506       0.7612769       0.8292771
SFEM         30       1.3719397       0.0300472       1.3251984       1.4366510
STIB         30       1.1476703       0.0210342       1.1037869       1.1759803
SFIB         30       1.1151149       0.0168375       1.0758190       1.1498369
PRIN1        30      -0.0113179       0.0341816      -0.0679615       0.0736687
PRIN2        30       0.0131093       0.0295460      -0.0525656       0.0658058
PRIN3        30      -0.0094957       0.0217201      -0.0463644       0.0314005
PRIN4        30      -0.0051237       0.0094142      -0.0248105       0.0150150
PRIN5        30       0.0051430       0.0063960      -0.0101621       0.0143849
PRIN6        30     0.000012810     0.000376990    -0.000439275       0.0011113
-------------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                          Decade of Birth = 1880

Variable     N           Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB         19        1884.00      2.9249881        1880.00        1888.00
MAXHT       19    159.0574274      7.9337690    143.7886400    173.5402800
HUM         19    309.1578947     19.6278237    266.0000000    348.0000000
RAD         19    235.6842105     17.5722402    199.0000000    265.0000000
ULNA        19    254.5789474     17.9886254    218.0000000    287.0000000
FEM         19    438.8421053     28.1232667    387.0000000    492.0000000
TIB         19    364.2631579     26.0338286    311.0000000    417.0000000
FIB         19    355.3684211     26.6003562    301.0000000    408.0000000
SIZE        19    318.9592838     21.7277897    274.8683806    361.0589010
SHUM        19      0.9697412      0.0210286      0.9259602      1.0123310
SRAD        19      0.7386144      0.0081409      0.7239829      0.7523427
SULNA       19      0.7980659      0.0091989      0.7802041      0.8214406
SFEM        19      1.3764935      0.0278804      1.3121376      1.4264315
STIB        19      1.1419510      0.0179788      1.1134555      1.1683466
SFIB        19      1.1137621      0.0158690      1.0832586      1.1429821
PRIN1       19     -0.0039846      0.0274745     -0.0600529      0.0472791
PRIN2       19      0.0054953      0.0257252     -0.0375564      0.0495495
PRIN3       19     -0.0068112      0.0192690     -0.0403984      0.0319685
PRIN4       19     -0.0028396      0.0105591     -0.0244735      0.0110104
PRIN5       19      0.0036385      0.0067825     -0.0078473      0.0167564
PRIN6       19   -0.000206497    0.000201654   -0.000481267    0.000219016
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                         Decade of Birth = 1890

Variable     N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB         40       1893.95      3.4711263        1890.00        1899.00
MAXHT       38   159.3391863      6.5176940    144.5000000    171.6490800
HUM         40   307.7000000     15.7922409    281.0000000    347.0000000
RAD         39   234.3333333     13.1335916    211.0000000    265.0000000
ULNA        39   252.1538462     13.1580243    226.0000000    285.0000000
FEM         40   436.0250000     24.1973589    389.0000000    491.0000000
TIB         39   364.4358974     21.2501330    331.0000000    430.0000000
FIB         39   355.2307692     21.2831309    318.0000000    418.0000000
SIZE        39   317.3295967     16.2006583    286.9592450    353.9803271
SHUM        39     0.9677166      0.0163828      0.9171138      0.9945663
SRAD        39     0.7384092      0.0151103      0.7034289      0.7769822
SULNA       39     0.7948093      0.0197462      0.7288541      0.8356224
SFEM        39     1.3719022      0.0311857      1.3155660      1.4381231
STIB        39     1.1482654      0.0233491      1.0936391      1.2147568
SFIB        39     1.1191223      0.0208158      1.0731151      1.1808566
PRIN1       39    -0.0067074      0.0358157     -0.0674868      0.0572223
PRIN2       39     0.0138785      0.0327697     -0.0682305      0.0976128
PRIN3       39    -0.0020054      0.0189146     -0.0382008      0.0597517
PRIN4       39    -0.0034181      0.0090449     -0.0195816      0.0232702
PRIN5       39     0.0018333      0.0064108     -0.0135669      0.0138620
PRIN6       39   0.000015339    0.000598296   -0.000475892      0.0029977
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                          Decade of Birth = 1900

Variable      N            Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB          55         1902.89       3.0164532         1900.00         1908.00
MAXHT        50     158.8072228       6.3085375     143.5000000     171.0000000
HUM          55     308.2727273      15.9993687     274.0000000     342.0000000
RAD          55     235.6363636      14.4470472     201.0000000     272.0000000
ULNA         54     254.0370370      14.5433159     215.0000000     290.0000000
FEM          55     440.6181818      23.2788975     387.0000000     493.0000000
TIB          55     367.2545455      21.0943368     323.0000000     418.0000000
FIB          55     357.4000000      20.0818695     306.0000000     407.0000000
SIZE         54     319.8451221      16.7186950     282.9388948     361.3412752
SHUM         54       0.9643895       0.0202185       0.9266494       1.0067378
SRAD         54       0.7378101       0.0165807       0.6780883       0.7702988
SULNA        54       0.7942148       0.0177687       0.7253183       0.8331804
SFEM         54       1.3783666       0.0339275       1.3047919       1.4676971
STIB         54       1.1492990       0.0220160       1.1083628       1.2246072
SFIB         54       1.1185099       0.0181547       1.0815056       1.1807507
PRIN1        54      -0.0019424       0.0374224      -0.0946726       0.1056652
PRIN2        54       0.0162038       0.0305292      -0.0434126       0.1129485
PRIN3        54      -0.0071010       0.0219640      -0.0610615       0.0437586
PRIN4        54      -0.0043769       0.0098219      -0.0294552       0.0140426
PRIN5        54       0.0019630       0.0072693      -0.0107842       0.0229625
PRIN6        54     0.000047319     0.000777532    -0.000479019       0.0049062
-------------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                       Decade of Birth = 1910

Variable      N          Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB          25       1912.24       2.9337121         1910.00         1918.00
MAXHT        21   160.0714286       7.8378660     146.5000000     172.5000000
HUM          25   311.9200000      12.3150315     291.0000000     337.0000000
RAD          25   237.7600000      12.2653985     214.0000000     256.0000000
ULNA         25   254.9200000      12.7407483     228.0000000     273.0000000
FEM          25   442.4800000      29.3174010     383.0000000     490.0000000
TIB          25   369.2000000      22.3289797     319.0000000     413.0000000
FIB          25   360.5600000      23.5903935     310.0000000     405.0000000
SIZE         25   321.8677610      16.6122749     286.6526456     347.3911406
SHUM         25     0.9700836       0.0306641       0.9237315       1.0490772
SRAD         25     0.7388014       0.0132731       0.7138927       0.7737755
SULNA        25     0.7922422       0.0173845       0.7521686       0.8294873
SFEM         25     1.3740054       0.0357965       1.2652347       1.4488033
STIB         25     1.1466666       0.0198772       1.0987612       1.1888616
SFIB         25     1.1195474       0.0224106       1.0814482       1.1658328
PRIN1        25    -0.0034962       0.0320310      -0.0835442       0.0641355
PRIN2        25     0.0122652       0.0352956      -0.0585698       0.0841040
PRIN3        25  -0.000974828       0.0335929      -0.0560501       0.0867654
PRIN4        25    -0.0024540       0.0105095      -0.0210701       0.0166415
PRIN5        25  -0.000309967       0.0092947      -0.0261596       0.0268398
PRIN6        25   0.000099559     0.000571741    -0.000486882       0.0016494
-------------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                          Decade of Birth = 1920

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           5       1921.00      0.7071068        1920.00        1922.00
MAXHT         3   151.7812267      7.7229622    143.3436800    158.5000000
HUM           5   302.6000000     17.0528590    282.0000000    323.0000000
RAD           5   234.2000000     14.4118007    216.0000000    251.0000000
ULNA          5   251.8000000     17.4842787    233.0000000    277.0000000
FEM           5   431.6000000     32.9211178    398.0000000    479.0000000
TIB           5   362.2000000     23.9311512    334.0000000    393.0000000
FIB           5   350.4000000     26.2068693    318.0000000    380.0000000
SIZE          5   315.0081783     20.9388727    290.4151310    342.2246428
SHUM          5     0.9611284      0.0104858      0.9438245      0.9710238
SRAD          5     0.7436856      0.0078104      0.7334364      0.7530715
SULNA         5     0.7993267      0.0131706      0.7763142      0.8094099
SFEM          5     1.3695207      0.0203366      1.3480910      1.3996654
STIB          5     1.1498773      0.0107794      1.1342559      1.1644712
SFIB          5     1.1118727      0.0143893      1.0949843      1.1303134
PRIN1         5    -0.0142059      0.0186545     -0.0372218      0.0050987
PRIN2         5     0.0129447      0.0151146     -0.0017948      0.0357016
PRIN3         5    -0.0096398      0.0165035     -0.0378155      0.0048801
PRIN4         5    -0.0094955      0.0118440     -0.0220703      0.0079329
PRIN5         5     0.0015829      0.0095991     -0.0101829      0.0152996
PRIN6         5  -0.000297907    0.000110813   -0.000411011   -0.000126127
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                         Decade of Birth = 1930

Variable      N           Mean        Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB           4        1935.25      3.4034296         1931.00         1938.00
MAXHT         2    157.7046400     10.3171971     150.4092800     165.0000000
HUM           4    307.0000000     24.0554914     273.0000000     325.0000000
RAD           4    236.5000000     10.4083300     221.0000000     243.0000000
ULNA          3    249.3333333     14.0118997     235.0000000     263.0000000
FEM           3    445.6666667     23.5867194     421.0000000     468.0000000
TIB           4    360.2500000     25.0383040     334.0000000     385.0000000
FIB           3    355.3333333     30.6648550     321.0000000     380.0000000
SIZE          2    330.8369695      5.8848472     326.6757541     334.9981849
SHUM          2      0.9795273      0.0216982       0.9641843       0.9948703
SRAD          2      0.7330864      0.0109026       0.7253771       0.7407957
SULNA         2      0.7751819      0.0139965       0.7652848       0.7850789
SFEM          2      1.3842065      0.0181246       1.3713904       1.3970225
STIB          2      1.1531853      0.0055513       1.1492600       1.1571107
SFIB          2      1.1258252      0.0120340       1.1173159       1.1343345
PRIN1         2      0.0161513      0.0074537       0.0108808       0.0214219
PRIN2         2      0.0184628      0.0139298       0.0086129       0.0283126
PRIN3         2      0.0103244      0.0235616      -0.0063362       0.0269849
PRIN4         2     -0.0039148      0.0161156      -0.0153102       0.0074807
PRIN5         2     -0.0069837      0.0150086      -0.0175964       0.0036290
PRIN6         2   -0.000188574    0.000057354    -0.000229129    -0.000148019
-------------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                          Decade of Birth = 1940

Variable     N          Mean        Std Dev        Minimum        Maximum
-------------------------------------------------------------------------
YOB          7       1945.00      2.8284271        1941.00        1948.00
MAXHT        5   164.8000000      4.6583259    158.0000000    170.0000000
HUM          6   318.5000000     14.5292808    297.0000000    335.0000000
RAD          6   244.6666667      8.6641022    230.0000000    255.0000000
ULNA         5   261.6000000      8.4439327    248.0000000    269.0000000
FEM          7   448.4285714     28.5415320    394.0000000    474.0000000
TIB          6   365.1666667     25.1826660    324.0000000    400.0000000
FIB          6   357.0000000     21.4476106    318.0000000    382.0000000
SIZE         5   328.5080176     11.2670810    317.2721008    341.3702384
SHUM         5     0.9676062      0.0188252      0.9358396      0.9819786
SRAD         5     0.7421735      0.0152728      0.7249298      0.7562340
SULNA        5     0.7965905      0.0211992      0.7704245      0.8192535
SFEM         5     1.3863133      0.0300420      1.3457444      1.4246446
STIB         5     1.1364549      0.0225009      1.1150781      1.1717483
SFIB         5     1.1106881      0.0149974      1.0855005      1.1217471
PRIN1        5     0.0026157      0.0368191     -0.0392766      0.0457212
PRIN2        5     0.0014372      0.0242476     -0.0343069      0.0270433
PRIN3        5    -0.0156559      0.0218368     -0.0406273      0.0149187
PRIN4        5    -0.0017579      0.0145386     -0.0212264      0.0186199
PRIN5        5  -0.000367294      0.0062418     -0.0097000      0.0069931
PRIN6        5  -0.000108859    0.000134941   -0.000236024    0.000084484
-------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                         Decade of Birth = 1950

Variable      N          Mean         Std Dev         Minimum         Maximum
------------------------------------------------------------------------------
YOB          10       1953.60       2.4129281         1951.00         1959.00
MAXHT         7   167.4285714      11.2673147     158.0000000     185.0000000
HUM           9   311.8888889       9.4531006     301.0000000     334.0000000
RAD           9   238.7777778      10.8025203     217.0000000     254.0000000
ULNA          9   255.2222222      13.4979422     228.0000000     273.0000000
FEM          10   456.8000000      36.6205771     410.0000000     525.0000000
TIB          10   378.1000000      25.4796215     346.0000000     422.0000000
FIB           9   369.6666667      23.3238076     342.0000000     407.0000000
SIZE          8   325.3576074      15.9621036     299.5535860     355.9794613
SHUM          8     0.9606443       0.0277857       0.9106214       1.0048286
SRAD          8     0.7374361       0.0129978       0.7135243       0.7558751
SULNA         8     0.7887266       0.0181030       0.7611326       0.8146138
SFEM          8     1.3855707       0.0315495       1.3380728       1.4439035
STIB          8     1.1521680       0.0173731       1.1307827       1.1798433
SFIB          8     1.1224721       0.0218785       1.0880945       1.1472632
PRIN1         8     0.0052835       0.0302145      -0.0414532       0.0640534
PRIN2         8     0.0231566       0.0337328      -0.0132961       0.0765254
PRIN3         8    -0.0097514       0.0295802      -0.0396535       0.0466006
PRIN4         8    -0.0037555       0.0072058      -0.0166910       0.0044616
PRIN5         8    -0.0015229       0.0081522      -0.0116435       0.0147188
PRIN6         8   0.000059985     0.000615032    -0.000429044       0.0011509
------------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                        Decade of Birth = 1960

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           2       1964.00      1.4142136        1963.00        1965.00
MAXHT         2   152.0000000      2.8284271    150.0000000    154.0000000
HUM           2   290.5000000      9.1923882    284.0000000    297.0000000
RAD           2   222.0000000      8.4852814    216.0000000    228.0000000
ULNA          2   240.5000000     10.6066017    233.0000000    248.0000000
FEM           2   419.5000000      4.9497475    416.0000000    423.0000000
TIB           1   344.0000000              .    344.0000000    344.0000000
FIB           1   334.0000000              .    334.0000000    334.0000000
SIZE          1   305.7018327              .    305.7018327    305.7018327
SHUM          1     0.9715349              .      0.9715349      0.9715349
SRAD          1     0.7458248              .      0.7458248      0.7458248
SULNA         1     0.8112480              .      0.8112480      0.8112480
SFEM          1     1.3837012              .      1.3837012      1.3837012
STIB          1     1.1252795              .      1.1252795      1.1252795
SFIB          1     1.0925679              .      1.0925679      1.0925679
PRIN1         1    -0.0060187              .     -0.0060187     -0.0060187
PRIN2         1    -0.0203255              .     -0.0203255     -0.0203255
PRIN3         1    -0.0244830              .     -0.0244830     -0.0244830
PRIN4         1    -0.0064487              .     -0.0064487     -0.0064487
PRIN5         1     0.0070846              .      0.0070846      0.0070846
PRIN6         1  -0.000325063              .   -0.000325063   -0.000325063
--------------------------------------------------------------------------
```

Appendix 2. (continued)

```
                     Decade of Birth = 1970

Variable     N         Mean      Std Dev       Minimum       Maximum
-----------------------------------------------------------------------
YOB          4      1972.00    2.4494897       1970.00       1975.00
MAXHT        2  163.0000000            0   163.0000000   163.0000000
HUM          3  302.0000000    4.0000000   298.0000000   306.0000000
RAD          3  240.0000000    5.2915026   234.0000000   244.0000000
ULNA         2  255.0000000    2.8284271   253.0000000   257.0000000
FEM          4  444.5000000   13.7719522   426.0000000   458.0000000
TIB          2  354.5000000   10.6066017   347.0000000   362.0000000
FIB          2  360.5000000   13.4350288   351.0000000   370.0000000
SIZE         1  314.6039956            .   314.6039956   314.6039956
SHUM         1    0.9472226            .     0.9472226     0.9472226
SRAD         1    0.7755782            .     0.7755782     0.7755782
SULNA        1    0.8169000            .     0.8169000     0.8169000
SFEM         1    1.3540832            .     1.3540832     1.3540832
STIB         1    1.1029739            .     1.1029739     1.1029739
SFIB         1    1.1156883            .     1.1156883     1.1156883
PRIN1        1   -0.0484796            .    -0.0484796    -0.0484796
PRIN2        1   -0.0141434            .    -0.0141434    -0.0141434
PRIN3        1   -0.0345355            .    -0.0345355    -0.0345355
PRIN4        1    0.0240463            .     0.0240463     0.0240463
PRIN5        1   -0.0162613            .    -0.0162613    -0.0162613
PRIN6        1  0.000340398            .   0.000340398   0.000340398
-----------------------------------------------------------------------
```

Appendix 3. Summary statistics for white males by decade of birth.

```
                      Decade of Birth = 1810

Variable      N          Mean        Std Dev        Minimum        Maximum
-----------------------------------------------------------------------------
YOB           1       1819.00              .        1819.00        1819.00
MAXHT         0             .              .              .              .
HUM           1   333.0000000              .    333.0000000    333.0000000
RAD           0             .              .              .              .
ULNA          0             .              .              .              .
FEM           1   470.0000000              .    470.0000000    470.0000000
TIB           0             .              .              .              .
FIB           0             .              .              .              .
SIZE          0             .              .              .              .
SHUM          0             .              .              .              .
SRAD          0             .              .              .              .
SULNA         0             .              .              .              .
SFEM          0             .              .              .              .
STIB          0             .              .              .              .
SFIB          0             .              .              .              .
PRIN1         0             .              .              .              .
PRIN2         0             .              .              .              .
PRIN3         0             .              .              .              .
PRIN4         0             .              .              .              .
PRIN5         0             .              .              .              .
PRIN6         0             .              .              .              .
-----------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                         Decade of Birth = 1820
Variable      N         Mean        Std Dev        Minimum        Maximum
-------------------------------------------------------------------------
YOB           7      1825.00      3.3665016        1820.00        1829.00
MAXHT         0            .              .              .              .
HUM           6  334.0000000     13.4461891    313.0000000    355.0000000
RAD           4  243.5000000     10.2794293    232.0000000    257.0000000
ULNA          3  259.0000000      5.2915026    253.0000000    263.0000000
FEM           3  456.6666667     21.5483951    440.0000000    481.0000000
TIB           5  378.8000000      8.1055537    367.0000000    389.0000000
FIB           1  351.0000000              .    351.0000000    351.0000000
SIZE          1  322.5975157              .    322.5975157    322.5975157
SHUM          1    1.0291462              .      1.0291462      1.0291462
SRAD          1    0.7191624              .      0.7191624      0.7191624
SULNA         1    0.7842590              .      0.7842590      0.7842590
SFEM          1    1.3918272              .      1.3918272      1.3918272
STIB          1    1.1376405              .      1.1376405      1.1376405
SFIB          1    1.0880431              .      1.0880431      1.0880431
PRIN1         1    0.0357863              .      0.0357863      0.0357863
PRIN2         1   -0.0373821              .     -0.0373821     -0.0373821
PRIN3         1    0.0276744              .      0.0276744      0.0276744
PRIN4         1   -0.0210073              .     -0.0210073     -0.0210073
PRIN5         1    0.0121922              .      0.0121922      0.0121922
PRIN6         1  0.000466170              .    0.000466170    0.000466170
-------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                           Decade of Birth = 1830

Variable      N           Mean        Std Dev        Minimum        Maximum
----------------------------------------------------------------------------
YOB           8        1834.38      3.1139089        1830.00        1839.00
MAXHT         0              .              .              .              .
HUM           6    322.6666667     23.6952879    284.0000000    358.0000000
RAD           4    240.2500000     17.5760253    218.0000000    261.0000000
ULNA          4    260.0000000     15.8954920    237.0000000    272.0000000
FEM           5    460.2000000     21.8449079    438.0000000    487.0000000
TIB           5    370.4000000     24.7446964    346.0000000    412.0000000
FIB           2    372.0000000     18.3847763    359.0000000    385.0000000
SIZE          0              .              .              .              .
SHUM          0              .              .              .              .
SRAD          0              .              .              .              .
SULNA         0              .              .              .              .
SFEM          0              .              .              .              .
STIB          0              .              .              .              .
SFIB          0              .              .              .              .
PRIN1         0              .              .              .              .
PRIN2         0              .              .              .              .
PRIN3         0              .              .              .              .
PRIN4         0              .              .              .              .
PRIN5         0              .              .              .              .
PRIN6         0              .              .              .              .
----------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                         Decade of Birth = 1840

Variable      N           Mean        Std Dev        Minimum        Maximum
---------------------------------------------------------------------------
YOB          25        1846.00      2.8722813        1840.00        1849.00
MAXHT         9    173.1744811      6.1053011    162.0907900    183.8169100
HUM          17    332.5294118     11.4734348    312.0000000    357.0000000
RAD          16    244.4375000      9.4514108    227.0000000    259.0000000
ULNA         16    262.8125000      8.6040204    248.0000000    274.0000000
FEM          20    462.2500000     17.9850084    409.0000000    492.0000000
TIB          23    377.2173913     16.9409577    330.0000000    402.0000000
FIB          17    373.3529412     16.6656127    325.0000000    394.0000000
SIZE         10    339.2459683      9.0263525    318.7780298    350.6623242
SHUM         10      0.9951782      0.0131916      0.9758378      1.0180734
SRAD         10      0.7291110      0.0185094      0.6961583      0.7612710
SULNA        10      0.7847764      0.0106549      0.7699715      0.7994815
SFEM         10      1.3782755      0.0268982      1.3461858      1.4341458
STIB         10      1.1394078      0.0124342      1.1199015      1.1562245
SFIB         10      1.1191037      0.0144433      1.0916687      1.1341229
PRIN1        10      0.0129255      0.0333102     -0.0354403      0.0754083
PRIN2        10     -0.0031069      0.0182954     -0.0400821      0.0202506
PRIN3        10      0.0171349      0.0097797      0.0019459      0.0312626
PRIN4        10      0.0010552      0.0104105     -0.0164334      0.0141328
PRIN5        10      0.0017464      0.0082685     -0.0135308      0.0171897
PRIN6        10   -0.000034413    0.000443375   -0.000421585      0.0010083
---------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                         Decade of Birth = 1850

Variable      N           Mean        Std Dev        Minimum        Maximum
---------------------------------------------------------------------------
YOB          61        1854.57      2.6549263        1850.00        1859.00
MAXHT        33    169.1276718      6.3878300    151.5653100    180.4315500
HUM          47    326.7021277     21.7374800    282.0000000    371.0000000
RAD          43    241.0697674     15.1632315    218.0000000    269.0000000
ULNA         42    259.5000000     15.3848992    237.0000000    291.0000000
FEM          50    450.5000000     25.1755064    390.0000000    506.0000000
TIB          56    367.7321429     22.9525131    308.0000000    409.0000000
FIB          41    361.3414634     24.5821172    313.0000000    408.0000000
SIZE         33    330.0873522     19.3365283    294.5138637    364.2620098
SHUM         33      0.9995970      0.0194972      0.9678519      1.0396224
SRAD         33      0.7361576      0.0127032      0.7122248      0.7658392
SULNA        33      0.7915036      0.0114915      0.7672603      0.8182976
SFEM         33      1.3793031      0.0237438      1.3097762      1.4228929
STIB         33      1.1241776      0.0220634      1.0457912      1.1622213
SFIB         33      1.1083438      0.0223591      1.0590545      1.1557466
PRIN1        33      0.0094864      0.0244627     -0.0562000      0.0476281
PRIN2        33     -0.0227604      0.0344122     -0.1194671      0.0437059
PRIN3        33      0.0094936      0.0179510     -0.0301172      0.0432382
PRIN4        33      0.0032497      0.0091053     -0.0126573      0.0213973
PRIN5        33    0.000356146      0.0059996     -0.0108400      0.0109118
PRIN6        33    0.000031511    0.000539590   -0.000488084      0.0021756
---------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                          Decade of Birth = 1860

Variable     N          Mean         Std Dev         Minimum         Maximum
----------------------------------------------------------------------------
YOB         86       1864.24       2.7735560         1860.00         1869.00
MAXHT       56   169.6146707       5.8991977     156.8551100     183.6508900
HUM         67   328.9850746      16.7896907     285.0000000     363.0000000
RAD         64   243.9687500      10.6472573     214.0000000     270.0000000
ULNA        67   261.8955224      11.2615386     231.0000000     288.0000000
FEM         77   456.0259740      21.6217325     392.0000000     508.0000000
TIB         80   370.5375000      20.0176781     305.0000000     415.0000000
FIB         69   365.6521739      20.1215615     305.0000000     405.0000000
SIZE        59   332.5802998      14.4879596     290.4166126     361.8532757
SHUM        59     0.9938357       0.0242644       0.9349061       1.0624164
SRAD        59     0.7363177       0.0123044       0.7063691       0.7648986
SULNA       59     0.7918932       0.0140620       0.7622085       0.8317954
SFEM        59     1.3775653       0.0254911       1.3175711       1.4559693
STIB        59     1.1289013       0.0187031       1.0737120       1.1691811
SFIB        59     1.1107298       0.0146965       1.0770259       1.1352471
PRIN1       59     0.0064157       0.0280788      -0.0490390       0.0885744
PRIN2       59    -0.0156067       0.0275238      -0.0924049       0.0441870
PRIN3       59     0.0079430       0.0207754      -0.0344455       0.0491019
PRIN4       59     0.0021161       0.0108892      -0.0253422       0.0246974
PRIN5       59   0.000668035       0.0075593      -0.0306749       0.0176280
PRIN6       59  -0.000035702     0.000420507    -0.000461670       0.0014677
----------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                           Decade of Birth = 1870

Variable     N          Mean       Std Dev        Minimum        Maximum
------------------------------------------------------------------------
YOB         99       1873.79     2.8971229        1870.00        1879.00
MAXHT       93   168.6561969     7.9568904    148.0012100    188.2134900
HUM         95   329.5684211    18.0399395    285.0000000    367.0000000
RAD         96   243.8854167    13.6527381    209.0000000    279.0000000
ULNA        96   261.5208333    14.6668112    225.0000000    301.0000000
FEM         94   453.9148936    26.4529038    390.0000000    511.0000000
TIB         98   372.5612245    22.4371132    314.0000000    424.0000000
FIB         97   366.1443299    21.6366730    306.0000000    417.0000000
SIZE        93   330.4597419    18.0569850    284.2331672    375.0823219
SHUM        93     0.9975105     0.0216464      0.9367809      1.0465305
SRAD        93     0.7375201     0.0128303      0.7031688      0.7697315
SULNA       93     0.7919819     0.0151981      0.7505873      0.8266720
SFEM        93     1.3740330     0.0291422      1.2912727      1.4627794
STIB        93     1.1277405     0.0204955      1.0821251      1.1835563
SFIB        93     1.1088010     0.0174323      1.0631750      1.1624214
PRIN1       93     0.0040344     0.0310228     -0.0750611      0.0866511
PRIN2       93    -0.0195363     0.0298099     -0.0897162      0.0762092
PRIN3       93     0.0111155     0.0210192     -0.0307261      0.0854358
PRIN4       93     0.0011939     0.0099420     -0.0220745      0.0206547
PRIN5       93  -0.000017516     0.0067448     -0.0123834      0.0153059
PRIN6       93   0.000034881   0.000441749   -0.000489322      0.0014436
------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                        Decade of Birth = 1880

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          43       1883.12      2.9456126        1880.00        1889.00
MAXHT        43   168.6520286      8.4489257    147.7310100    181.8805900
HUM          43   328.0465116     18.7438288    282.0000000    367.0000000
RAD          43   242.9302326     14.1663507    202.0000000    276.0000000
ULNA         43   261.4186047     14.4605087    222.0000000    298.0000000
FEM          43   458.5116279     25.9975934    385.0000000    506.0000000
TIB          43   372.1860465     22.6571295    314.0000000    417.0000000
FIB          43   366.6744186     21.3393454    311.0000000    411.0000000
SIZE         43   330.4375571     17.6917807    279.3727459    368.2357716
SHUM         43     0.9928467      0.0228206      0.9252637      1.0400638
SRAD         43     0.7351504      0.0158834      0.6941487      0.7745217
SULNA        43     0.7912795      0.0190484      0.7474439      0.8301795
SFEM         43     1.3878194      0.0371077      1.3153397      1.4758850
STIB         43     1.1260271      0.0192792      1.0807997      1.1676650
SFIB         43     1.1095356      0.0189793      1.0557377      1.1510566
PRIN1        43     0.0150465      0.0417803     -0.0712540      0.1250089
PRIN2        43    -0.0171288      0.0285800     -0.0791988      0.0565337
PRIN3        43     0.0016782      0.0223385     -0.0587305      0.0505207
PRIN4        43     0.0033060      0.0112298     -0.0248087      0.0265969
PRIN5        43   0.000876435      0.0075402     -0.0161098      0.0177405
PRIN6        43   0.000154356    0.000641694   -0.000448499      0.0024394
--------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                        Decade of Birth = 1890

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          20       1895.15      2.7003898        1890.00        1899.00
MAXHT        18   171.4389294      7.1259158    154.5041100    181.6753100
HUM          20   332.1500000     19.1785928    289.0000000    371.0000000
RAD          20   244.8500000     16.0534469    211.0000000    270.0000000
ULNA         20   263.4000000     16.0440184    228.0000000    284.0000000
FEM          20   457.8000000     27.6911538    393.0000000    493.0000000
TIB          20   372.0500000     23.1300101    324.0000000    404.0000000
FIB          20   367.8500000     22.2409650    322.0000000    399.0000000
SIZE         20   332.0823861     19.6067096    287.9506719    360.2164902
SHUM         20     1.0005644      0.0236132      0.9475006      1.0317125
SRAD         20     0.7370926      0.0092502      0.7214711      0.7563529
SULNA        20     0.7931669      0.0110595      0.7687807      0.8166448
SFEM         20     1.3786248      0.0234237      1.3332952      1.4163616
STIB         20     1.1202317      0.0130541      1.0985740      1.1495202
SFIB         20     1.1077267      0.0157758      1.0798483      1.1295163
PRIN1        20     0.0081833      0.0247043     -0.0484521      0.0471157
PRIN2        20    -0.0264569      0.0248771     -0.0638789      0.0182397
PRIN3        20     0.0086914      0.0198578     -0.0275158      0.0439872
PRIN4        20     0.0054803      0.0087560     -0.0105732      0.0184807
PRIN5        20   0.000398372      0.0057574     -0.0164404      0.0091514
PRIN6        20  -0.000035037    0.000322076   -0.000420936    0.000493220
--------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                         Decade of Birth = 1900

Variable      N           Mean        Std Dev        Minimum        Maximum
-----------------------------------------------------------------------------
YOB          50        1906.34      2.6542996        1900.00        1909.00
MAXHT        45    172.2991133      6.6576347    156.2100000    186.0900900
HUM          47    331.0212766     13.7231784    297.0000000    360.0000000
RAD          45    247.0888889     10.5568208    224.0000000    268.0000000
ULNA         46    267.1304348     11.3462842    242.0000000    286.0000000
FEM          49    463.8367347     21.3486406    412.0000000    504.0000000
TIB          50    377.5600000     18.8237366    333.0000000    417.0000000
FIB          48    372.2500000     18.4396658    330.0000000    415.0000000
SIZE         38    334.9049029     13.4783634    302.7607871    359.6215450
SHUM         38      0.9875253      0.0198720      0.9416131      1.0335929
SRAD         38      0.7366281      0.0120868      0.7064133      0.7592730
SULNA        38      0.7956659      0.0166846      0.7617256      0.8430299
SFEM         38      1.3818207      0.0277081      1.3147615      1.4540341
STIB         38      1.1271624      0.0160145      1.0998782      1.1751368
SFIB         38      1.1103222      0.0173608      1.0705458      1.1466140
PRIN1        38      0.0065587      0.0315926     -0.0721769      0.0901273
PRIN2        38     -0.0141844      0.0270055     -0.0620290      0.0510440
PRIN3        38   -0.000256345      0.0152101     -0.0381181      0.0423732
PRIN4        38      0.0036714      0.0091280     -0.0198172      0.0243734
PRIN5        38      0.0026060      0.0101377     -0.0247345      0.0262764
PRIN6        38   -0.000076718    0.000363546   -0.000526959    0.000964107
-----------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                            Decade of Birth = 1910

Variable      N           Mean        Std Dev        Minimum        Maximum
----------------------------------------------------------------------------
YOB         472        1915.96      2.6517893        1910.00        1919.00
MAXHT       465    173.6212226      6.5273840    157.4800000    190.5000000
HUM         469    335.2430704     16.9405881    286.0000000    384.0000000
RAD         460    250.5217391     12.9248526    215.0000000    300.0000000
ULNA        444    269.0427928     13.0688563    232.0000000    315.0000000
FEM         469    471.3091684     24.2724991    408.0000000    556.0000000
TIB         469    386.1151386     21.8428626    315.0000000    459.0000000
FIB         416    379.1225962     20.5621449    319.0000000    450.0000000
SIZE        392    340.0659243     15.9683267    295.9995972    381.9129295
SHUM        392      0.9842986      0.0204237      0.8669103      1.0441719
SRAD        392      0.7355877      0.0129564      0.6999748      0.7728941
SULNA       392      0.7904755      0.0159670      0.7290710      0.8358510
SFEM        392      1.3840819      0.0283457      1.2989059      1.4625894
STIB        392      1.1341443      0.0188344      1.0728279      1.1954487
SFIB        392      1.1142326      0.0178044      1.0609259      1.1760709
PRIN1       392      0.0100593      0.0302454     -0.0889901      0.0940449
PRIN2       392     -0.0050091      0.0273204     -0.0778594      0.0835140
PRIN3       392    0.000894417      0.0214463     -0.0965736      0.0648879
PRIN4       392      0.0015536      0.0105585     -0.0384837      0.0279513
PRIN5       392    0.000296190      0.0090759     -0.0499958      0.0309026
PRIN6       392   -0.000064488    0.000406555   -0.000498792      0.0026016
----------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                         Decade of Birth = 1920

Variable      N           Mean        Std Dev        Minimum        Maximum
-----------------------------------------------------------------------------
YOB         657        1922.77      2.0380005        1920.00        1928.00
MAXHT       643    174.7084824      6.0441258    156.2100000    190.5000000
HUM         649    336.8859784     15.9587413    284.0000000    381.0000000
RAD         642    252.2866044     12.7840131    208.0000000    288.0000000
ULNA        622    270.9035370     12.8178250    231.0000000    308.0000000
FEM         653    474.9969372     22.9462560    411.0000000    537.0000000
TIB         649    390.7981510     21.2621265    322.0000000    454.0000000
FIB         581    383.7332186     20.5406934    313.0000000    436.0000000
SIZE        547    343.1007169     16.2757560    290.1394763    385.0762277
SHUM        547      0.9814935      0.0209532      0.9184401      1.0772378
SRAD        547      0.7349546      0.0130906      0.6861929      0.7705496
SULNA       547      0.7890520      0.0148451      0.7426603      0.8361321
SFEM        547      1.3826712      0.0285887      1.2911205      1.4719346
STIB        547      1.1374131      0.0190046      1.0807115      1.1945737
SFIB        547      1.1183200      0.0184749      1.0665539      1.1773078
PRIN1       547      0.0090739      0.0309460     -0.0785098      0.1175550
PRIN2       547      0.0010147      0.0289151     -0.0750989      0.0759226
PRIN3       547      0.0020989      0.0193079     -0.0556862      0.0637534
PRIN4       547      0.0023761      0.0107303     -0.0367750      0.0394005
PRIN5       547   -0.000244914      0.0082927     -0.0272956      0.0485497
PRIN6       547   -0.000066681    0.000381399   -0.000505994      0.0021605
-----------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                             Decade of Birth = 1930

Variable      N           Mean        Std Dev        Minimum        Maximum
-------------------------------------------------------------------------------
YOB          45        1934.78      2.6447967        1930.00        1939.00
MAXHT        24    175.1339096      8.3435152    153.0000000    188.5079900
HUM          42    338.7142857     17.6597734    296.0000000    389.0000000
RAD          42    253.9761905     12.7957464    223.0000000    281.0000000
ULNA         42    272.9047619     12.7256406    243.0000000    297.0000000
FEM          40    473.9500000     26.4865229    407.0000000    528.0000000
TIB          42    391.2619048     24.5695226    337.0000000    445.0000000
FIB          41    387.0000000     24.1443575    338.0000000    446.0000000
SIZE         37    344.6489645     18.5850044    300.9936335    380.4088151
SHUM         37      0.9826812      0.0235672      0.9146501      1.0355005
SRAD         37      0.7360316      0.0120291      0.7085952      0.7681253
SULNA        37      0.7916078      0.0154792      0.7558349      0.8209889
SFEM         37      1.3726625      0.0295647      1.3118487      1.4437627
STIB         37      1.1346467      0.0228411      1.0884323      1.1810657
SFIB         37      1.1227610      0.0229370      1.0797639      1.1824172
PRIN1        37    0.000036560      0.0301605     -0.0551471      0.0863165
PRIN2        37    0.000381584      0.0357635     -0.0585179      0.1000491
PRIN3        37      0.0073885      0.0215244     -0.0598523      0.0680343
PRIN4        37      0.0075278      0.0121210     -0.0211256      0.0326635
PRIN5        37   -0.000015288      0.0079083     -0.0186352      0.0156108
PRIN6        37     3.27195E-6    0.000412579   -0.000497949      0.0013745
-------------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                              Decade of Birth = 1940

Variable      N           Mean         Std Dev         Minimum         Maximum
------------------------------------------------------------------------------
YOB          33        1944.33       2.7462095         1940.00         1949.00
MAXHT        22    178.4996859       8.8060188     162.5900900     198.0000000
HUM          30    334.4000000      19.3187420     278.0000000     366.0000000
RAD          32    252.4375000      12.2525508     227.0000000     270.0000000
ULNA         31    271.0645161      13.3863998     245.0000000     292.0000000
FEM          30    473.5000000      23.8656440     421.0000000     520.0000000
TIB          31    390.5806452      24.1174545     336.0000000     430.0000000
FIB          29    383.4482759      23.1000714     334.0000000     417.0000000
SIZE         24    341.6038899      18.5235640     302.9582866     367.2565321
SHUM         24      0.9720606       0.0182149       0.9176181       1.0062101
SRAD         24      0.7371585       0.0103460       0.7159116       0.7533055
SULNA        24      0.7929840       0.0146017       0.7577459       0.8152938
SFEM         24      1.3778849       0.0272331       1.3230236       1.4318232
STIB         24      1.1392797       0.0180539       1.1012593       1.1810312
SFIB         24      1.1220074       0.0151464       1.0945215       1.1521599
PRIN1        24    0.000477510       0.0282912      -0.0570266       0.0589492
PRIN2        24      0.0081418       0.0222656      -0.0507929       0.0466927
PRIN3        24     -0.0023658       0.0213196      -0.0679087       0.0313149
PRIN4        24      0.0044422       0.0113141      -0.0184738       0.0255071
PRIN5        24    0.000370609       0.0083830      -0.0118369       0.0173708
PRIN6        24   -0.000178257     0.000273642    -0.000488679     0.000491495
------------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                    Decade of Birth = 1950

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          39       1953.74      2.8258017        1950.00        1959.00
MAXHT        26   175.3092342      7.5201570    155.0000000    188.0000000
HUM          32   334.8437500     16.2005762    297.0000000    369.0000000
RAD          28   254.6428571     12.5763278    222.0000000    281.0000000
ULNA         29   271.3793103     12.8630528    246.0000000    307.0000000
FEM          38   474.1842105     20.5831934    422.0000000    508.0000000
TIB          39   391.2564103     20.0666232    345.0000000    435.0000000
FIB          31   390.2903226     15.2407208    361.0000000    425.0000000
SIZE         22   346.8277532     12.0108824    317.2229238    377.6402446
SHUM         22     0.9685482      0.0226567      0.9266505      1.0189172
SRAD         22     0.7422336      0.0130463      0.7249109      0.7787819
SULNA        22     0.7908538      0.0127407      0.7697379      0.8129430
SFEM         22     1.3713420      0.0244436      1.3312399      1.4240345
STIB         22     1.1397914      0.0239312      1.0909897      1.1698775
SFIB         22     1.1265278      0.0225767      1.0838252      1.1627260
PRIN1        22    -0.0065523      0.0245839     -0.0443405      0.0428817
PRIN2        22     0.0123407      0.0339184     -0.0649037      0.0572407
PRIN3        22  -0.000815233      0.0195798     -0.0339831      0.0423765
PRIN4        22     0.0068092      0.0163083     -0.0136099      0.0644092
PRIN5        22    -0.0052035      0.0110251     -0.0409644      0.0103795
PRIN6        22  -0.000073725    0.000221019   -0.000399333    0.000308011
--------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                         Decade of Birth = 1960

Variable     N           Mean        Std Dev        Minimum        Maximum
---------------------------------------------------------------------------
YOB         18        1963.83      3.0146700        1960.00        1969.00
MAXHT       10    177.0000000      9.4280904    155.0000000    189.0000000
HUM         15    332.2666667     13.8691161    312.0000000    358.0000000
RAD         14    252.5714286     12.7744594    236.0000000    282.0000000
ULNA        15    269.4666667     12.5406007    254.0000000    302.0000000
FEM         16    475.7500000     25.3732142    438.0000000    547.0000000
TIB         15    394.4666667     22.4940204    365.0000000    442.0000000
FIB         14    390.5000000     24.4878306    365.0000000    445.0000000
SIZE        12    345.2893018     17.3969733    327.3304150    377.5300036
SHUM        12      0.9714621      0.0304469      0.9237976      1.0230243
SRAD        12      0.7366976      0.0127818      0.7217839      0.7589745
SULNA       12      0.7870365      0.0166683      0.7534142      0.8107921
SFEM        12      1.3814222      0.0327203      1.3296956      1.4562458
STIB        12      1.1410000      0.0223233      1.1127355      1.1728222
SFIB        12      1.1280487      0.0276655      1.0937901      1.1846972
PRIN1       12      0.0058524      0.0328032     -0.0505147      0.0727948
PRIN2       12      0.0138782      0.0417598     -0.0339971      0.0835198
PRIN3       12   -0.000576864      0.0207454     -0.0397745      0.0335651
PRIN4       12      0.0071378      0.0180712     -0.0255391      0.0424510
PRIN5       12     -0.0035746      0.0111925     -0.0217994      0.0088205
PRIN6       12    0.000118770    0.000634669   -0.000479336      0.0020354
---------------------------------------------------------------------------
```

Appendix 3. (continued)

```
                              Decade of Birth = 1970

Variable       N          Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB            6       1971.00       1.5491933         1970.00         1973.00
MAXHT          5   181.6000000      12.3612297     165.0000000     198.0000000
HUM            6   341.8333333      18.4977476     322.0000000     371.0000000
RAD            5   259.2000000      13.7731623     248.0000000     283.0000000
ULNA           5   277.8000000      13.9892816     265.0000000     299.0000000
FEM            6   486.1666667      28.0529262     455.0000000     520.0000000
TIB            5   403.6000000      22.1088218     375.0000000     431.0000000
FIB            3   392.3333333      29.1947484     374.0000000     426.0000000
SIZE           3   351.2638582      24.7806134     332.4639922     379.3454019
SHUM           3     0.9763446       0.0071363       0.9685259       0.9825073
SRAD           3     0.7468481       0.0014977       0.7459454       0.7485770
SULNA          3     0.7954967       0.0066484       0.7881999       0.8012113
SFEM           3     1.3627464       0.0058877       1.3567958       1.3685693
STIB           3     1.1328905       0.0043603       1.1279417       1.1361677
SFIB           3     1.1167725       0.0124879       1.1023966       1.1249339
PRIN1          3    -0.0151509       0.0055777      -0.0215427      -0.0112700
PRIN2          3    -0.0028226       0.0097616      -0.0140916       0.0030248
PRIN3          3     0.0020602       0.0068332      -0.0054040       0.0080074
PRIN4          3     0.0039780       0.0107603      -0.0074747       0.0138771
PRIN5          3    -0.0052505       0.0042567      -0.0096105      -0.0011052
PRIN6          3  -0.000469021     0.000037395    -0.000495662    -0.000426271
-------------------------------------------------------------------------------
```

Appendix 4. Summary statistics for black males by decade of birth.

```
                         Decade of Birth = 1750

Variable     N          Mean       Std Dev       Minimum       Maximum
----------------------------------------------------------------------
YOB          3       1755.67     2.8867513       1754.00       1759.00
MAXHT        0             .             .             .             .
HUM          2   352.0000000    21.2132034   337.0000000   367.0000000
RAD          2   283.5000000     0.7071068   283.0000000   284.0000000
ULNA         3   304.0000000     1.0000000   303.0000000   305.0000000
FEM          1   510.0000000             .   510.0000000   510.0000000
TIB          1   417.0000000             .   417.0000000   417.0000000
FIB          0             .             .             .             .
SIZE         0             .             .             .             .
SHUM         0             .             .             .             .
SRAD         0             .             .             .             .
SULNA        0             .             .             .             .
SFEM         0             .             .             .             .
STIB         0             .             .             .             .
SFIB         0             .             .             .             .
PRIN1        0             .             .             .             .
PRIN2        0             .             .             .             .
PRIN3        0             .             .             .             .
PRIN4        0             .             .             .             .
PRIN5        0             .             .             .             .
PRIN6        0             .             .             .             .
----------------------------------------------------------------------
```

Appendix 4. (continued)

```
                          Decade of Birth = 1760

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           1       1769.00              .        1769.00        1769.00
MAXHT         0             .              .              .              .
HUM           1   366.0000000              .    366.0000000    366.0000000
RAD           1   290.0000000              .    290.0000000    290.0000000
ULNA          0             .              .              .              .
FEM           1   514.0000000              .    514.0000000    514.0000000
TIB           1   441.0000000              .    441.0000000    441.0000000
FIB           1   416.0000000              .    416.0000000    416.0000000
SIZE          0             .              .              .              .
SHUM          0             .              .              .              .
SRAD          0             .              .              .              .
SULNA         0             .              .              .              .
SFEM          0             .              .              .              .
STIB          0             .              .              .              .
SFIB          0             .              .              .              .
PRIN1         0             .              .              .              .
PRIN2         0             .              .              .              .
PRIN3         0             .              .              .              .
PRIN4         0             .              .              .              .
PRIN5         0             .              .              .              .
PRIN6         0             .              .              .              .
--------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                              Decade of Birth = 1770

Variable       N           Mean          Std Dev          Minimum          Maximum
-----------------------------------------------------------------------------------
YOB            1        1774.00                .          1774.00          1774.00
MAXHT          0              .                .                .                .
HUM            1    333.0000000                .      333.0000000      333.0000000
RAD            1    260.0000000                .      260.0000000      260.0000000
ULNA           1    277.0000000                .      277.0000000      277.0000000
FEM            1    446.0000000                .      446.0000000      446.0000000
TIB            1    384.0000000                .      384.0000000      384.0000000
FIB            1    372.0000000                .      372.0000000      372.0000000
SIZE           1    339.3785545                .      339.3785545      339.3785545
SHUM           1      0.9812052                .        0.9812052        0.9812052
SRAD           1      0.7661062                .        0.7661062        0.7661062
SULNA          1      0.8161977                .        0.8161977        0.8161977
SFEM           1      1.3141667                .        1.3141667        1.3141667
STIB           1      1.1314799                .        1.1314799        1.1314799
SFIB           1      1.0961211                .        1.0961211        1.0961211
PRIN1          1     -0.0684951                .       -0.0684951       -0.0684951
PRIN2          1     -0.0241458                .       -0.0241458       -0.0241458
PRIN3          1      0.0124401                .        0.0124401        0.0124401
PRIN4          1     -0.0101983                .       -0.0101983       -0.0101983
PRIN5          1     -0.0038617                .       -0.0038617       -0.0038617
PRIN6          1    0.000279391                .      0.000279391      0.000279391
-----------------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                     Decade of Birth = 1790

Variable     N           Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          1        1794.00              .        1794.00        1794.00
MAXHT        0              .              .              .              .
HUM          1    303.0000000              .    303.0000000    303.0000000
RAD          1    241.0000000              .    241.0000000    241.0000000
ULNA         1    260.0000000              .    260.0000000    260.0000000
FEM          1    434.0000000              .    434.0000000    434.0000000
TIB          1    354.0000000              .    354.0000000    354.0000000
FIB          1    352.0000000              .    352.0000000    352.0000000
SIZE         1    317.6226360              .    317.6226360    317.6226360
SHUM         1      0.9539622              .      0.9539622      0.9539622
SRAD         1      0.7587620              .      0.7587620      0.7587620
SULNA        1      0.8185815              .      0.8185815      0.8185815
SFEM         1      1.3664014              .      1.3664014      1.3664014
STIB         1      1.1145301              .      1.1145301      1.1145301
SFIB         1      1.1082334              .      1.1082334      1.1082334
PRIN1        1     -0.0316930              .     -0.0316930     -0.0316930
PRIN2        1     -0.0124127              .     -0.0124127     -0.0124127
PRIN3        1     -0.0317150              .     -0.0317150     -0.0317150
PRIN4        1      0.0124293              .      0.0124293      0.0124293
PRIN5        1   -0.000640342              .   -0.000640342   -0.000640342
PRIN6        1   -0.000085012              .   -0.000085012   -0.000085012
--------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1820

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB           1       1829.00              .        1829.00        1829.00
MAXHT         0             .              .              .              .
HUM           0             .              .              .              .
RAD           0             .              .              .              .
ULNA          0             .              .              .              .
FEM           1   447.0000000              .    447.0000000    447.0000000
TIB           1   357.0000000              .    357.0000000    357.0000000
FIB           0             .              .              .              .
SIZE          0             .              .              .              .
SHUM          0             .              .              .              .
SRAD          0             .              .              .              .
SULNA         0             .              .              .              .
SFEM          0             .              .              .              .
STIB          0             .              .              .              .
SFIB          0             .              .              .              .
PRIN1         0             .              .              .              .
PRIN2         0             .              .              .              .
PRIN3         0             .              .              .              .
PRIN4         0             .              .              .              .
PRIN5         0             .              .              .              .
PRIN6         0             .              .              .              .
--------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1840

Variable      N          Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB           4       1845.25       3.8622101         1841.00         1849.00
MAXHT         4   168.7307500       5.3605669     163.4053900     176.0907900
HUM           4   331.7500000      10.5948101     318.0000000     343.0000000
RAD           4   258.2500000       6.8980674     251.0000000     267.0000000
ULNA          4   280.2500000       9.2870878     271.0000000     292.0000000
FEM           4   457.0000000      22.0151463     439.0000000     488.0000000
TIB           4   387.0000000      13.6381817     372.0000000     405.0000000
FIB           4   379.5000000      14.3874946     365.0000000     398.0000000
SIZE          4   342.3779855      11.3248660     330.5329942     356.7236348
SHUM          4     0.9691717       0.0221974       0.9419056       0.9932169
SRAD          4     0.7544016       0.0047713       0.7484786       0.7593796
SULNA         4     0.8185400       0.0016338       0.8162349       0.8198879
SFEM          4     1.3344056       0.0277876       1.3030077       1.3680058
STIB          4     1.1303481       0.0155260       1.1119396       1.1486651
SFIB          4     1.1082935       0.0054442       1.1041432       1.1157096
PRIN1         4    -0.0518758       0.0183949      -0.0744802      -0.0297395
PRIN2         4    -0.0104339       0.0191323      -0.0342127       0.0123010
PRIN3         4  -0.000678128       0.0265790      -0.0315224       0.0251238
PRIN4         4     0.0014500       0.0119352      -0.0149323       0.0133788
PRIN5         4     0.0047595       0.0027669       0.0015912       0.0082982
PRIN6         4   0.000095741     0.000198424    -0.000091063     0.000325099
-------------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                          Decade of Birth = 1850

Variable      N           Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
YOB          14        1855.64       3.3191088         1850.00         1859.00
MAXHT        12    169.0782050       7.4395894     157.2771900     183.6454900
HUM          13    333.1538462      15.8105774     311.0000000     376.0000000
RAD          14    252.9285714      13.8312038     235.0000000     286.0000000
ULNA         14    269.9285714      15.2187348     250.0000000     304.0000000
FEM          14    458.5714286      27.9799771     414.0000000     521.0000000
TIB          12    383.3333333      21.2360471     359.0000000     435.0000000
FIB          12    375.4166667      22.3014811     345.0000000     425.0000000
SIZE         12    339.3752852      18.1026674     318.6945576     382.8458073
SHUM         12      0.9805353       0.0158408       0.9522829       1.0119358
SRAD         12      0.7471317       0.0112911       0.7228113       0.7641150
SULNA        12      0.8037652       0.0128018       0.7781755       0.8221038
SFEM         12      1.3605377       0.0299974       1.3086834       1.3947249
STIB         12      1.1295009       0.0147057       1.1054699       1.1572370
SFIB         12      1.1059318       0.0147092       1.0767817       1.1277908
PRIN1        12     -0.0194614       0.0297551      -0.0672920       0.0317041
PRIN2        12     -0.0144595       0.0181969      -0.0490844       0.0203395
PRIN3        12   -0.000270071       0.0237424      -0.0325943       0.0258647
PRIN4        12   -0.000997751       0.0078074      -0.0150559       0.0142703
PRIN5        12    0.000717086       0.0057938      -0.0092307       0.0110256
PRIN6        12   -0.000153231     0.000229802    -0.000491040     0.000232688
-------------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                              Decade of Birth = 1860

Variable       N            Mean          Std Dev          Minimum          Maximum
-----------------------------------------------------------------------------------
YOB           43         1866.07        2.1424880          1861.00          1868.00
MAXHT         43     170.5291895        6.7539134      154.9634900      189.7528100
HUM           43     337.7906977       19.0107215      291.0000000      384.0000000
RAD           43     263.2093023       17.3322685      228.0000000      320.0000000
ULNA          43     281.4418605       15.6270558      246.0000000      328.0000000
FEM           43     473.6744186       25.5237713      418.0000000      546.0000000
TIB           43     400.0232558       22.4653049      357.0000000      462.0000000
FIB           43     387.6976744       22.1687628      343.0000000      444.0000000
SIZE          43     349.9282246       18.7975466      306.8906051      399.0095567
SHUM          43       0.9654371        0.0232280        0.9300691        1.0210391
SRAD          43       0.7519155        0.0185498        0.7221259        0.8250341
SULNA         43       0.8043925        0.0171502        0.7657348        0.8521303
SFEM          43       1.3538684        0.0265296        1.2781955        1.4077471
STIB          43       1.1431194        0.0152018        1.1167364        1.1768513
SFIB          43       1.1078529        0.0167015        1.0726167        1.1394430
PRIN1         43      -0.0306860        0.0331578       -0.1353754        0.0248127
PRIN2         43       0.0021377        0.0240287       -0.0464038        0.0404768
PRIN3         43      -0.0051408        0.0199365       -0.0395977        0.0453848
PRIN4         43      -0.0084256        0.0095593       -0.0291045        0.0099163
PRIN5         43      -0.0013955        0.0150152       -0.0820991        0.0166713
PRIN6         43     0.000069777      0.000704697     -0.000500805        0.0029002
-----------------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                          Decade of Birth = 1870

Variable     N           Mean        Std Dev        Minimum        Maximum
----------------------------------------------------------------------------
YOB         68        1873.62      1.9318958        1870.00        1877.00
MAXHT       67    170.8061676      7.9064846    152.2509100    187.2926100
HUM         68    338.6029412     20.0812824    295.0000000    386.0000000
RAD         67    263.1791045     16.7927883    226.0000000    308.0000000
ULNA        67    282.2238806     17.9273119    243.0000000    334.0000000
FEM         68    476.3088235     29.6966038    413.0000000    549.0000000
TIB         68    399.9264706     24.3716964    341.0000000    450.0000000
FIB         68    390.1029412     24.5315147    326.0000000    441.0000000
SIZE        67    350.7918774     20.8961067    303.6663745    400.4596705
SHUM        67      0.9652052      0.0214865      0.9062079      1.0292813
SRAD        67      0.7501504      0.0125361      0.7272228      0.7765258
SULNA       67      0.8044963      0.0156250      0.7759249      0.8527133
SFEM        67      1.3569435      0.0273798      1.2922562      1.4219573
STIB        67      1.1397128      0.0194367      1.1004231      1.1765344
SFIB        67      1.1112034      0.0165938      1.0712689      1.1441215
PRIN1       67     -0.0276137      0.0301875     -0.1060716      0.0360581
PRIN2       67      0.0022317      0.0280348     -0.0519011      0.0754341
PRIN3       67     -0.0062890      0.0205136     -0.0565138      0.0429133
PRIN4       67     -0.0035021      0.0098899     -0.0256559      0.0186917
PRIN5       67   -0.000724015      0.0070520     -0.0186055      0.0139260
PRIN6       67   -0.000020644    0.000411577   -0.000467935      0.0019687
----------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                              Decade of Birth = 1880

Variable     N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB         72       1885.04      2.4289191        1881.00        1889.00
MAXHT       72   170.5564464      7.6175703    152.6895100    186.7766900
HUM         72   337.1805556     19.4170873    282.0000000    391.0000000
RAD         72   262.0277778     14.6296749    221.0000000    296.0000000
ULNA        72   280.0277778     14.5737292    244.0000000    315.0000000
FEM         72   473.9166667     26.9578440    398.0000000    536.0000000
TIB         72   399.8750000     25.4585759    342.0000000    462.0000000
FIB         72   388.3611111     23.4240189    330.0000000    444.0000000
SIZE        72   349.3647554     18.7590110    300.8419665    397.0886027
SHUM        72     0.9651383      0.0210231      0.9151443      1.0198532
SRAD        72     0.7501138      0.0169028      0.7190693      0.8054755
SULNA       72     0.8018246      0.0187983      0.7619321      0.8539982
SFEM        72     1.3565972      0.0302357      1.2799336      1.4279425
STIB        72     1.1441719      0.0238694      1.0702893      1.1931213
SFIB        72     1.1113818      0.0205472      1.0451912      1.1522000
PRIN1       72    -0.0268228      0.0346787     -0.1112668      0.0518688
PRIN2       72     0.0055624      0.0335057     -0.1035966      0.0681313
PRIN3       72    -0.0042740      0.0218812     -0.0561568      0.0504987
PRIN4       72    -0.0066369      0.0114985     -0.0432650      0.0171326
PRIN5       72    -0.0019709      0.0071087     -0.0214653      0.0158297
PRIN6       72   0.000112269    0.000637107   -0.000485807      0.0036748
--------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                          Decade of Birth = 1890

Variable      N           Mean        Std Dev        Minimum        Maximum
---------------------------------------------------------------------------
YOB          73        1896.03      2.5329638        1890.00        1899.00
MAXHT        73    170.7519166      8.1159938    155.5000000    200.5000000
HUM          73    337.3150685     16.7189818    303.0000000    384.0000000
RAD          73    262.9178082     14.2221984    231.0000000    312.0000000
ULNA         73    280.8767123     15.4262990    254.0000000    331.0000000
FEM          73    473.9726027     27.7428532    424.0000000    559.0000000
TIB          73    399.1095890     23.9203317    359.0000000    470.0000000
FIB          73    388.9452055     23.4146739    341.0000000    465.0000000
SIZE         73    349.7629471     18.5629303    315.3891424    411.3511715
SHUM         73      0.9647873      0.0209570      0.9200840      1.0213273
SRAD         73      0.7517662      0.0127883      0.7172541      0.7848749
SULNA        73      0.8031462      0.0170532      0.7519599      0.8371999
SFEM         73      1.3550068      0.0279935      1.2951808      1.4202081
STIB         73      1.1408030      0.0182410      1.1034952      1.1944594
SFIB         73      1.1117414      0.0184341      1.0446739      1.1568614
PRIN1        73     -0.0293035      0.0323251     -0.0978693      0.0412945
PRIN2        73      0.0033980      0.0272666     -0.0825379      0.0692566
PRIN3        73     -0.0052101      0.0199070     -0.0407180      0.0394796
PRIN4        73     -0.0041287      0.0109199     -0.0319059      0.0268960
PRIN5        73     -0.0027399      0.0067526     -0.0156366      0.0131068
PRIN6        73   6.3050658E-6    0.000481609   -0.000510502      0.0015376
---------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1900

Variable     N          Mean        Std Dev        Minimum        Maximum
-----------------------------------------------------------------------------
YOB         83       1903.99      2.8176014        1900.00        1909.00
MAXHT       76   173.6590807     19.6804295    157.5000000    332.0000000
HUM         83   336.3012048     18.2621393    303.0000000    404.0000000
RAD         81   262.6049383     15.1448663    231.0000000    314.0000000
ULNA        81   281.1358025     15.6042887    248.0000000    334.0000000
FEM         81   472.6543210     26.5575604    416.0000000    550.0000000
TIB         82   399.2682927     25.0012586    345.0000000    469.0000000
FIB         80   388.2125000     23.8920005    336.0000000    456.0000000
SIZE        78   349.2216052     19.3404930    307.9964002    413.2945158
SHUM        78     0.9638592      0.0204626      0.9100721      1.0032585
SRAD        78     0.7513012      0.0144901      0.7175156      0.7925604
SULNA       78     0.8045744      0.0167628      0.7642016      0.8597740
SFEM        78     1.3533159      0.0292234      1.2779704      1.4185596
STIB        78     1.1422332      0.0191709      1.0845250      1.1947201
SFIB        78     1.1115673      0.0175018      1.0687181      1.1481370
PRIN1       78    -0.0313146      0.0332220     -0.1338951      0.0399932
PRIN2       78     0.0044821      0.0276727     -0.0625389      0.0817104
PRIN3       78    -0.0050590      0.0205764     -0.0704904      0.0423396
PRIN4       78    -0.0049790      0.0095705     -0.0352039      0.0164340
PRIN5       78    -0.0012959      0.0072600     -0.0261971      0.0127248
PRIN6       78   0.000046139    0.000584315   -0.000508005      0.0031192
-----------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1910

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          76       1913.93      2.9679871        1910.00        1919.00
MAXHT        68   173.8076799      7.9119854    149.6521900    197.5000000
HUM          76   340.9342105     19.0887999    281.0000000    390.0000000
RAD          76   268.1973684     16.2045424    216.0000000    308.0000000
ULNA         75   287.9200000     16.3250429    232.0000000    329.0000000
FEM          76   485.7894737     27.7052658    400.0000000    537.0000000
TIB          75   410.7733333     27.2250746    331.0000000    473.0000000
FIB          71   401.9154930     26.1647235    325.0000000    462.0000000
SIZE         70   359.2026022     20.0530111    290.8952080    402.7120788
SHUM         70     0.9518086      0.0237061      0.8964221      1.0083943
SRAD         70     0.7492368      0.0142723      0.7135801      0.7763293
SULNA        70     0.8036191      0.0148302      0.7694286      0.8377180
SFEM         70     1.3589762      0.0308558      1.2581085      1.4315258
STIB         70     1.1481189      0.0215919      1.1083499      1.1942898
SFIB         70     1.1197365      0.0191746      1.0841262      1.1623418
PRIN1        70    -0.0286175      0.0315351     -0.1237036      0.0250016
PRIN2        70     0.0194210      0.0310524     -0.0433724      0.0846977
PRIN3        70    -0.0118283      0.0244864     -0.0861049      0.0462572
PRIN4        70    -0.0022845      0.0107288     -0.0356955      0.0201421
PRIN5        70  -0.000781108      0.0098931     -0.0189109      0.0366033
PRIN6        70   0.000152862    0.000530696   -0.000508803      0.0018525
--------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1920

Variable      N          Mean        Std Dev        Minimum        Maximum
--------------------------------------------------------------------------
YOB          49       1922.96      2.2634706        1920.00        1929.00
MAXHT        40   173.5684825      6.9548240    161.9250000    193.5012100
HUM          48   341.6666667     15.4882706    311.0000000    391.0000000
RAD          47   266.4468085     13.6808475    231.0000000    304.0000000
ULNA         44   285.0000000     14.7663981    258.0000000    322.0000000
FEM          47   483.3617021     21.8904640    441.0000000    533.0000000
TIB          48   409.0833333     25.5998947    359.0000000    475.0000000
FIB          44   399.6136364     24.3360350    355.0000000    465.0000000
SIZE         37   355.3070653     16.7757568    319.9611538    387.5949602
SHUM         37     0.9577532      0.0239106      0.9175692      0.9981625
SRAD         37     0.7507596      0.0140253      0.7219626      0.7792922
SULNA        37     0.8030078      0.0192483      0.7571015      0.8459232
SFEM         37     1.3566338      0.0297212      1.2775757      1.4211258
STIB         37     1.1453949      0.0231215      1.0930210      1.1952905
SFIB         37     1.1161126      0.0223070      1.0729447      1.1680043
PRIN1        37    -0.0293215      0.0342686     -0.1299616      0.0251455
PRIN2        37     0.0124970      0.0352374     -0.0548732      0.0892237
PRIN3        37    -0.0083552      0.0199741     -0.0560383      0.0373016
PRIN4        37    -0.0036011      0.0126124     -0.0362366      0.0185177
PRIN5        37    -0.0021364      0.0089501     -0.0228919      0.0231086
PRIN6        37   0.000161905    0.000573059   -0.000523235      0.0025367
--------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1930

Variable     N          Mean       Std Dev       Minimum       Maximum
----------------------------------------------------------------------
YOB         11       1935.36     2.6934263       1930.00       1939.00
MAXHT        5   178.6564020    11.2754632   159.5012100   188.0000000
HUM         10   353.3000000    15.7413115   329.0000000   370.0000000
RAD          9   274.1111111    13.8964424   255.0000000   295.0000000
ULNA         9   292.3333333    10.4880885   276.0000000   309.0000000
FEM         11   495.7272727    25.8576523   453.0000000   524.0000000
TIB         11   417.1818182    18.6000978   384.0000000   446.0000000
FIB         11   407.4545455    16.6934936   377.0000000   427.0000000
SIZE         9   365.4297176    14.7958631   343.4107188   385.8899993
SHUM         9     0.9620047     0.0159953     0.9406826     0.9837742
SRAD         9     0.7499482     0.0157955     0.7148340     0.7648945
SULNA        9     0.8003479     0.0212187     0.7737027     0.8386459
SFEM         9     1.3640649     0.0268111     1.3191202     1.4016354
STIB         9     1.1410804     0.0162024     1.1181946     1.1633573
SFIB         9     1.1137506     0.0155800     1.0978108     1.1465377
PRIN1        9    -0.0209417     0.0341033    -0.0724714     0.0344814
PRIN2        9     0.0069567     0.0233941    -0.0293651     0.0454534
PRIN3        9    -0.0096985     0.0161058    -0.0364064     0.0059974
PRIN4        9    -0.0028047     0.0092031    -0.0182646     0.0115365
PRIN5        9    -0.0034827     0.0111860    -0.0157140     0.0157457
PRIN6        9  -0.000074170   0.000352281  -0.000529074   0.000620292
----------------------------------------------------------------------
```

Appendix 4. (continued)

```
                          Decade of Birth = 1940

Variable      N          Mean         Std Dev         Minimum         Maximum
------------------------------------------------------------------------------
YOB          11       1945.55       2.3817488         1942.00         1949.00
MAXHT         8   172.8146288       7.2894189     163.0900900     185.0000000
HUM          10   341.1000000      14.4794874     318.0000000     363.0000000
RAD          10   268.5000000       8.6184556     258.0000000     286.0000000
ULNA          6   285.5000000      13.2325357     265.0000000     302.0000000
FEM          11   481.4545455      22.0152839     444.0000000     520.0000000
TIB          10   404.5000000      16.9394346     385.0000000     429.0000000
FIB           8   398.5000000      19.3095091     370.0000000     420.0000000
SIZE          5   354.1471127      18.8967599     335.0873759     378.4410637
SHUM          5     0.9593039       0.0109135       0.9467207       0.9766027
SRAD          5     0.7577615       0.0145718       0.7349779       0.7710712
SULNA         5     0.8032345       0.0146113       0.7896231       0.8189953
SFEM          5     1.3490753       0.0196282       1.3218364       1.3740581
STIB          5     1.1403942       0.0165988       1.1145091       1.1557459
SFIB          5     1.1138806       0.0175510       1.1015303       1.1448169
PRIN1         5    -0.0376322       0.0244029      -0.0740064      -0.0148626
PRIN2         5     0.0063003       0.0228378      -0.0257365       0.0381809
PRIN3         5    -0.0070767       0.0112677      -0.0200486       0.0099963
PRIN4         5    -0.0026333       0.0131451      -0.0166498       0.0104032
PRIN5         5    -0.0074757       0.0098401      -0.0232025       0.0016752
PRIN6         5  -0.000081156     0.000324658    -0.000440975     0.000435850
------------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                          Decade of Birth = 1950

Variable      N          Mean        Std Dev        Minimum        Maximum
---------------------------------------------------------------------------
YOB           4       1958.25      0.9574271        1957.00        1959.00
MAXHT         2   168.0000000      2.8284271    166.0000000    170.0000000
HUM           4   338.0000000     34.0293991    305.0000000    378.0000000
RAD           4   259.2500000     18.0254450    240.0000000    277.0000000
ULNA          4   278.7500000     17.4618632    260.0000000    296.0000000
FEM           4   478.7500000     33.1800643    445.0000000    512.0000000
TIB           4   394.0000000     23.1948270    373.0000000    422.0000000
FIB           4   380.5000000     23.2737334    361.0000000    409.0000000
SIZE          4   347.1729074     23.5049721    326.6457860    368.7672713
SHUM          4     0.9722472      0.0420156      0.9337332      1.0320804
SRAD          4     0.7467316      0.0109160      0.7338820      0.7592322
SULNA         4     0.8031780      0.0121083      0.7945381      0.8204606
SFEM          4     1.3789875      0.0198907      1.3612922      1.3979502
STIB          4     1.1355348      0.0221410      1.1030701      1.1528064
SFIB          4     1.0965142      0.0211739      1.0648449      1.1091006
PRIN1         4    -0.0066252      0.0321712     -0.0412560      0.0285285
PRIN2         4    -0.0110729      0.0445350     -0.0777286      0.0133393
PRIN3         4    -0.0160129      0.0176410     -0.0389397      0.0035649
PRIN4         4    -0.0114442      0.0045115     -0.0160407     -0.0070289
PRIN5         4     0.0019251      0.0038822     -0.0021088      0.0067700
PRIN6         4   0.000026328    0.000544896   -0.000410291    0.000742782
---------------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1960

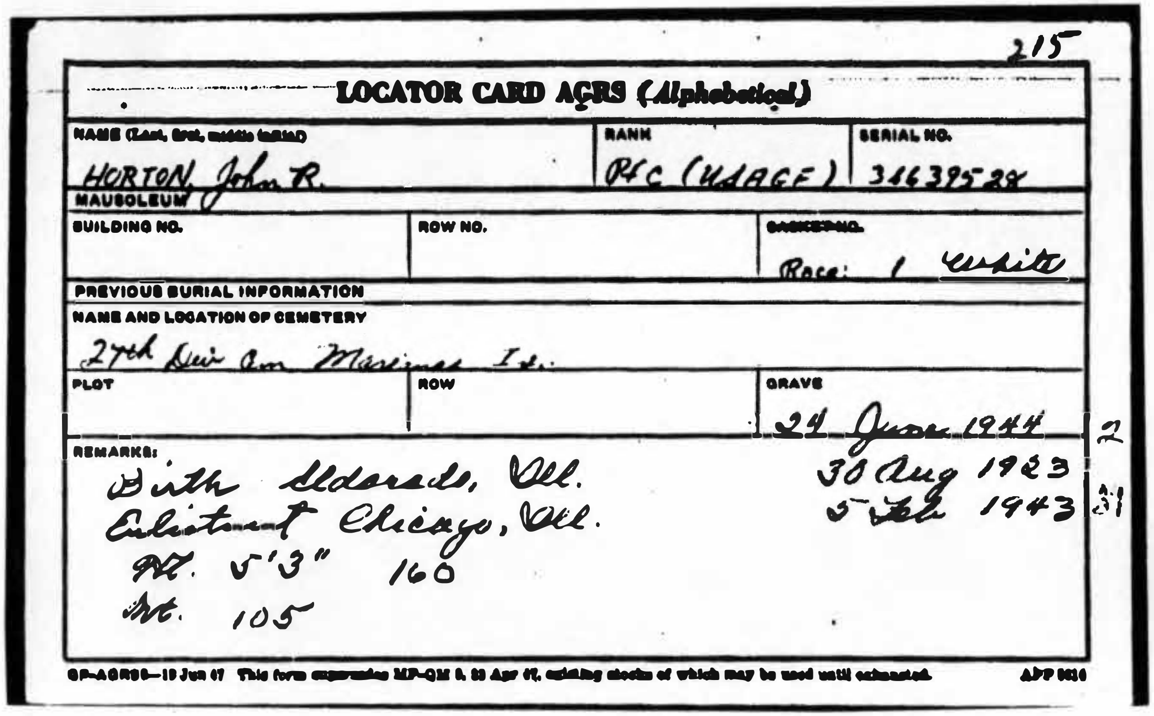
Variable     N          Mean       Std Dev       Minimum       Maximum
----------------------------------------------------------------------
YOB          7       1961.71     2.1380899       1960.00       1966.00
MAXHT        5   178.8000000     8.4083292   168.0000000   191.0000000
HUM          7   347.2857143    17.9324128   327.0000000   382.0000000
RAD          7   268.0000000    15.6737573   250.0000000   299.0000000
ULNA         7   285.0000000    15.4919334   270.0000000   316.0000000
FEM          7   489.8571429    21.8283346   469.0000000   537.0000000
TIB          7   418.8571429    28.0620062   398.0000000   479.0000000
FIB          6   407.0000000    32.9241553   381.0000000   466.0000000
SIZE         6   361.7111297    22.5697877   341.0518214   403.6635714
SHUM         6     0.9624048     0.0102411     0.9463326     0.9737279
SRAD         6     0.7441555     0.0069141     0.7330264     0.7533139
SULNA        6     0.7908418     0.0053746     0.7828301     0.7963963
SFEM         6     1.3571202     0.0277250     1.3303157     1.3932510
STIB         6     1.1578421     0.0167521     1.1456899     1.1866317
SFIB         6     1.1242395     0.0236867     1.0950449     1.1544267
PRIN1        6    -0.0203439     0.0225084    -0.0412329     0.0078780
PRIN2        6     0.0250841     0.0254779    -0.0024181     0.0691781
PRIN3        6     0.0050162     0.0190454    -0.0213335     0.0251949
PRIN4        6    -0.0068907     0.0152230    -0.0221849     0.0208697
PRIN5        6    -0.0045282     0.0064486    -0.0113280     0.0061062
PRIN6        6  -0.000168000   0.000362384  -0.000450670   0.000511521
----------------------------------------------------------------------
```

Appendix 4. (continued)

```
                         Decade of Birth = 1970

Variable      N           Mean        Std Dev        Minimum        Maximum
-----------------------------------------------------------------------------
YOB           2        1970.50      0.7071068        1970.00        1971.00
MAXHT         1    337.0000000              .    337.0000000    337.0000000
HUM           2    350.0000000     18.3847763    337.0000000    363.0000000
RAD           2    277.0000000      1.4142136    276.0000000    278.0000000
ULNA          2    297.0000000      2.8284271    295.0000000    299.0000000
FEM           2    506.5000000      4.9497475    503.0000000    510.0000000
TIB           2    423.5000000      9.1923882    417.0000000    430.0000000
FIB           2    408.0000000      5.6568542    404.0000000    412.0000000
SIZE          2    368.8486035      4.2485189    365.8444470    371.8527601
SHUM          2      0.9486747      0.0389165      0.9211565      0.9761928
SRAD          2      0.7510134      0.0048163      0.7476077      0.7544190
SULNA         2      0.8052177      0.0016065      0.8040817      0.8063536
SFEM          2      1.3732059      0.0023976      1.3715106      1.3749013
STIB          2      1.1483873      0.0381493      1.1214116      1.1753629
SFIB          2      1.1061299      0.0025958      1.1042945      1.1079654
PRIN1         2     -0.0195785      0.0106737     -0.0271260     -0.0120311
PRIN2         2      0.0135508      0.0418451     -0.0160382      0.0431398
PRIN3         2     -0.0255687      0.0217360     -0.0409384     -0.0101991
PRIN4         2     -0.0121556      0.0258692     -0.0304479      0.0061367
PRIN5         2    0.000111674      0.0010858   -0.000656130    0.000879477
PRIN6         2   -0.000029046    0.000588397   -0.000445105    0.000387014
-----------------------------------------------------------------------------
```

Appendix 5. Figures.



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LOCATOR CARD AGRS (Alphabetical)

NAME (Last, first, middle initial): HORTON, John R.

RANK: Pfc (USAGF)

SERIAL NO.: 34639528

MAUSOLEUM

BUILDING NO.

ROW NO.

~~CASKET NO.~~ Race: 1 White

PREVIOUS BURIAL INFORMATION

NAME AND LOCATION OF CEMETERY: 27th Div Cem Marianas Is.

PLOT

ROW

GRAVE

24 June 1944 2

REMARKS:

Birth Eldorado, Ill. 30 Aug 1923

Enlistment Chicago, Ill. 5 Feb 1943 [illegible]

Ht. 5'3" 160

Wt. 105

Figure 3.1. Photocopy of a Locator card used by M. Trotter for World War II data collection.

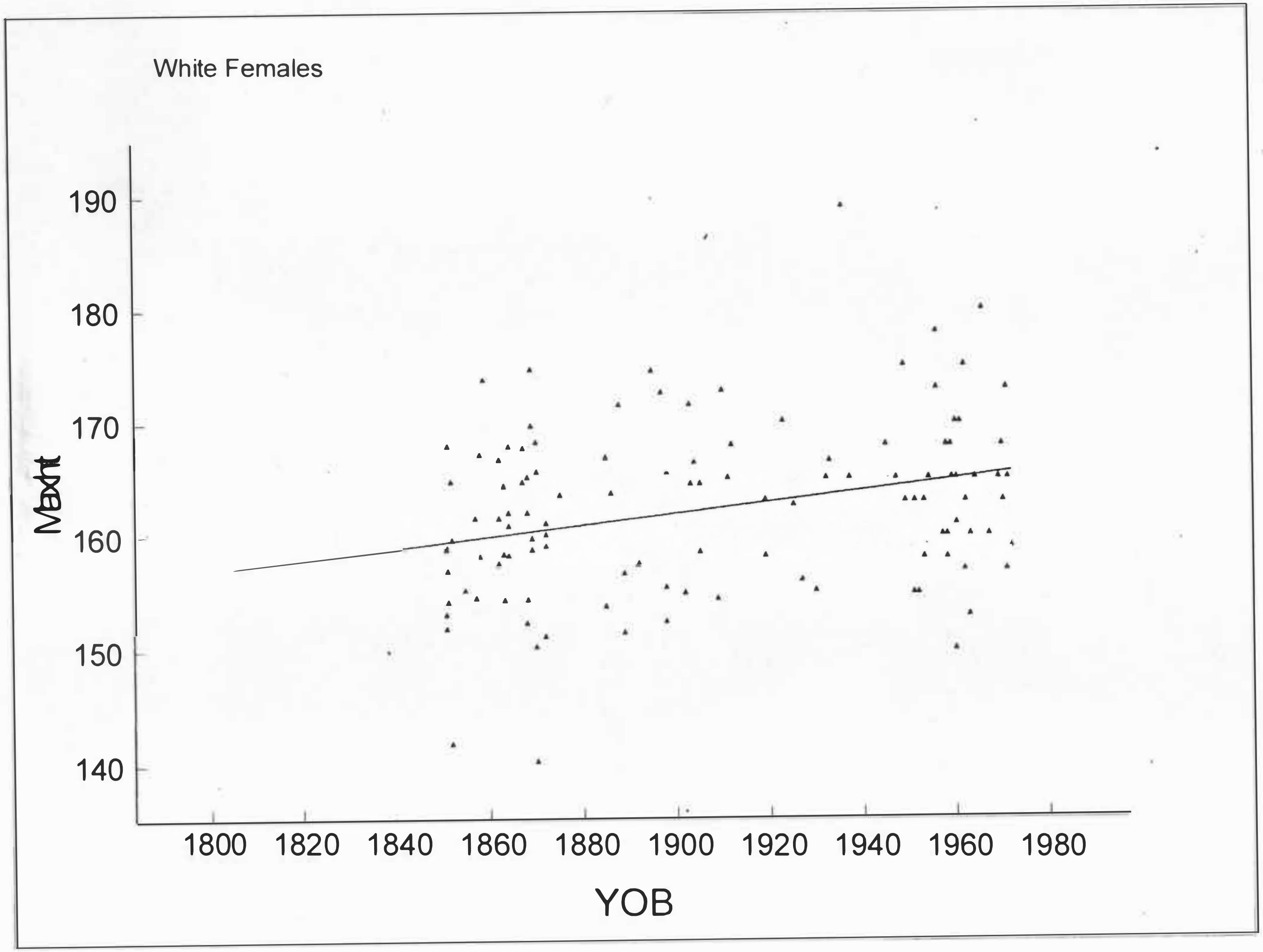

Figure 5.1. Plot of regression of maximum height (in cm) onto year of birth for white females.

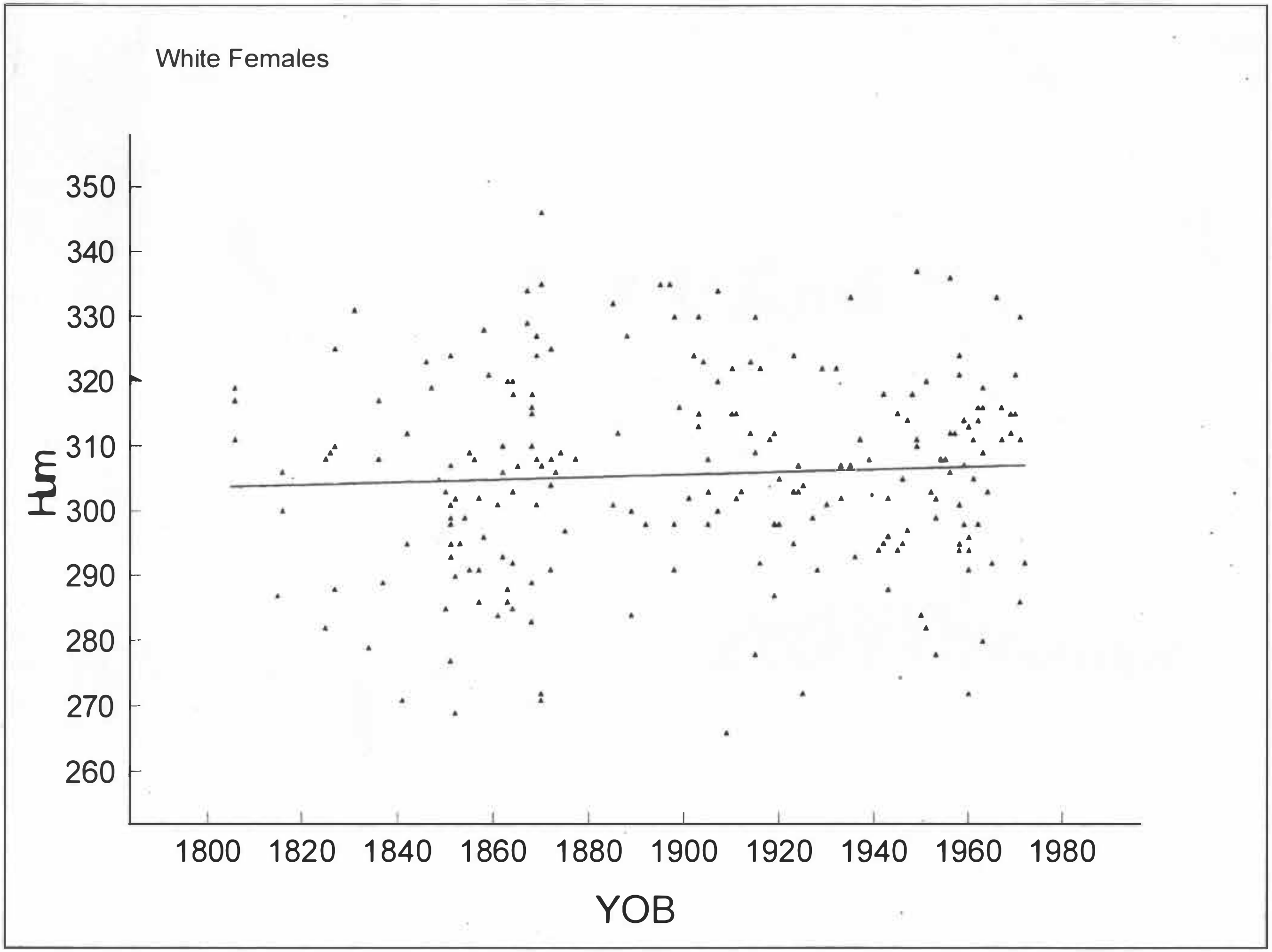

Figure 5.2. Plot of regression of humerus length (mm) onto year of birth for white females.

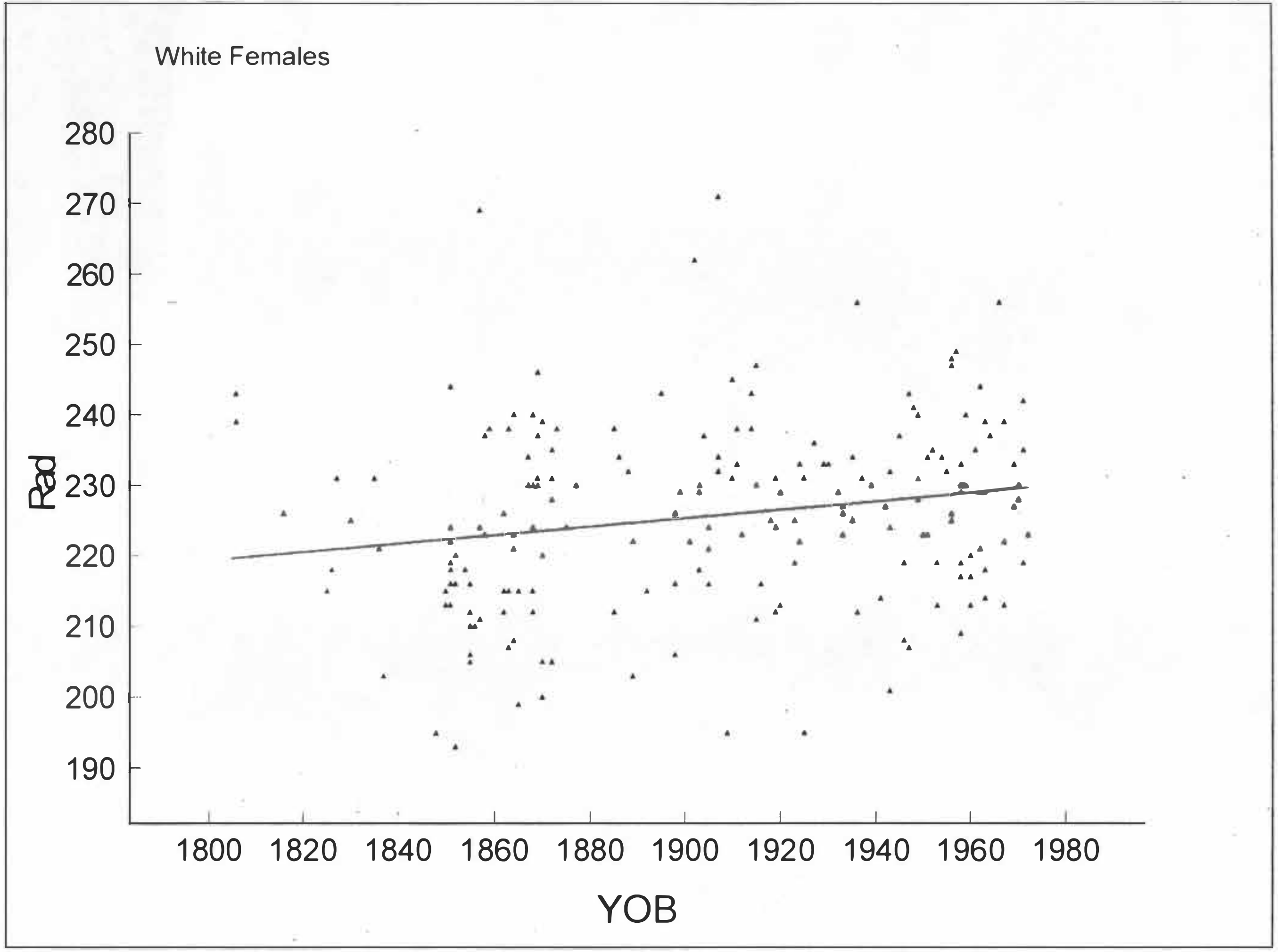

Figure 5.3. Plot of regression of radius length (mm) onto year of birth for white females.

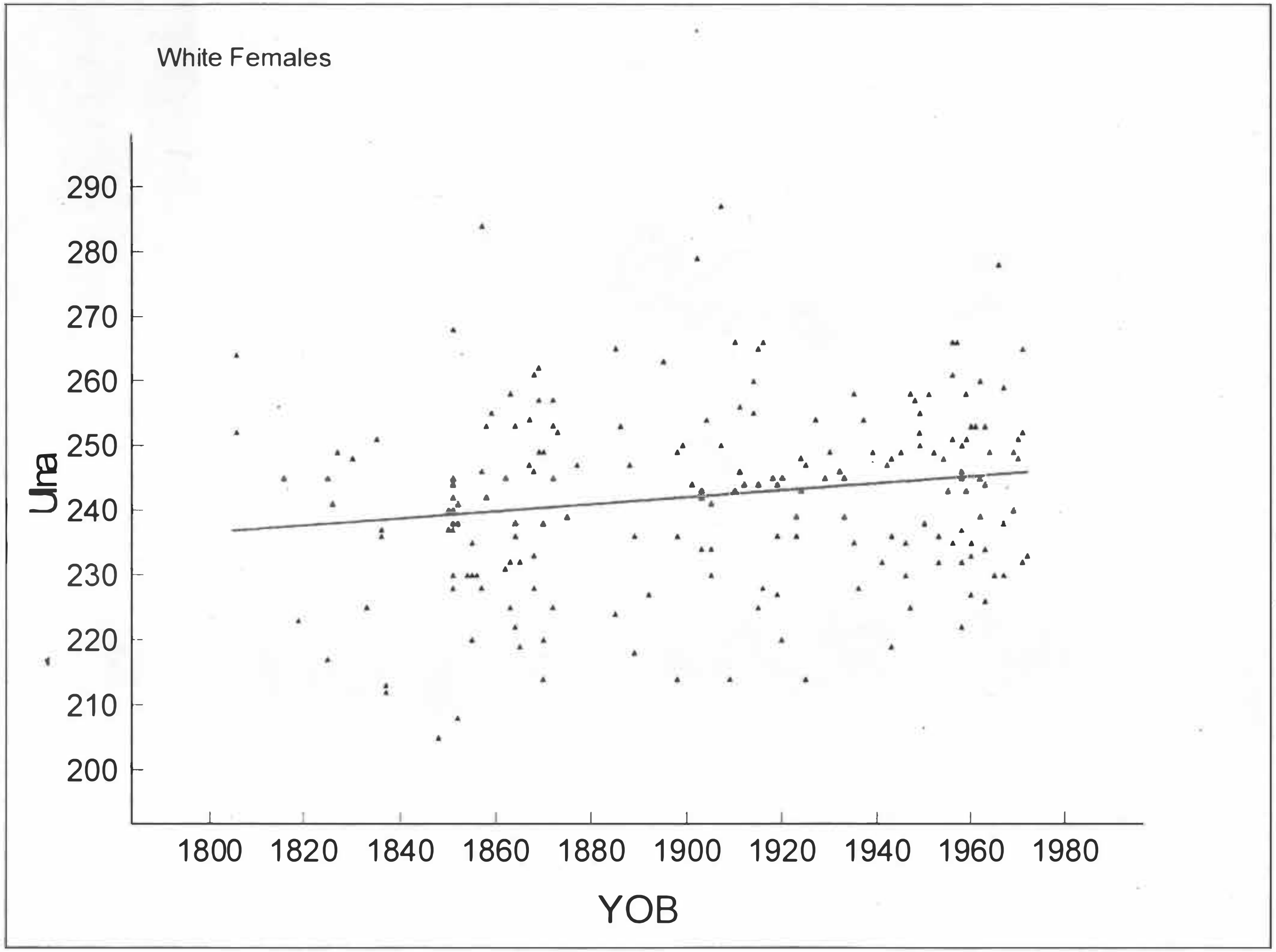

Figure 5.4. Plot of regression of ulna length (mm) onto year of birth for white females.

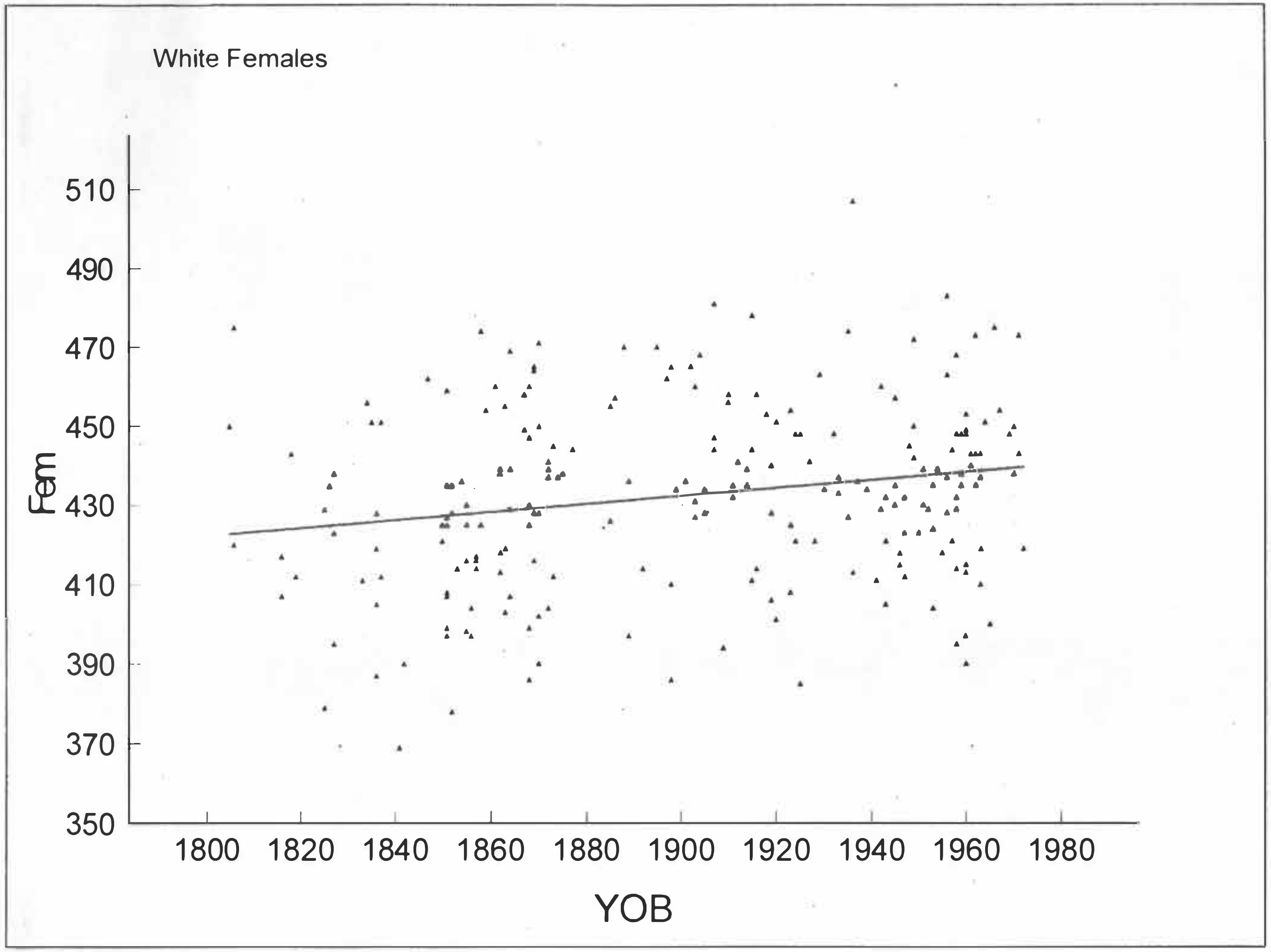

Figure 5.5. Plot of regression of femur length (mm) onto year of birth for white females.

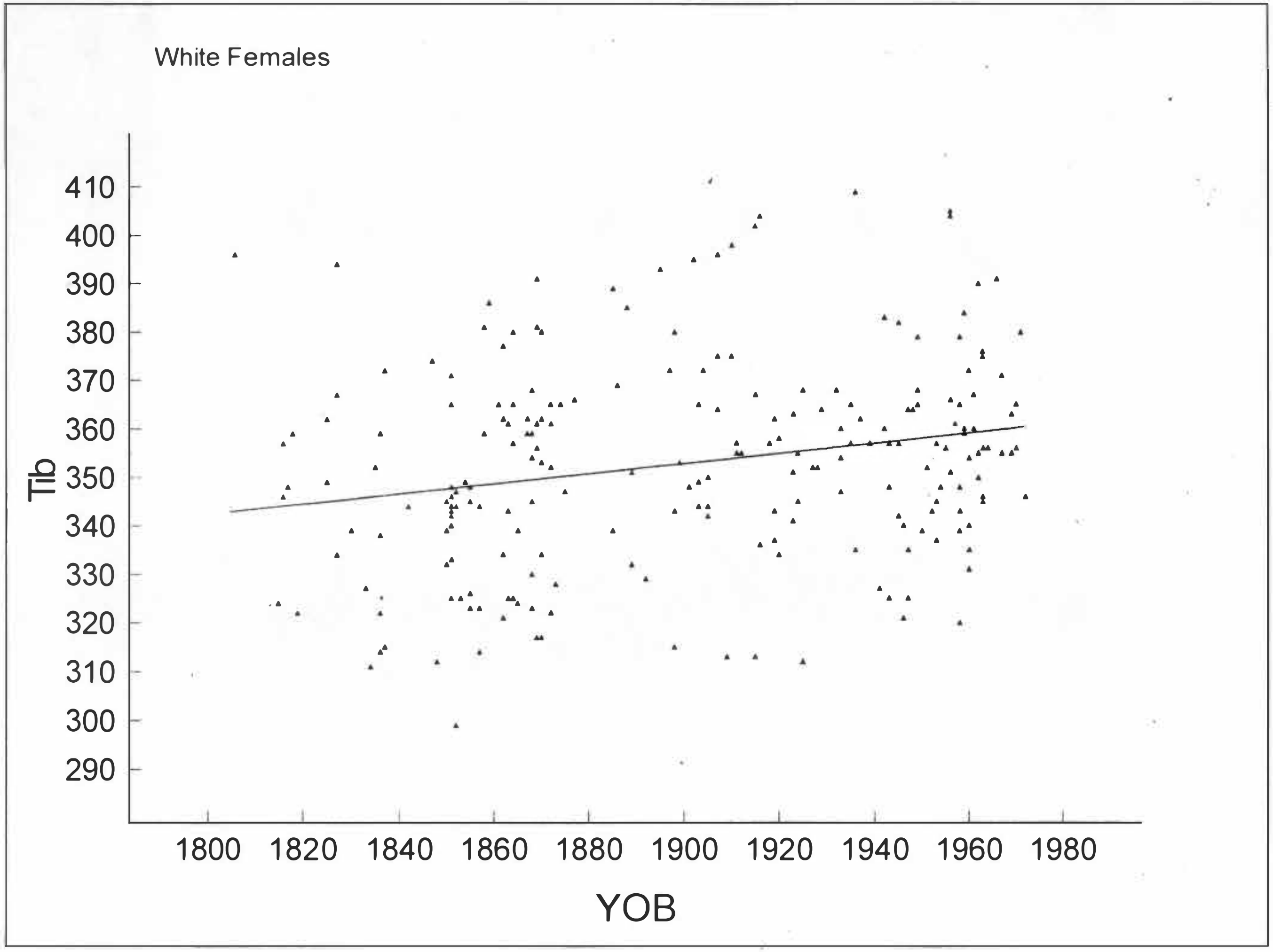

Figure 5.6. Plot of regression of tibia length (mm) onto year of birth for white females.

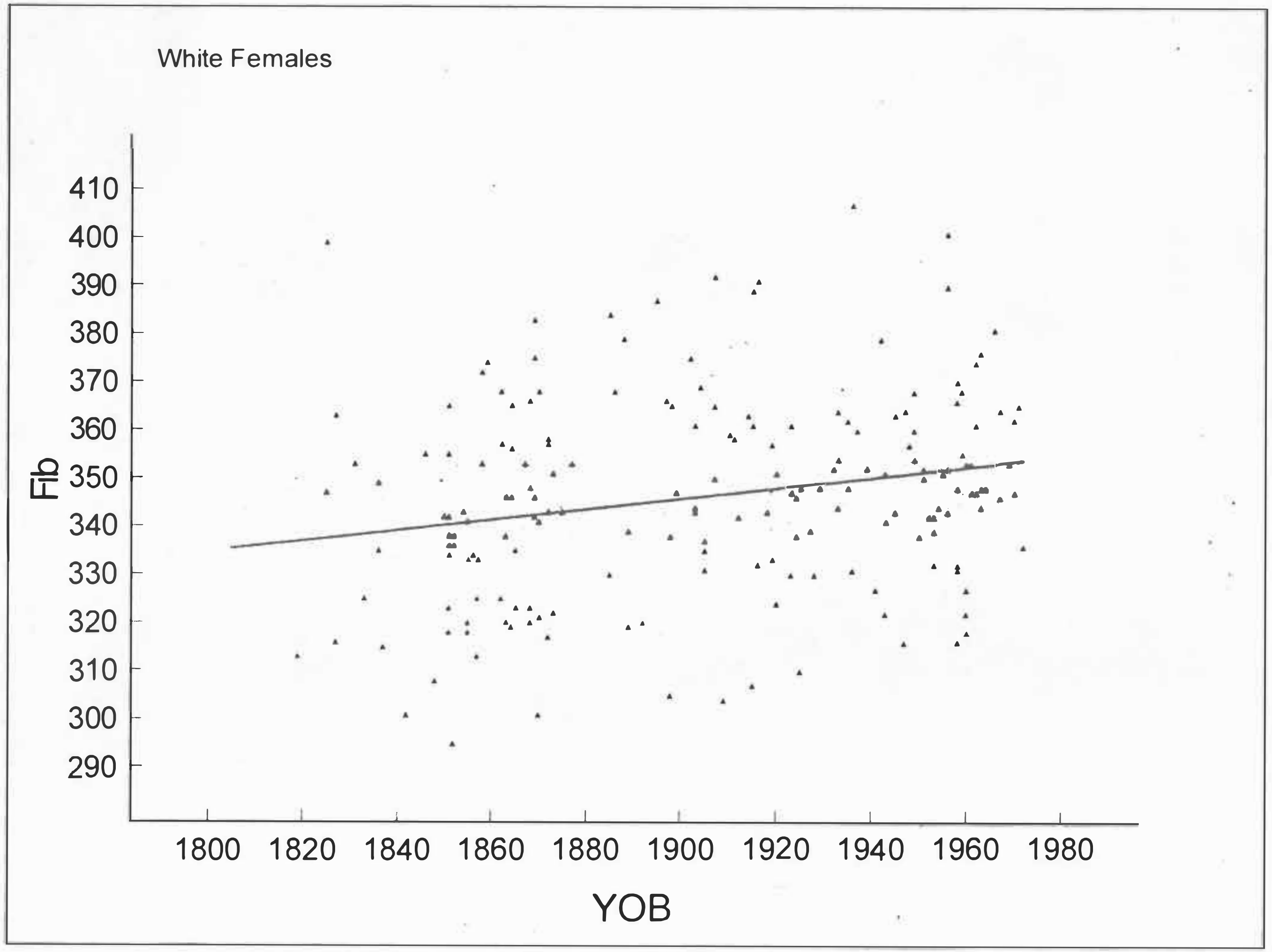

Figure 5.7. Plot of regression of fibula length (mm) onto year of birth for white females.

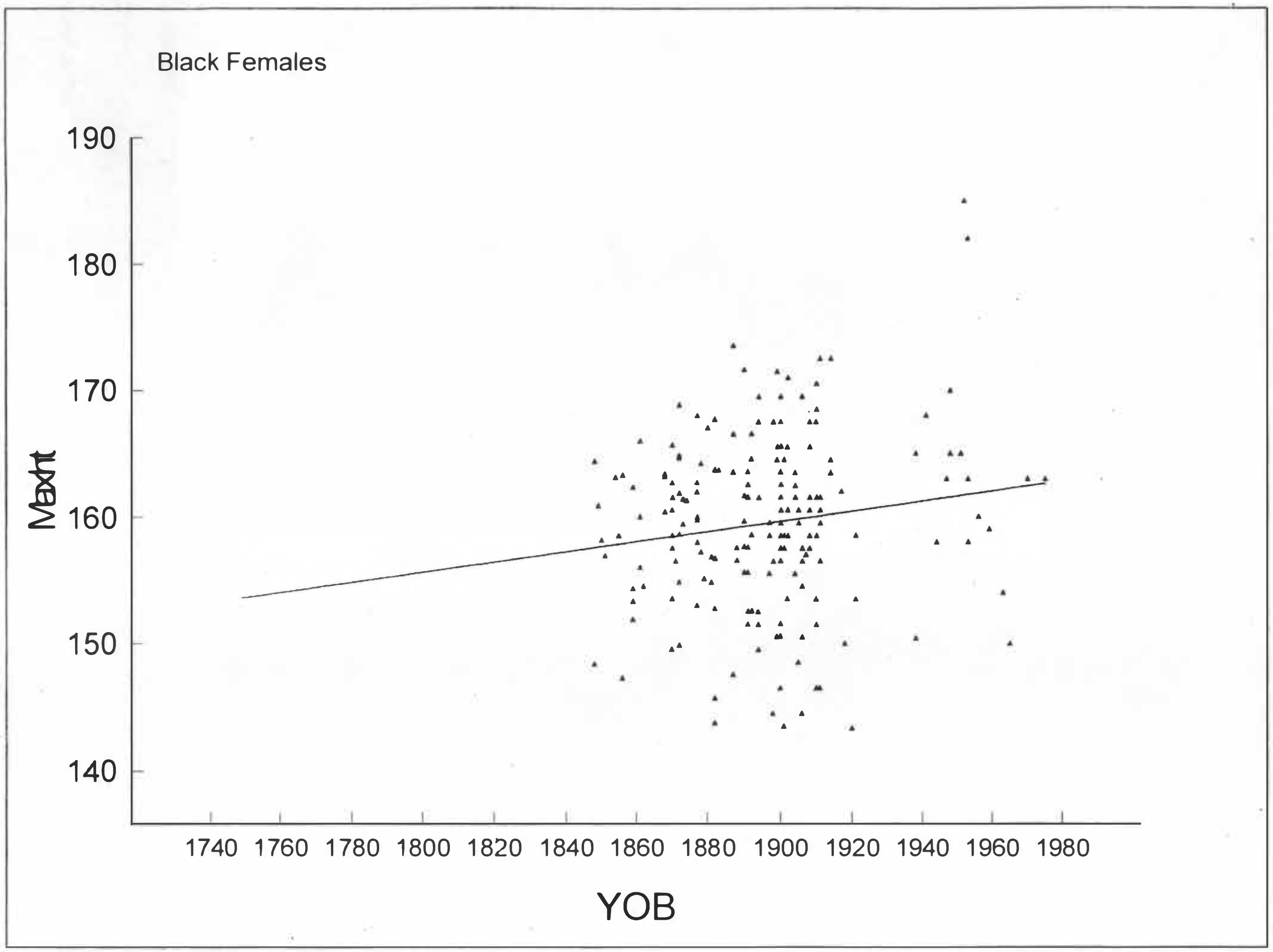

Figure 5.8. Plot of regression of maximum height (cm) onto year of birth for black females.

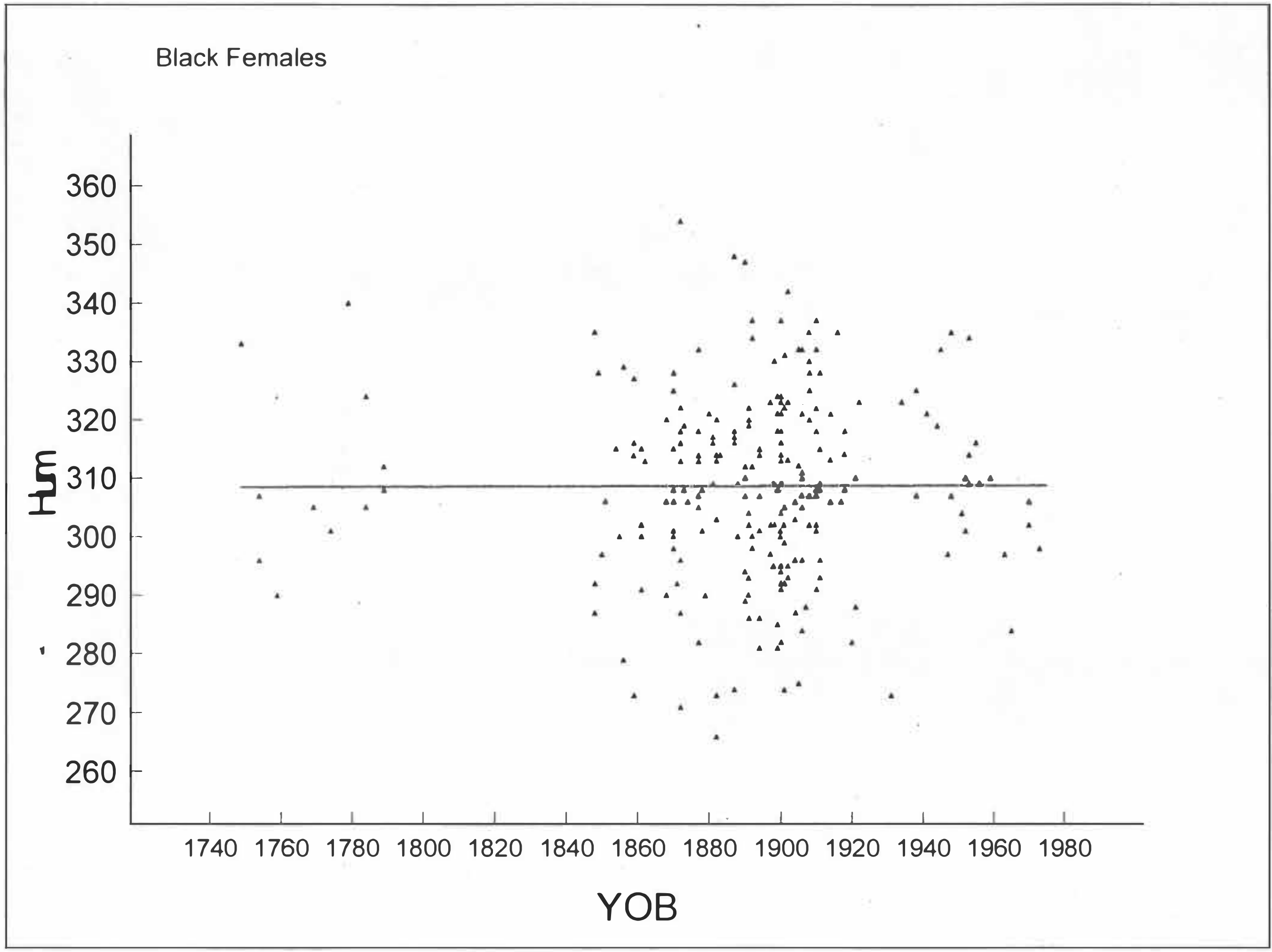

Figure 5.9. Plot of regression of humerus length (mm) onto year of birth for black females.

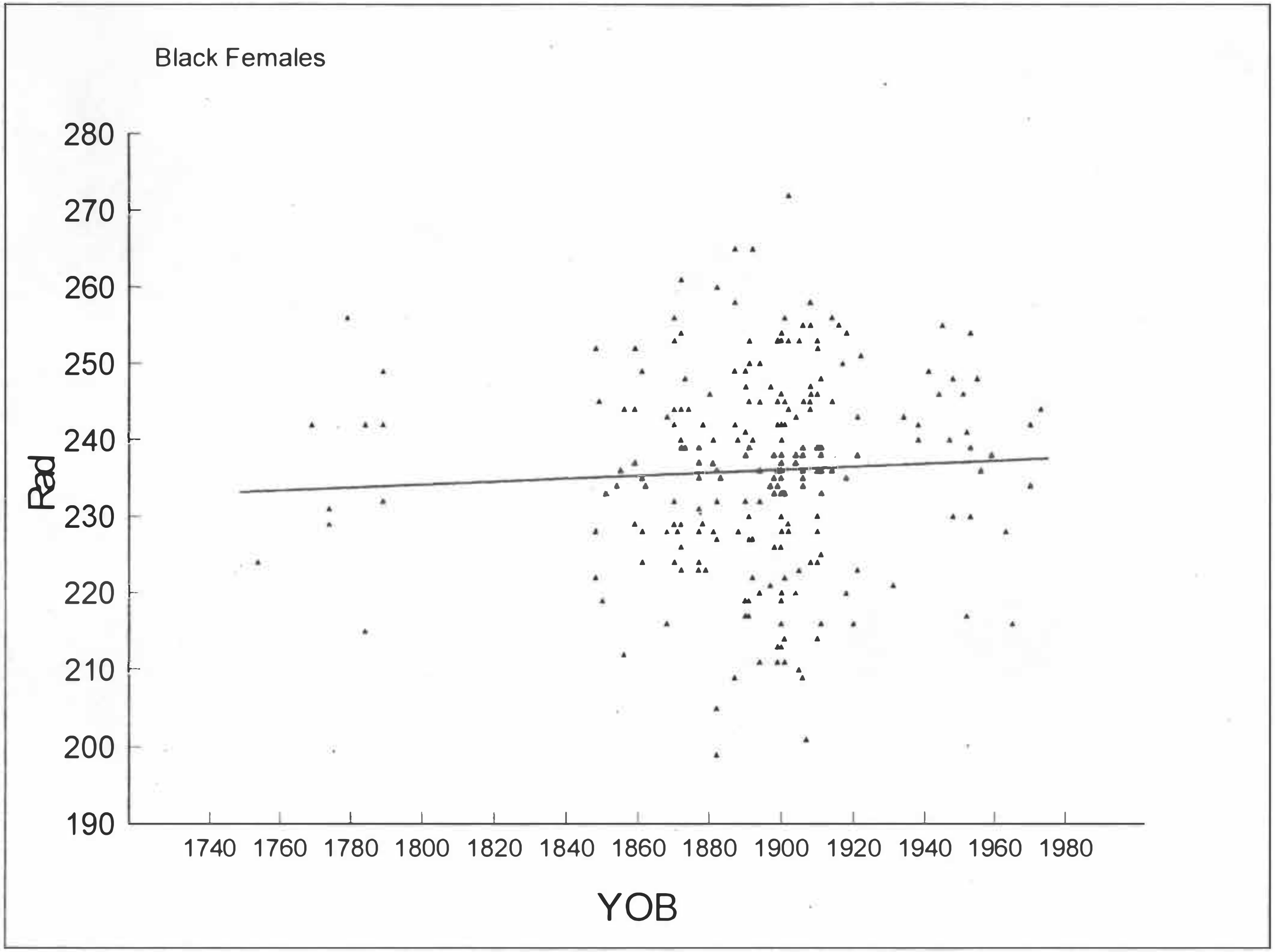

Figure 5.10. Plot of regression of radius length (mm) onto year of birth for black females.

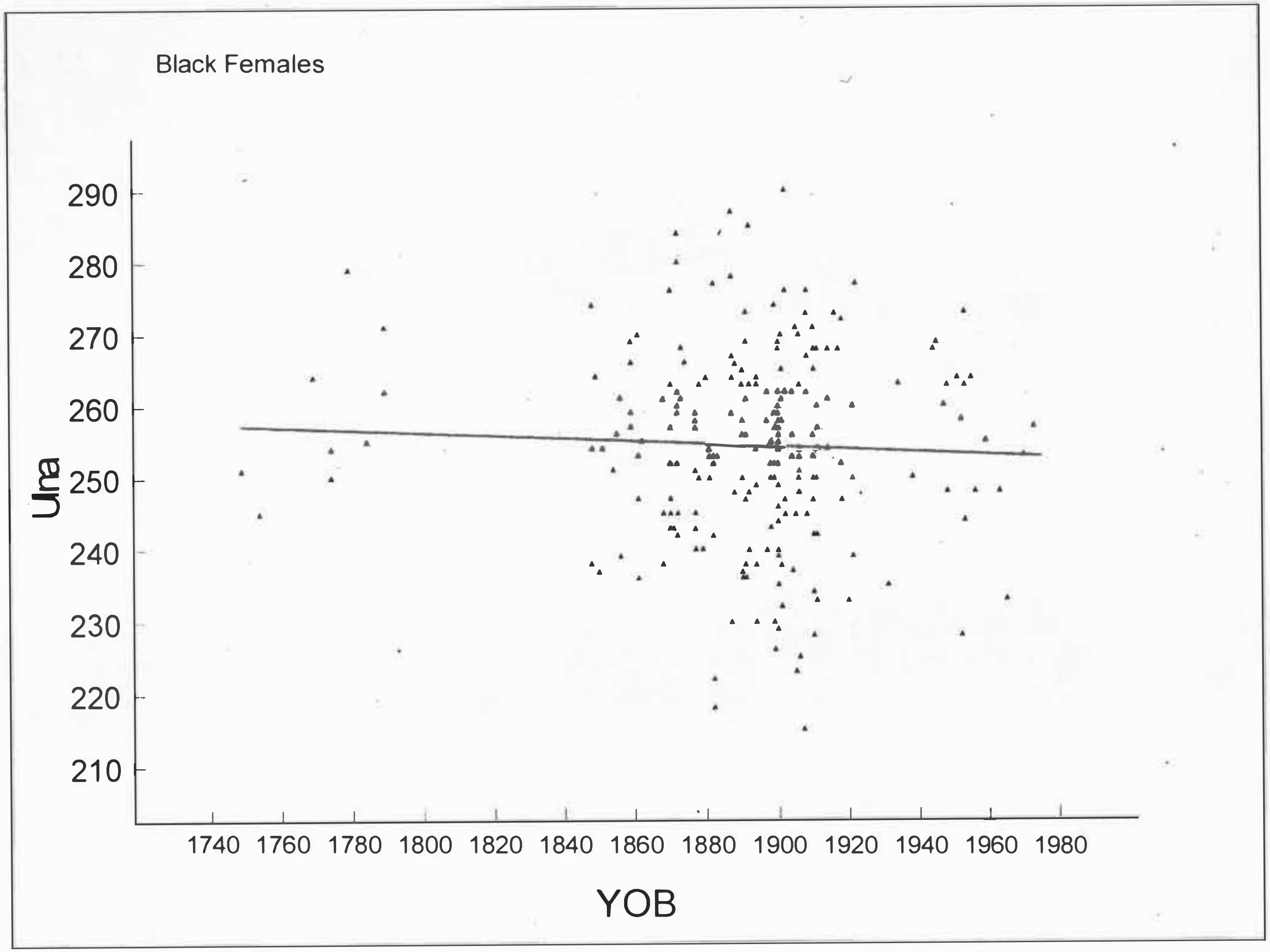

Figure 5.11. Plot of regression of ulna length (mm) onto year of birth for black females.

Figure 5.12. Plot of regression of femur length (mm) onto year of birth for black females.

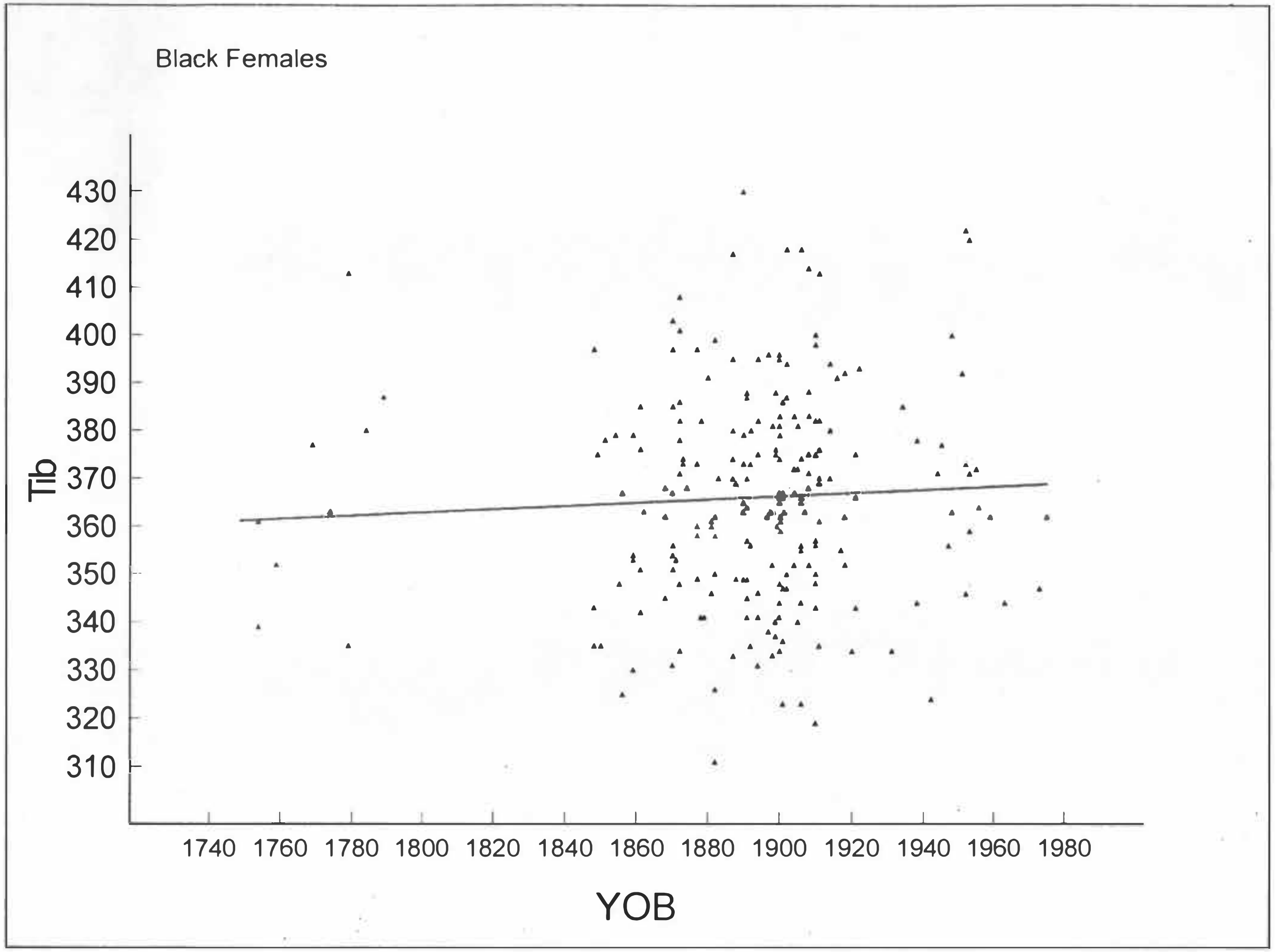

Figure 5.13. Plot of regression of tibia length (mm) onto year of birth for black females.

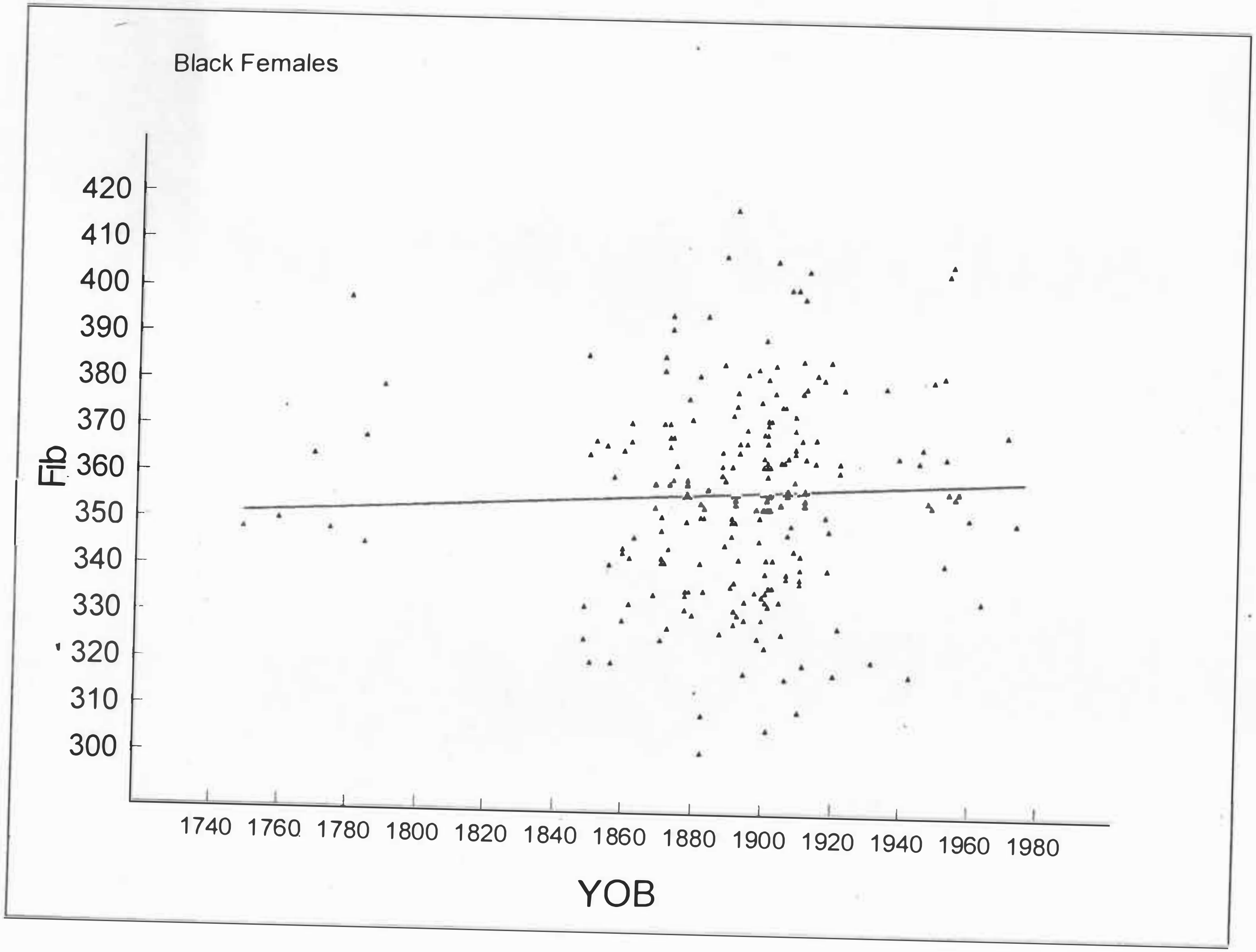

Figure 5.14. Plot of regression of fibula length (mm) onto year of birth for black females.

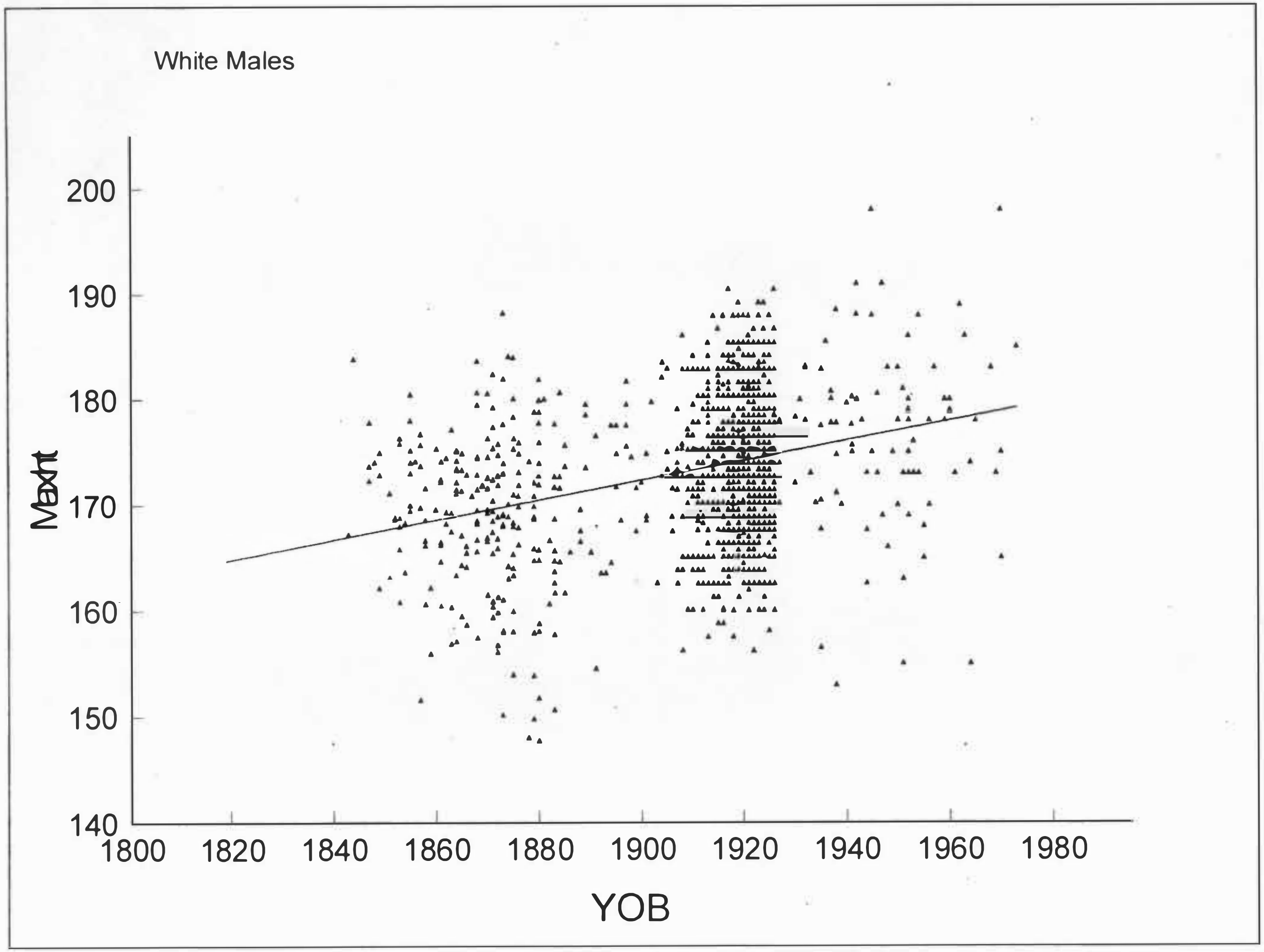

Figure 5.15. Plot of regression of maximum height (in cm) onto year of birth for white males.

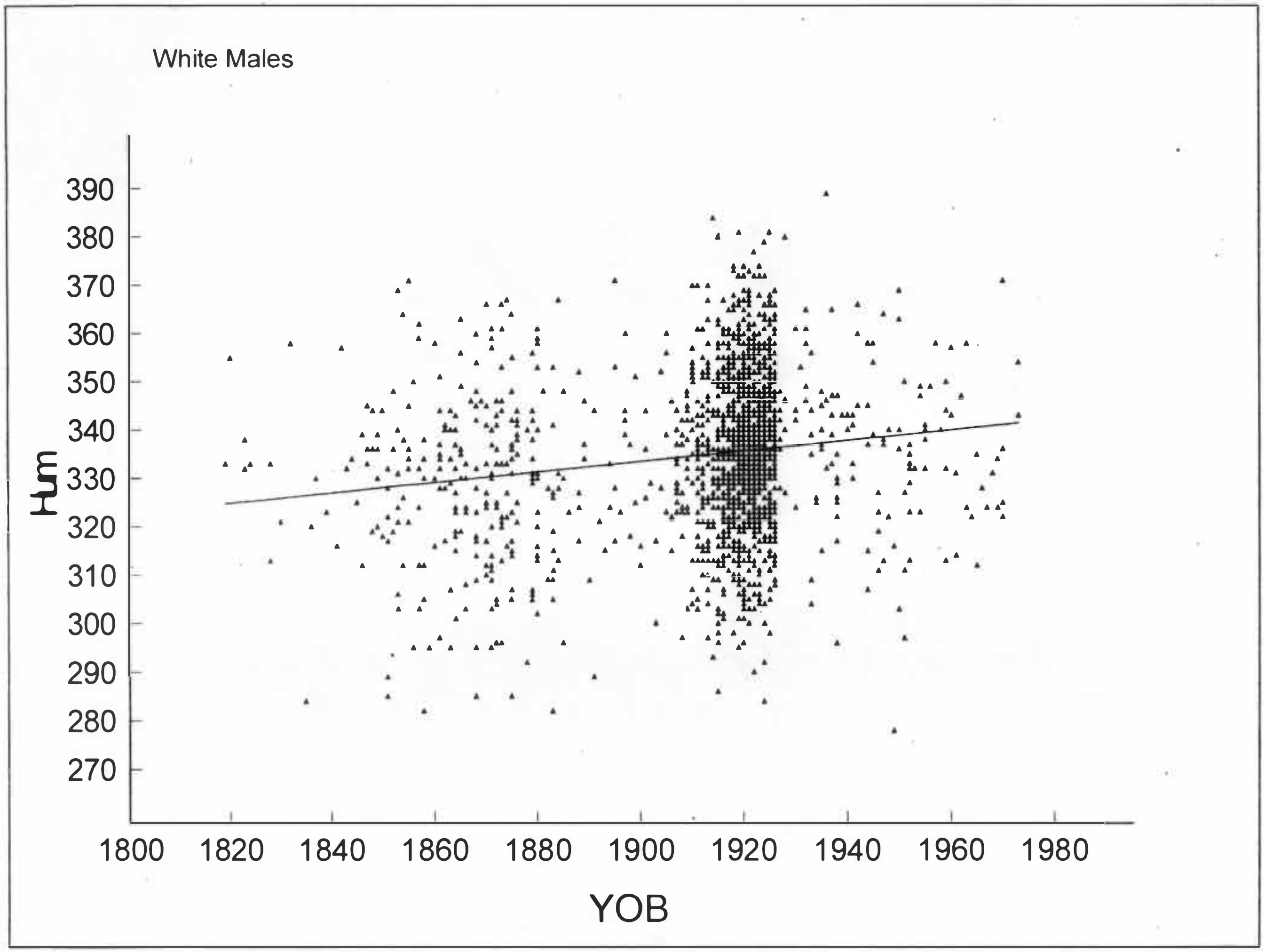

Figure 5.16. Plot of regression of humerus length (mm) onto year of birth for white males.

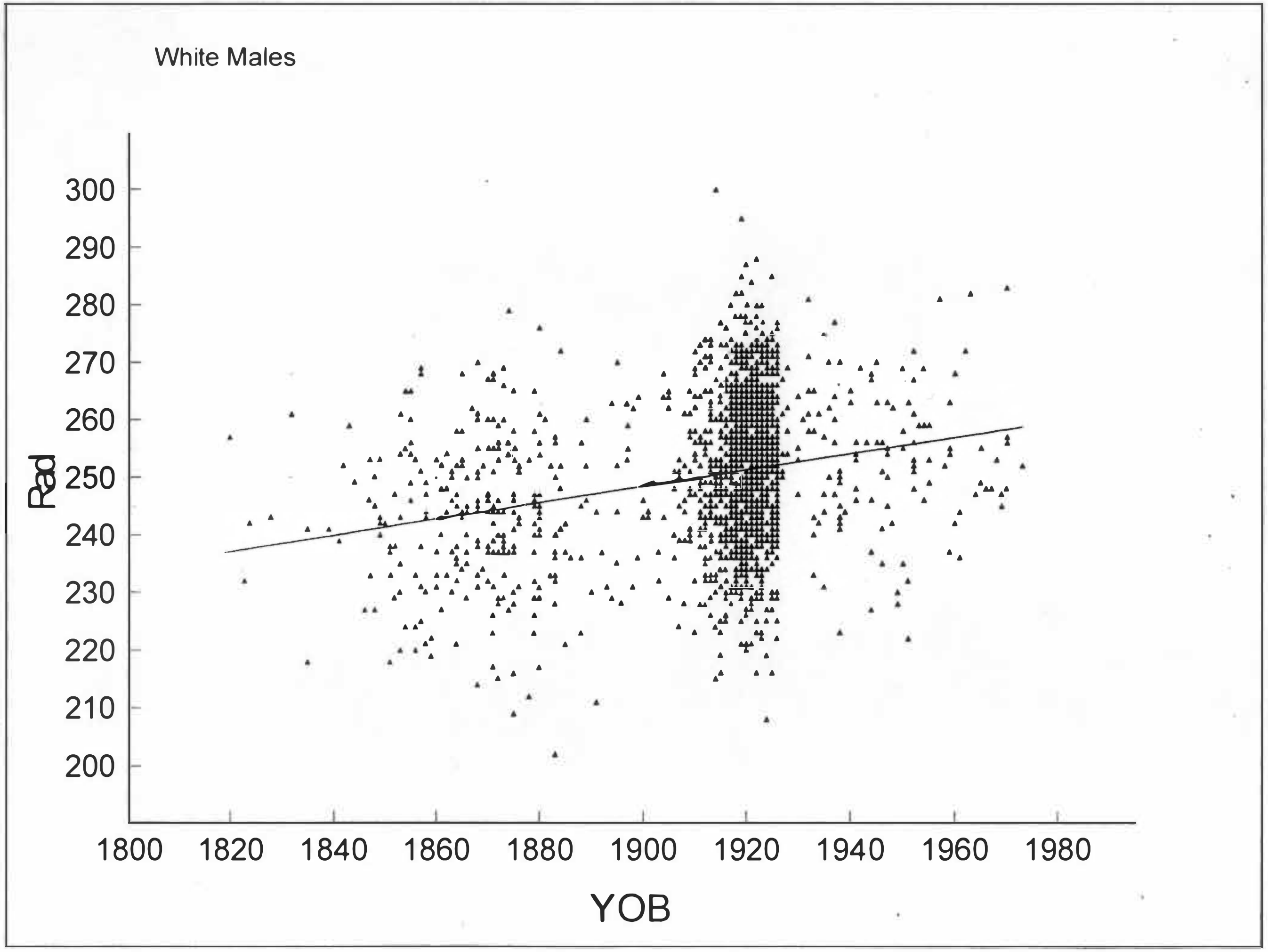

Figure 5.17. Plot of regression of radius length (mm) onto year of birth for white males.

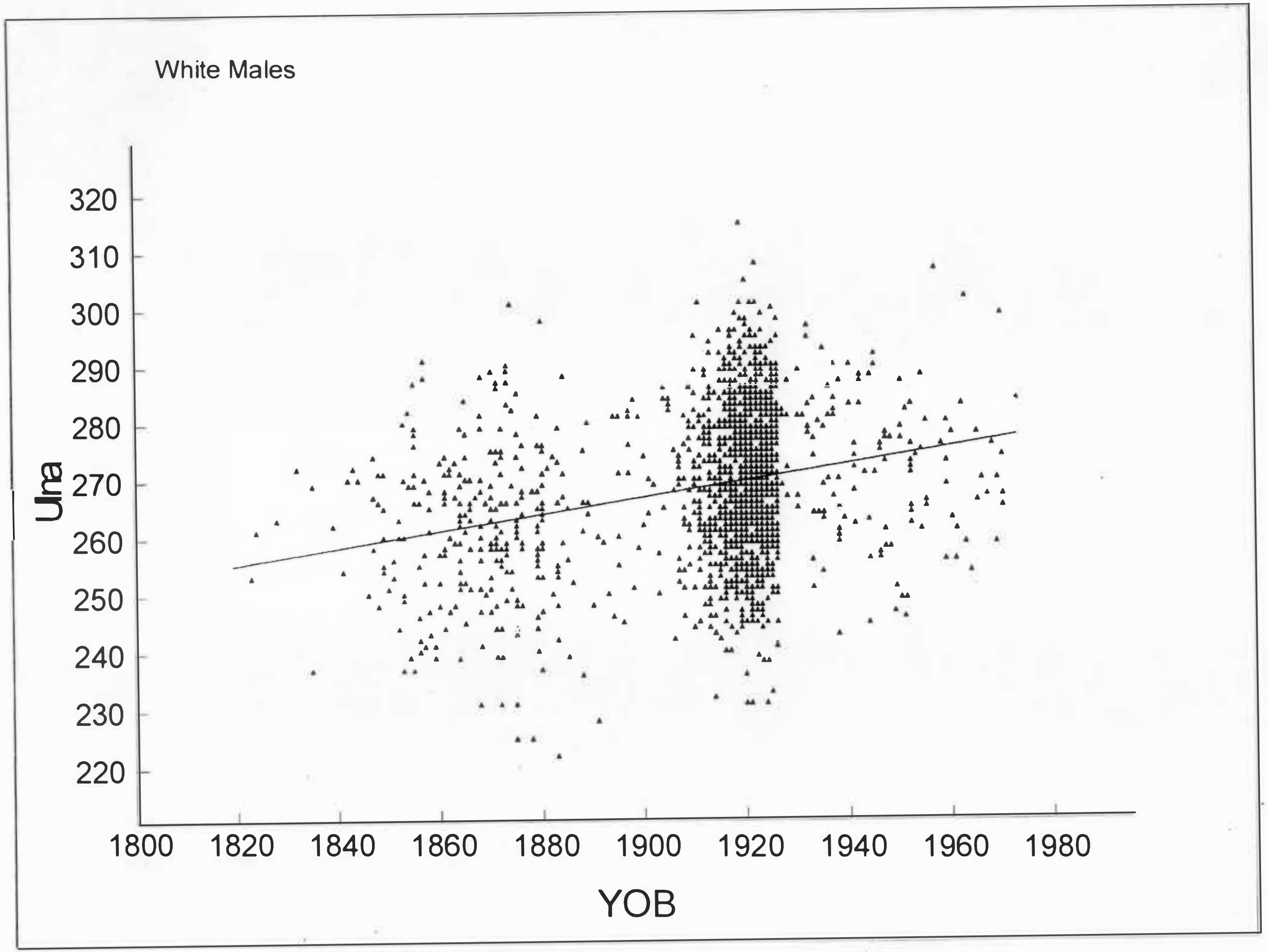

Figure 5.18. Plot of regression of ulna length (mm) onto year of birth for white females.

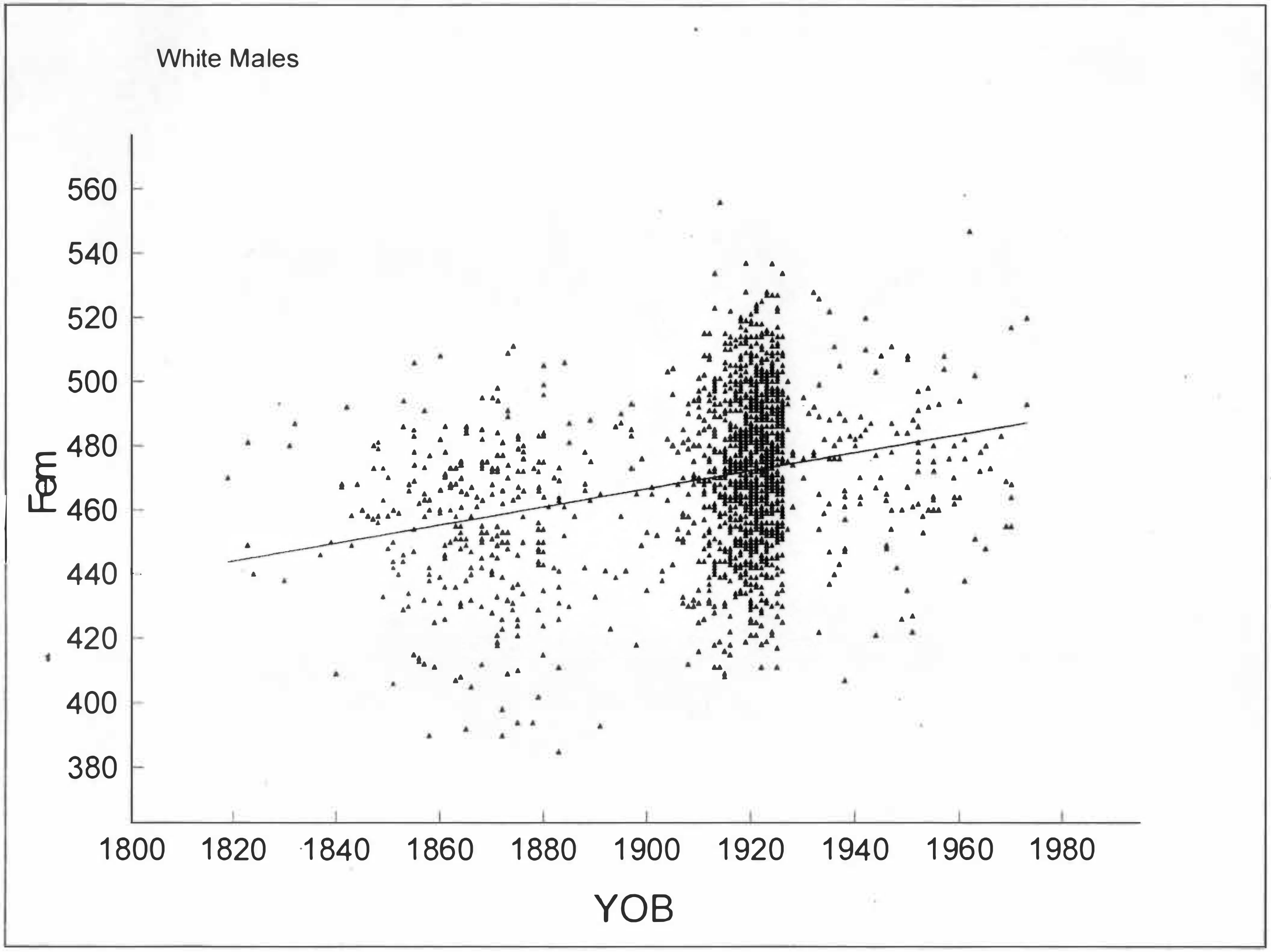

Figure 5.19. Plot of regression of femur length (mm) onto year of birth for white males.

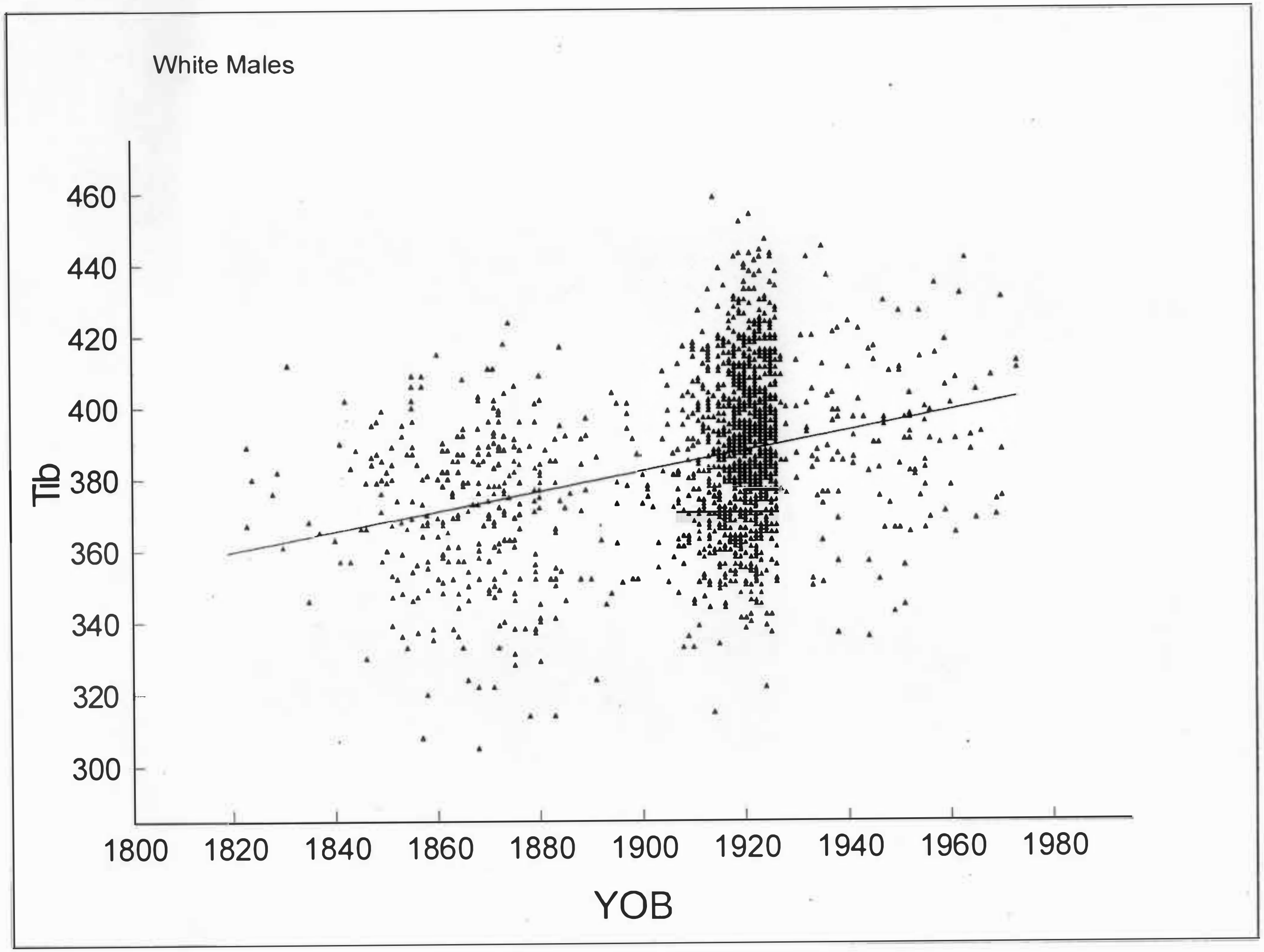

Figure 5.20. Plot of regression of tibia length (mm) onto year of birth for white males.

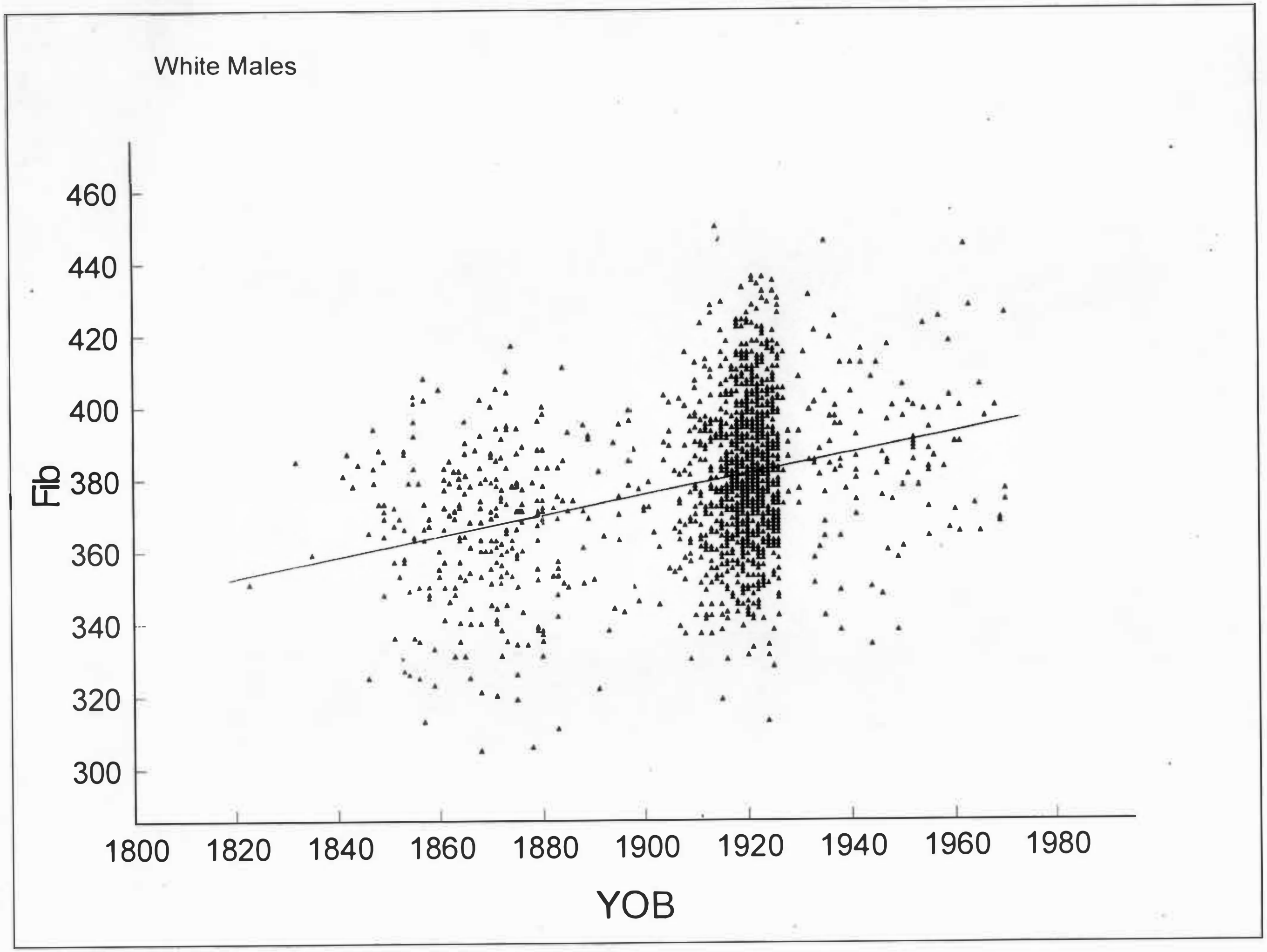

Figure 5.21. Plot of regression of fibula length (mm) onto year of birth for white males.

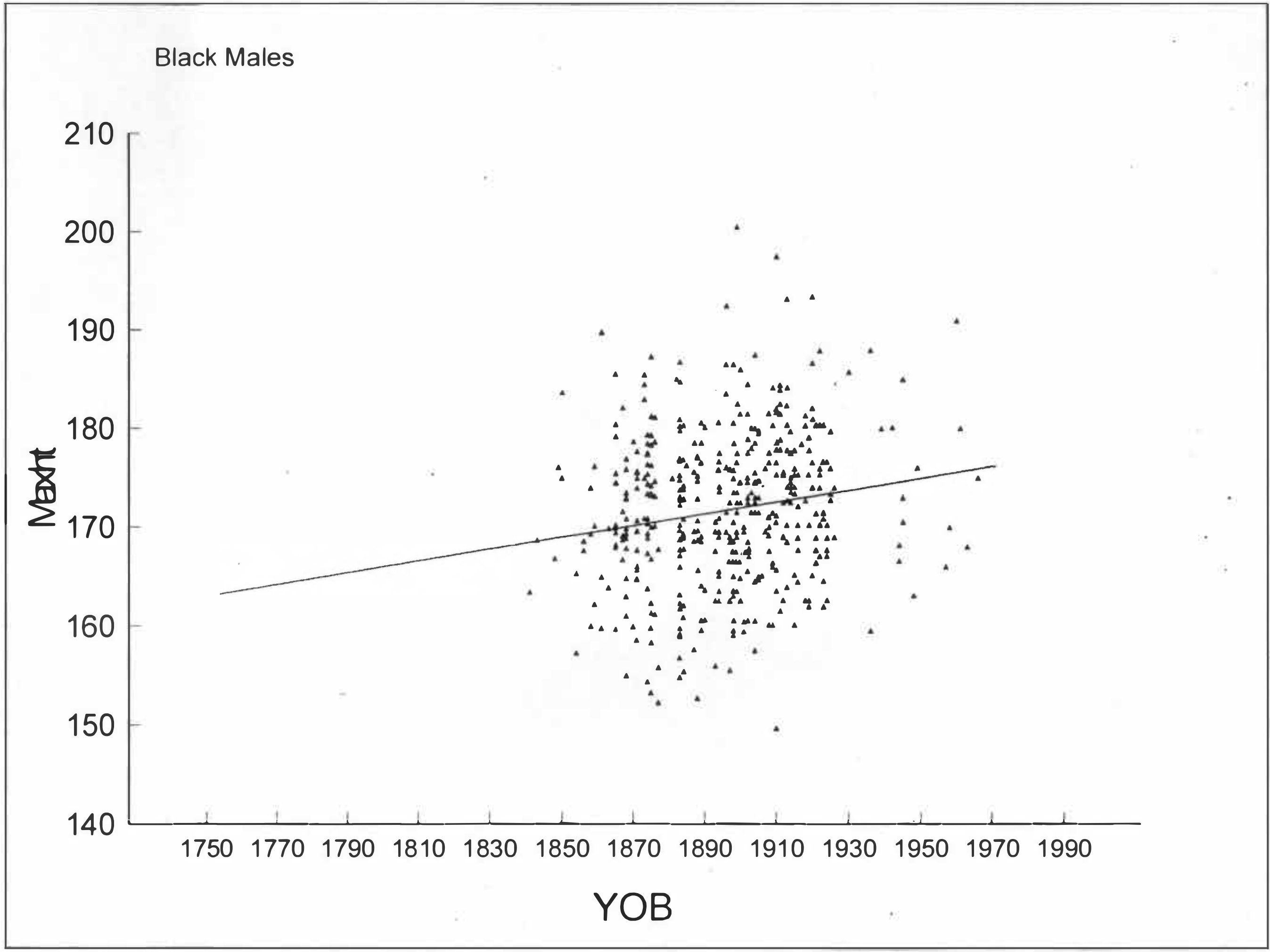

Figure 5.22. Plot of regression of maximum height (cm) onto year of birth for black males.

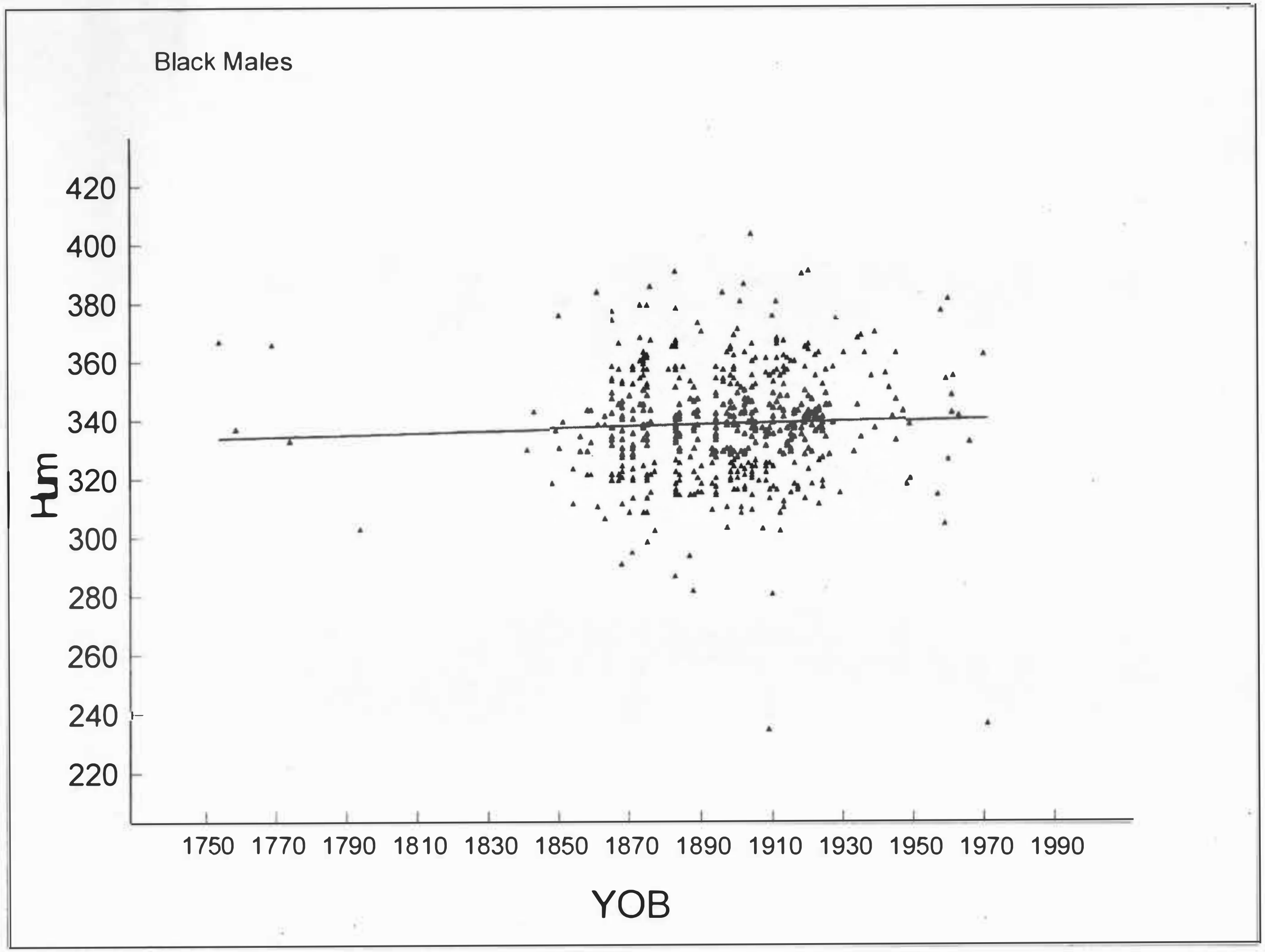

Figure 5.23. Plot of regression of humerus length (mm) onto year of birth for black males.

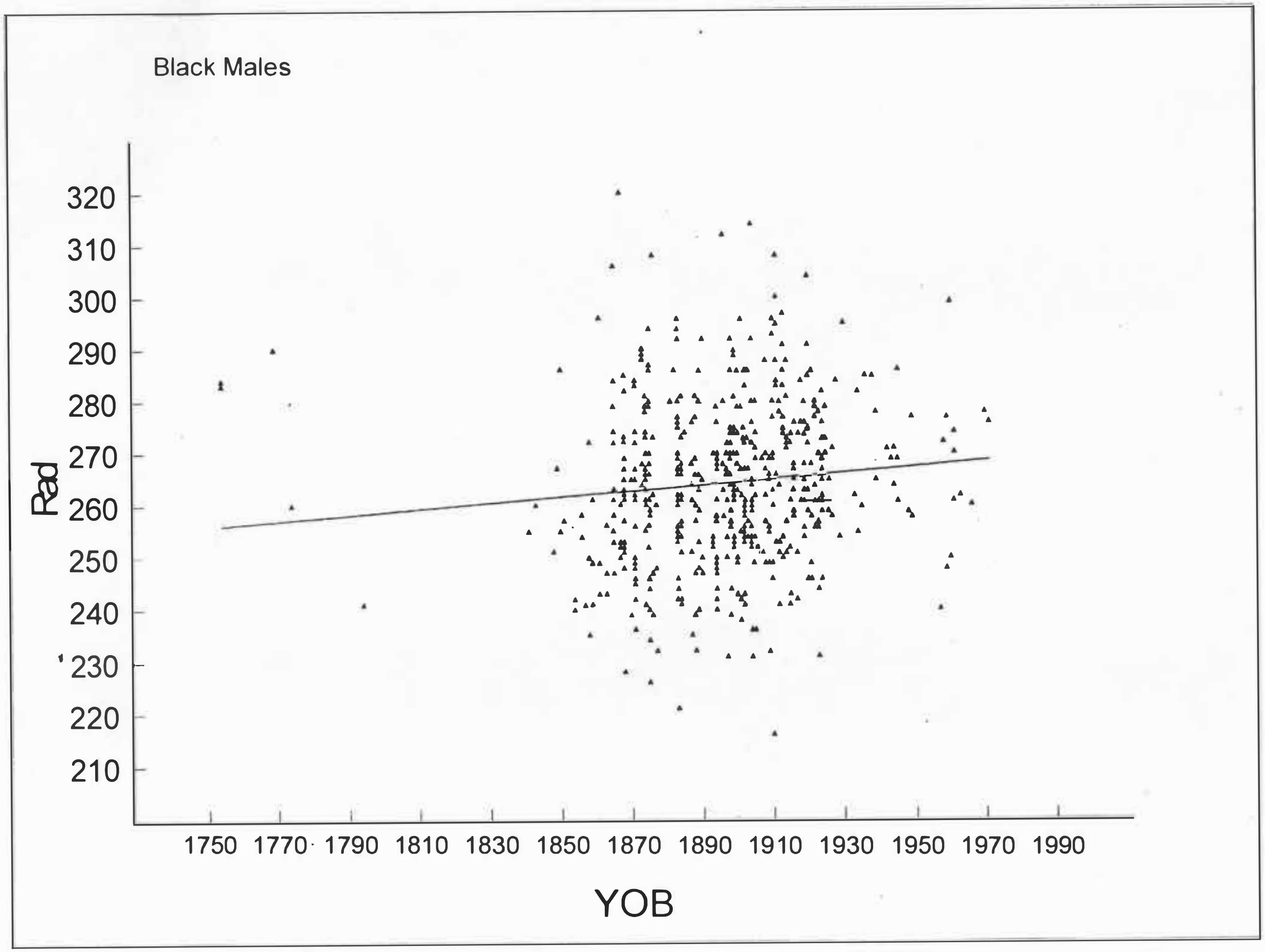

Figure 5.24. Plot of regression of radius length (mm) onto year of birth for black males.

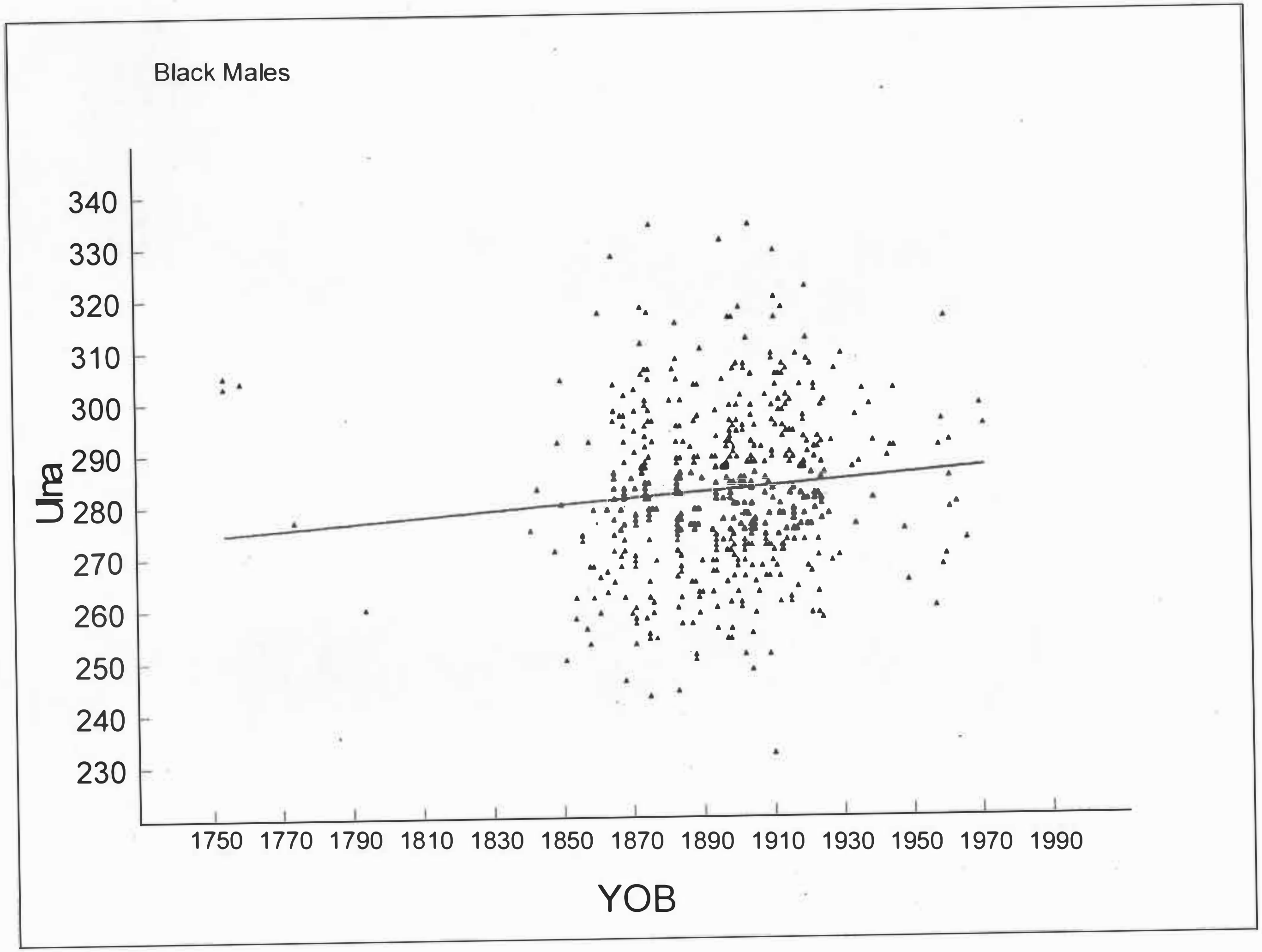

Figure 5.25. Plot of regression of ulna length (mm) onto year of birth for black males.

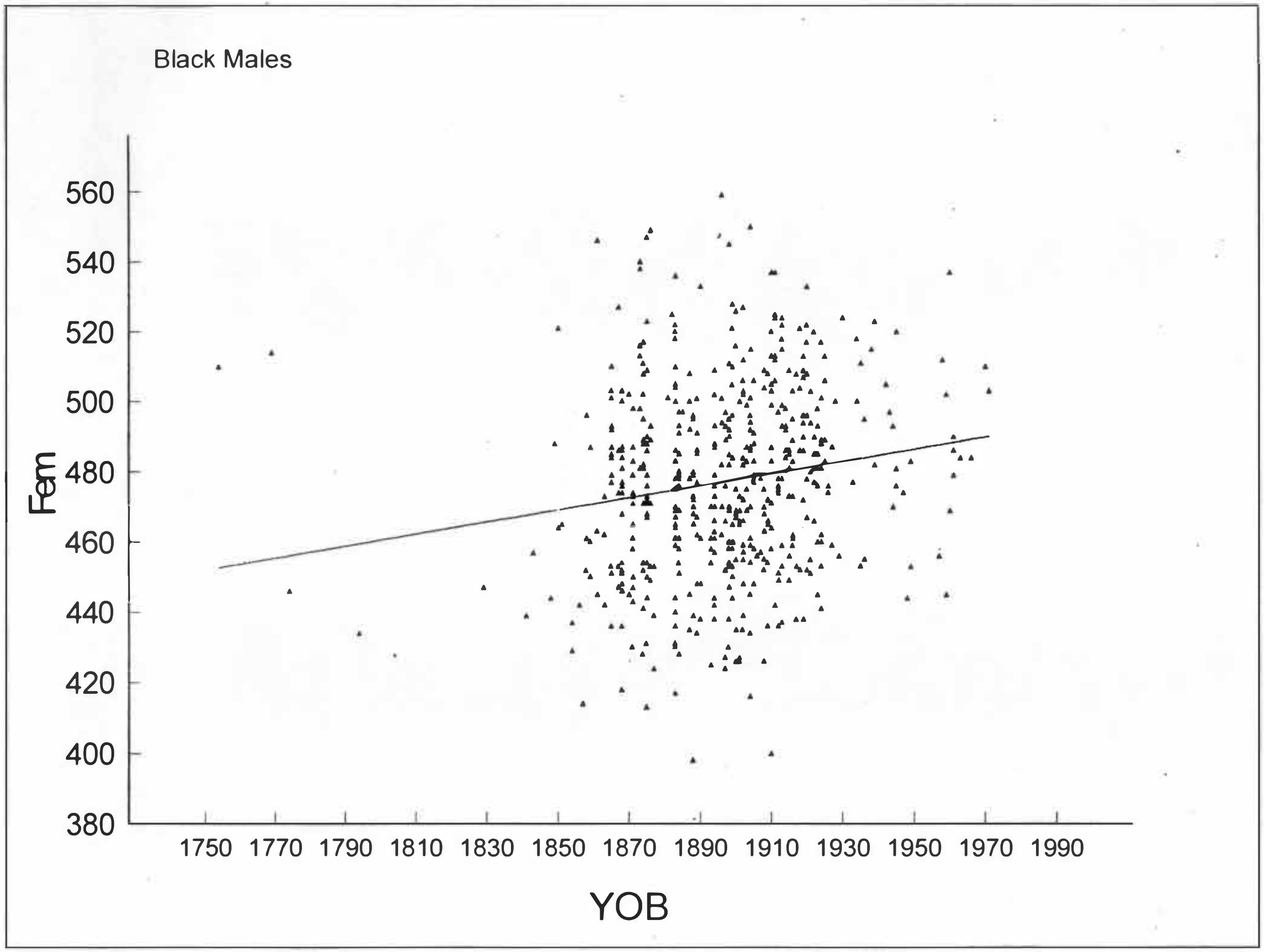

Figure 5.26. Plot of regression of femur length (mm) onto year of birth for black males.

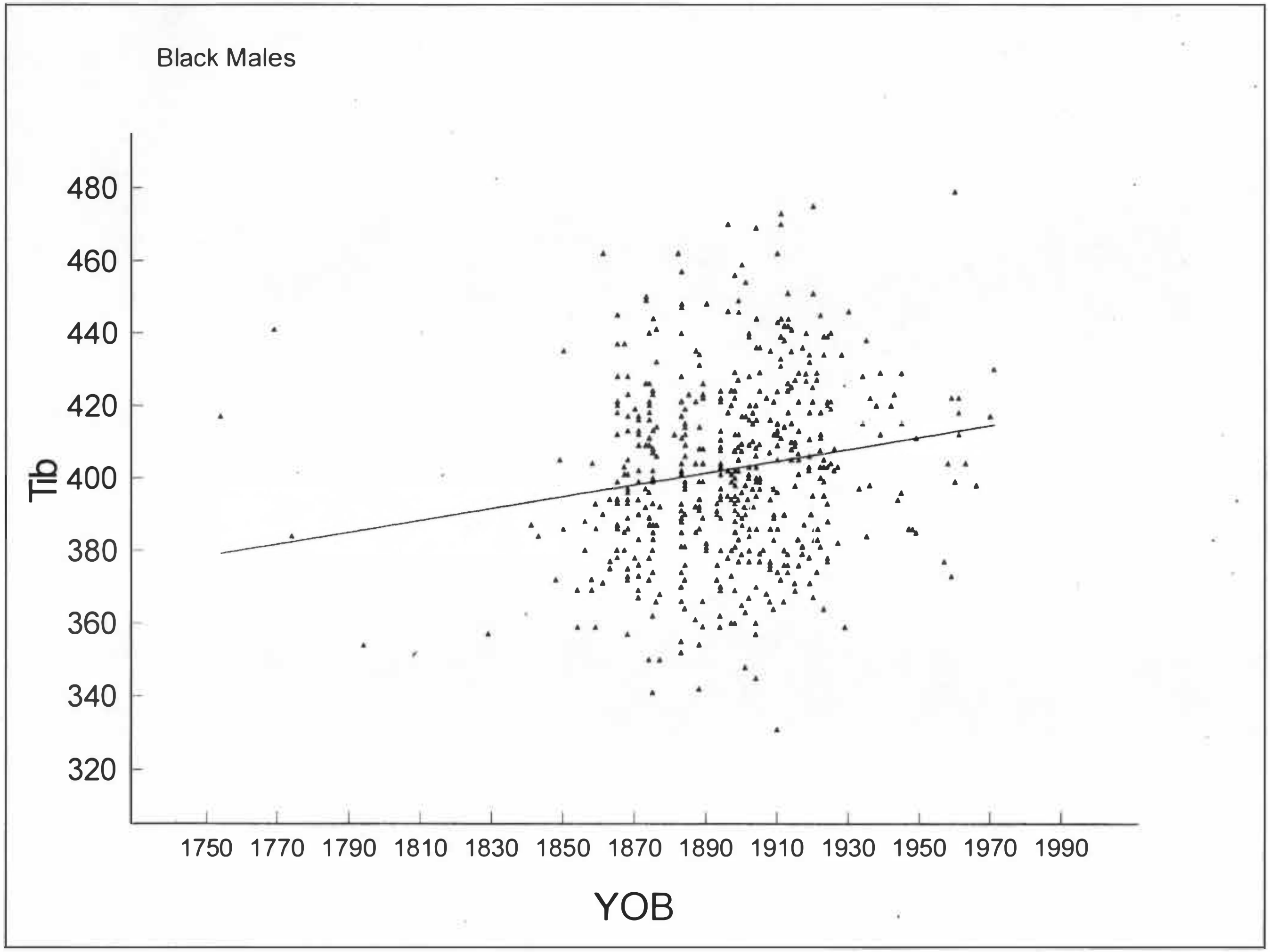

Figure 5.27. Plot of regression of tibia length (mm) onto year of birth for black males.

Figure 5.28. Plot of regression of fibula length (mm) onto year of birth for black males.

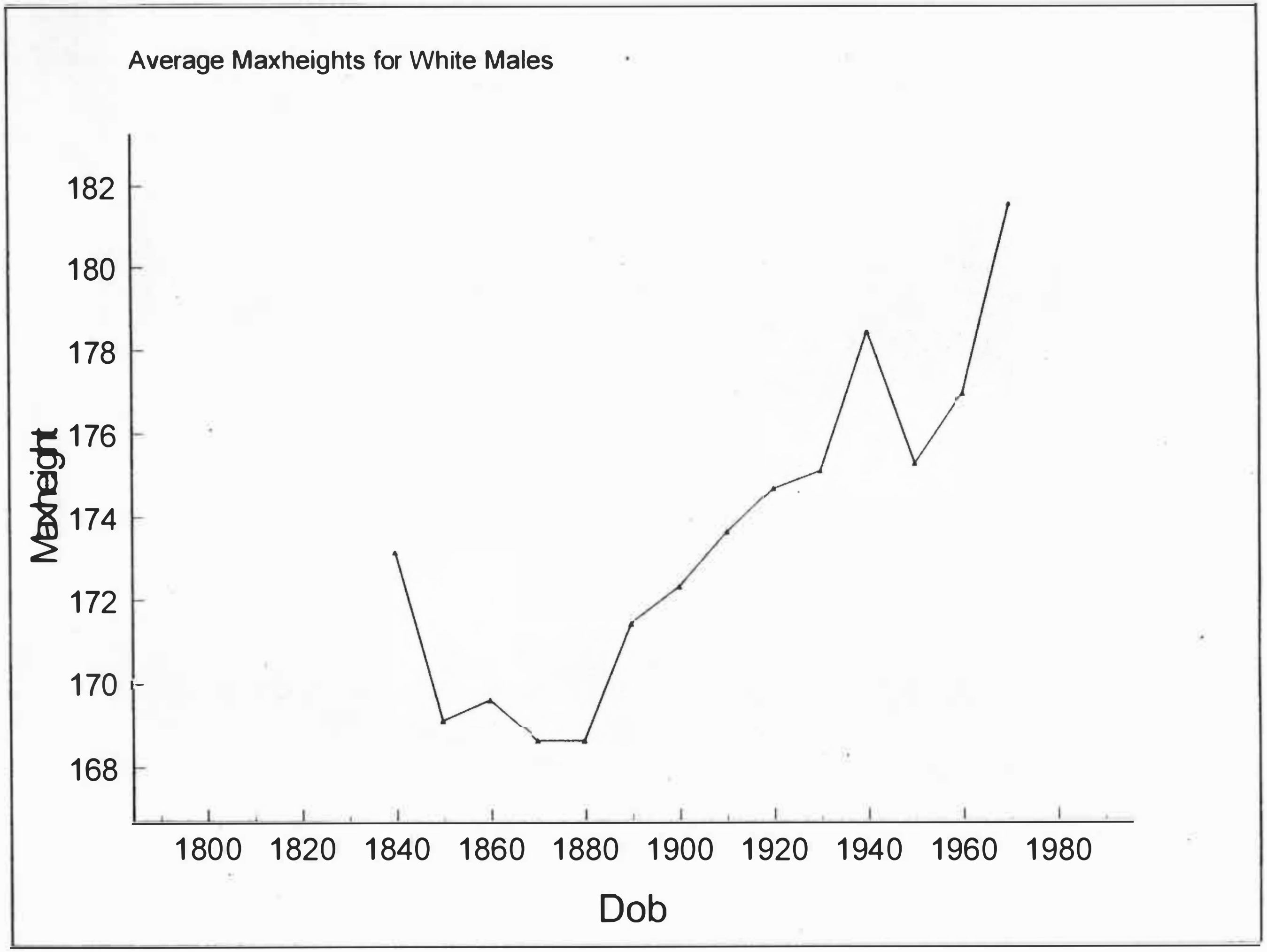

Figure 6.1. Decade means of maximum heights for white males.

VITA

Lee Meadows Jantz was born in Knoxville, Tennessee on December 3, 1962. She attended elementary and middle schools in Knox County, and she graduated from Farragut High School with honors in 1981. In the fall of 1982, Lee entered the University of Tennessee at Knoxville and received a Bachelor of Arts degree with honors majoring in anthropology in the spring of 1987.

In the fall of 1987, she began her graduate studies in anthropology at the University of Tennessee, and in May 1990, Lee was awarded the Master of Arts degree in Anthropology. Throughout the Master's program, Lee held a position as Graduate Assistant in Forensic Anthropology. Fall of 1991, Lee entered the doctoral program at the University of Tennessee. Lee was awarded the position as Graduate Assistant in Forensic Anthropology for four more years, and the fifth year was the Graduate Teaching Associate. The doctoral degree was received in December, 1996.

Lee's main areas of interest include skeletal biology, forensic anthropology, secular change and stature investigations, and human variation. Professional memberships include Sigma Xi, American Academy of Forensic Sciences, and American Association of Physical Anthropologists.