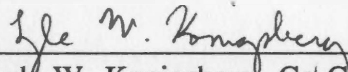
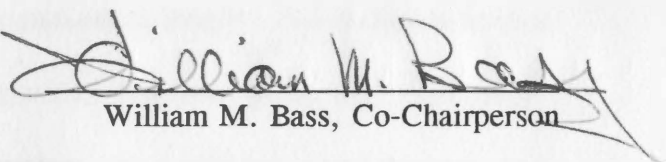


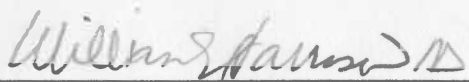
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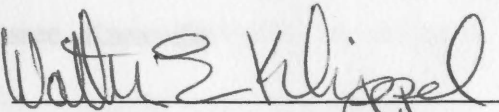
We are submitting herewith a dissertation written by Lee Meadows Jantz entitled "Secular Change and Allometry in the Long Limb Bones of Americans from the Mid 1700s through the 1970s". We have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial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

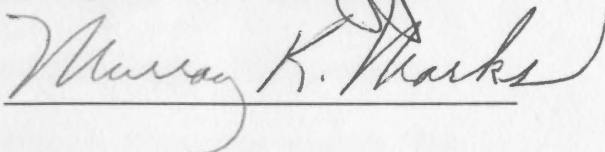

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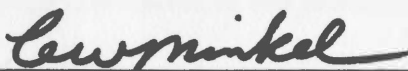
We have read this dissertation
and recommend its acceptance:


William J. Starna


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Accepted for the Council:


Lew Mink

Associate Vice Chancellor and
Dean of The Graduate School

December 1980

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

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 proportions was investigated in five U.S. skeletal samples (Total N=2100) with dates of birth ranging from mid 1700 to 1970s. The six long bones are measured for maximum length, and gender is known for approximately 2000 individuals. The goals of this study include 1) examining any changes in the long bones and

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

In order to test the hypothesis that secular change in size and shape is employed with each of the variables regressed onto year of birth. The second analysis involves the examination of allometric secular change. Size (symmetric mass) 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 previous group. Using Trotter's WWII sample, geographic differences are examined by using size and shape in principal components analysis and multivariate analysis of variance.

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 boundaries. 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) Blanksby (1995)	Australian
Gray (1927) Meredith (1963) Dreizen et al. (1967) Moore (1970) Eveleth et al. (1979)	American
Lasker and Mascie-Taylor (1989) Chinn et al. (1989) Chinn and Rona (1984) Himes (1984) Billewicz et al. (1983) Goldstein (1971) Clements (1953) Roberts (1994)	English
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) Tanner et al. (1982) Greulich (1976)	Japanese

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 an 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 countries. 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)	American males
Borkan et al. (1983)	
Damon (1968)	
Damon (1974)	American females
Bock and Sykes (1989)	Americans
Bakwin and McLaughlin (1964)	
Holmgren (1952)	Swedish adults
Relethford (1995)	Irish adults
Facchini and Gualdi-Russo (1982)	Italians
Terrenato and Ulizza (1983)	
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 successfully 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.

	Females	Males
Decade of Birth		
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.

Decade of Birth	Females		Males	
	White	Black	White	Black
1800 - 1809	4	-	-	-
1810 - 1819	6	-	1	-
1820 - 1829	8	-	7	1
1830 - 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.

Decade of Birth	Females		Males	
	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 cards¹), 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)

¹All 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.

Decade of Birth	Females		Males	
	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:

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

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

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:

$$Y = b_0 + b_1(YOB) + b_2(YOB)^2$$

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:

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

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 $(\prod_{i=1}^n X_i)^{1/n}$ which is calculated by taking the n th root of the product of n variables as follows:

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

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 effect 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.

Variable	D-W d (n)			
	Females		Males	
	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 $\alpha = 0.05$

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 $\alpha = 0.05$

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

Variable	N	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 $\alpha = 0.05$

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 $\alpha = 0.05$

of significance is the tibia ($p = 0.0007$). Rates of secular change are given as the slope, 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.

	<u>Eigenvectors</u>					
	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
8 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.

Variable	D-W d			
	Females		Males	
	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 significant 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 significant 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 significant 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 significant 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
<u>North Central</u>					
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
<u>Northeast</u>					
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
<u>South Central</u>					
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
<u>Southeast</u>					
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
<u>West</u>					
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
<u>North Central</u>					
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
<u>South Central</u>					
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)

<u>SouthEast</u>					
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.

<u>Whites</u>					
H = Type III SS&CP Matrix for REGION E = Error SS&CP Matrix					
<u>S=4 M=1.5 N=459</u>					
<u>Statistic</u>	<u>Value</u>	<u>F</u>	<u>Num DF</u>	<u>Den DF</u>	<u>Pr > F</u>
Wilks' Lambda	0.90627457	2.8688	32	3394.388	0.0001
<u>Blacks</u>					
<u>S=3 M=2 N=30.5</u>					
<u>Statistic</u>	<u>Value</u>	<u>F</u>	<u>Num DF</u>	<u>Den DF</u>	<u>Pr > F</u>
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 linear 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.

		<u>Eigenvectors</u>				
	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.

<u>Eigenvectors</u>						
	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.

Population	N	Females		N	Males	
		Mean	S.D.		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 α 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 both 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*.

Region	<u>Whites</u>			
	<u>Trotter's Sample</u>		<u>Karpinos' Sample¹</u>	
	Mean	S.D.	Mean	S.D
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
<u>Blacks</u>				
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	.	.	.	.

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

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

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)

Variable	N	Decade of Birth = 1820		Minimum	Maximum
		Mean	Std Dev		
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)		RANK
HORTON, John R.		Pfc (USAGF)
SERIAL NO.		34439528
MAUSOLEUM		
BUILDING NO.	ROW NO.	SECTION NO.
		Race: 1 White
PREVIOUS BURIAL INFORMATION		
NAME AND LOCATION OF CEMETERY		
27th Air Am Marine I.		
PLOT	ROW	GRAVE
		24 June 1944
REMARKS:		2
Birth Eldorado, Ill.		30 Aug 1923
Enlistment Chicago, Ill.		5 Feb 1943
Ht. 5'3" 160		31
Wt. 105		

GP-AGRS-19 Jun 47 This form supersedes MP-QM 6, 29 Apr 47, existing stocks of which may be used until exhausted. APP 0016

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

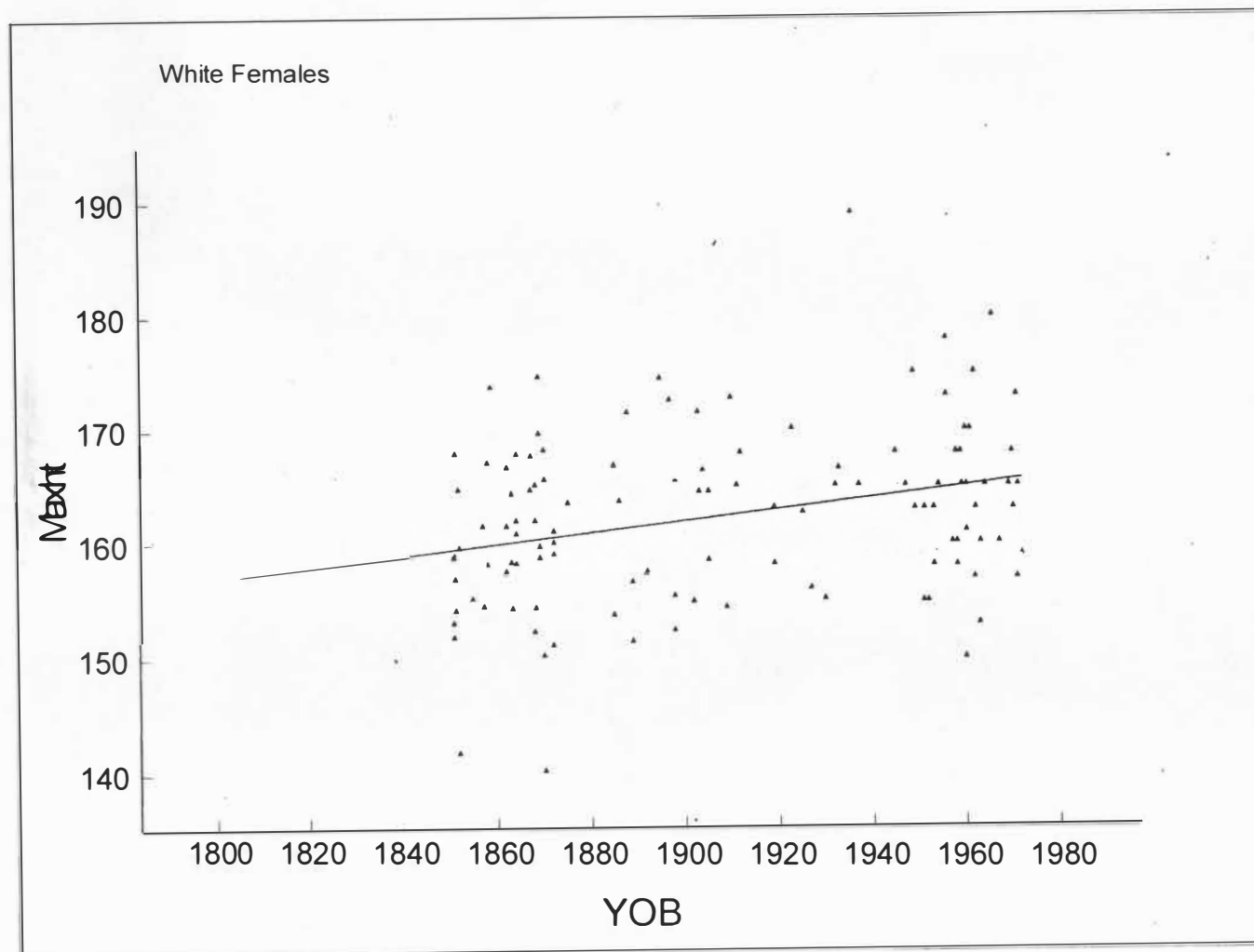


Figure 5.1. Plot of regression of maximum height (in cm) onto year of birth for white females.

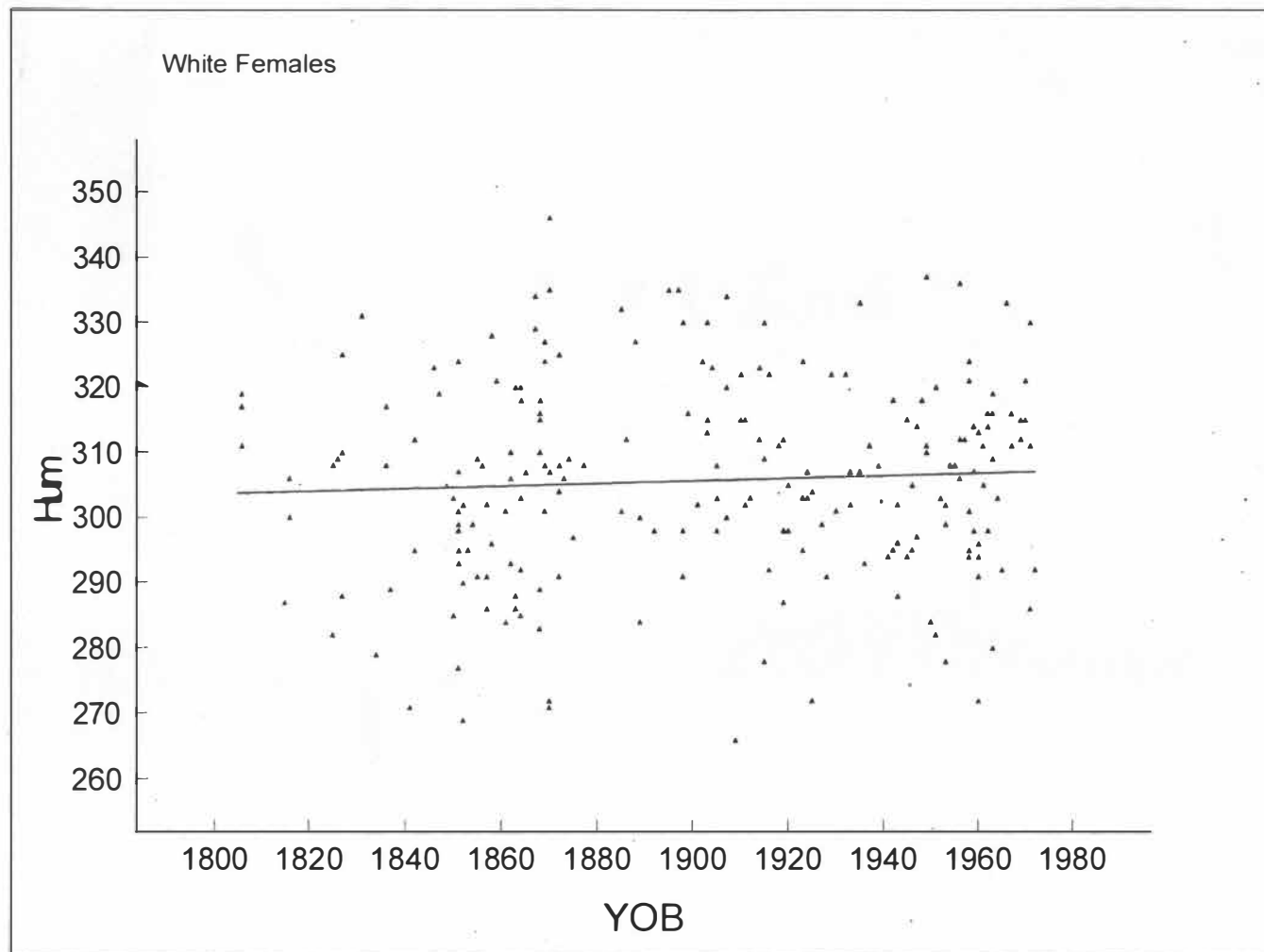


Figure 5.2. Plot of regression of humerus length (mm) onto year of birth for white females.

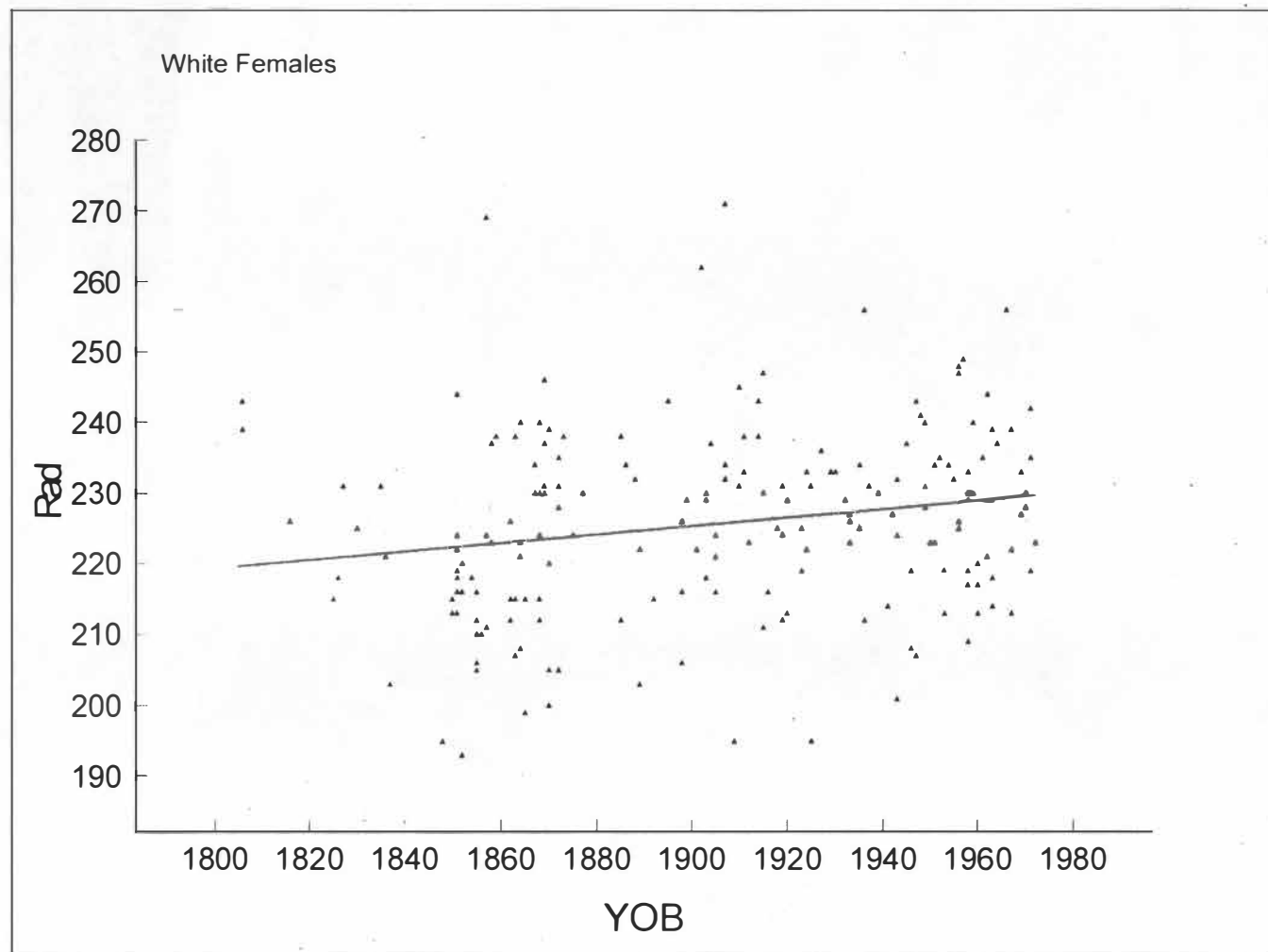


Figure 5.3. Plot of regression of radius length (mm) onto year of birth for white females.

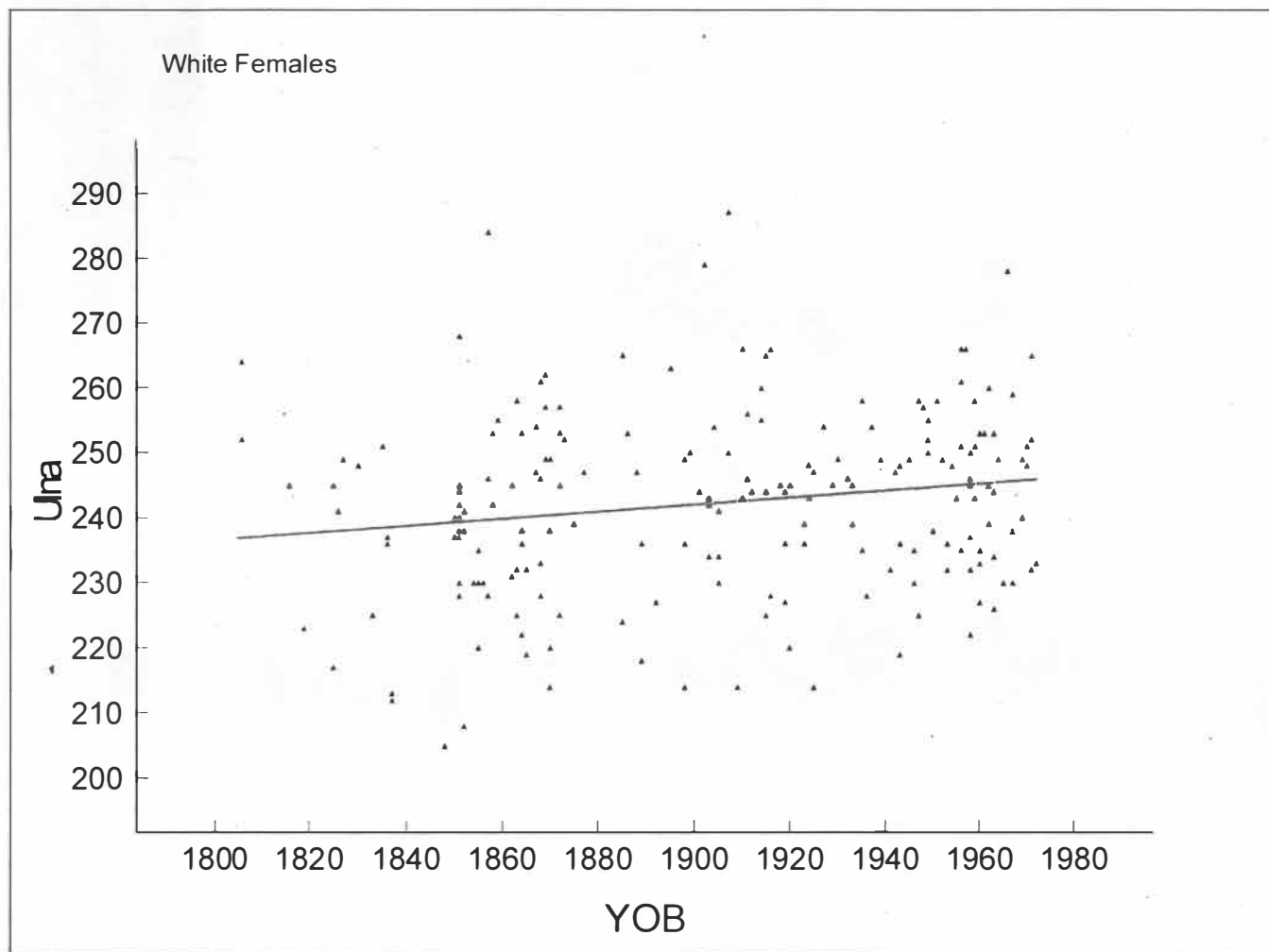


Figure 5.4. Plot of regression of ulna length (mm) onto year of birth for white females.

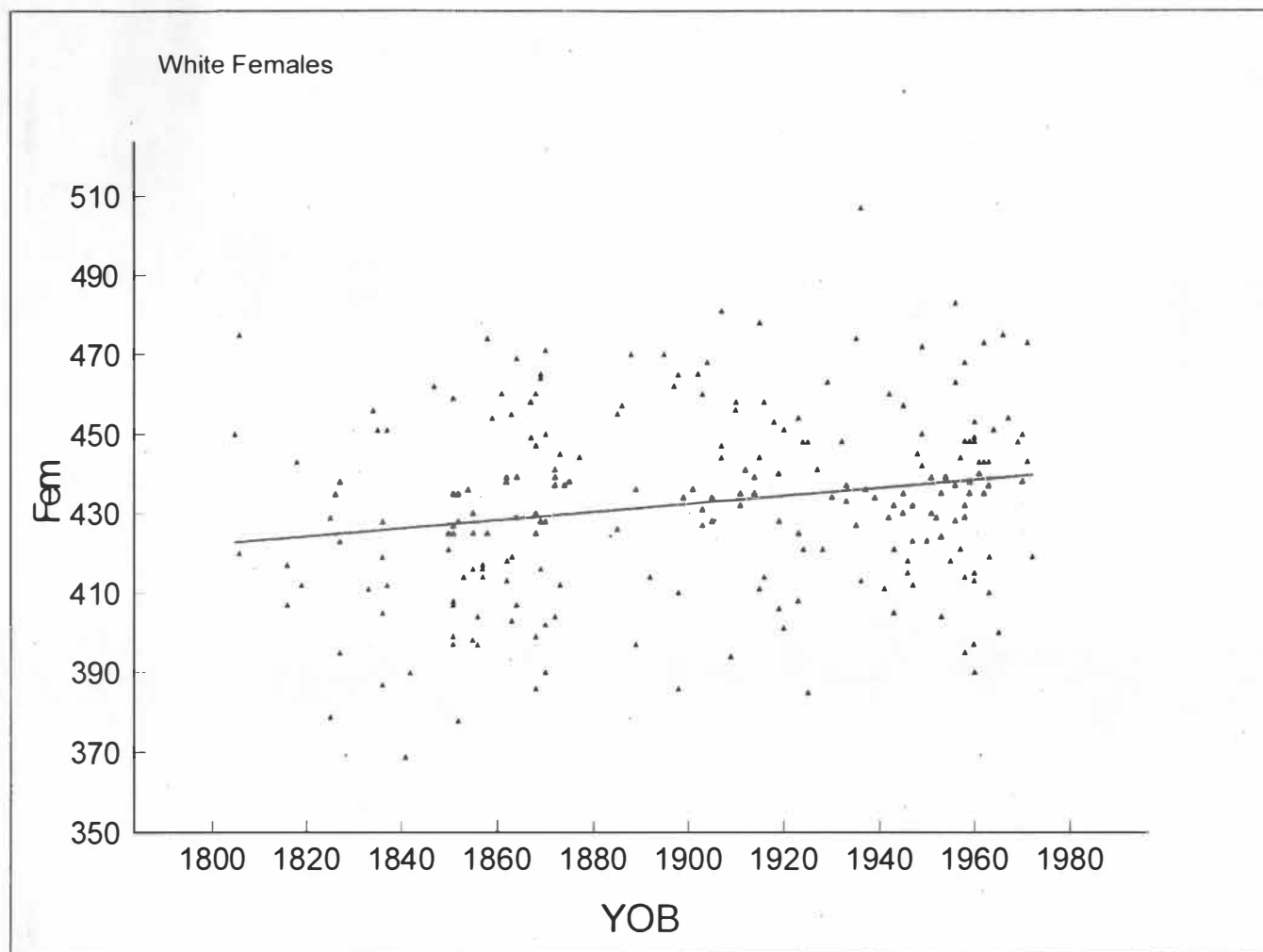


Figure 5.5. Plot of regression of femur length (mm) onto year of birth for white females.

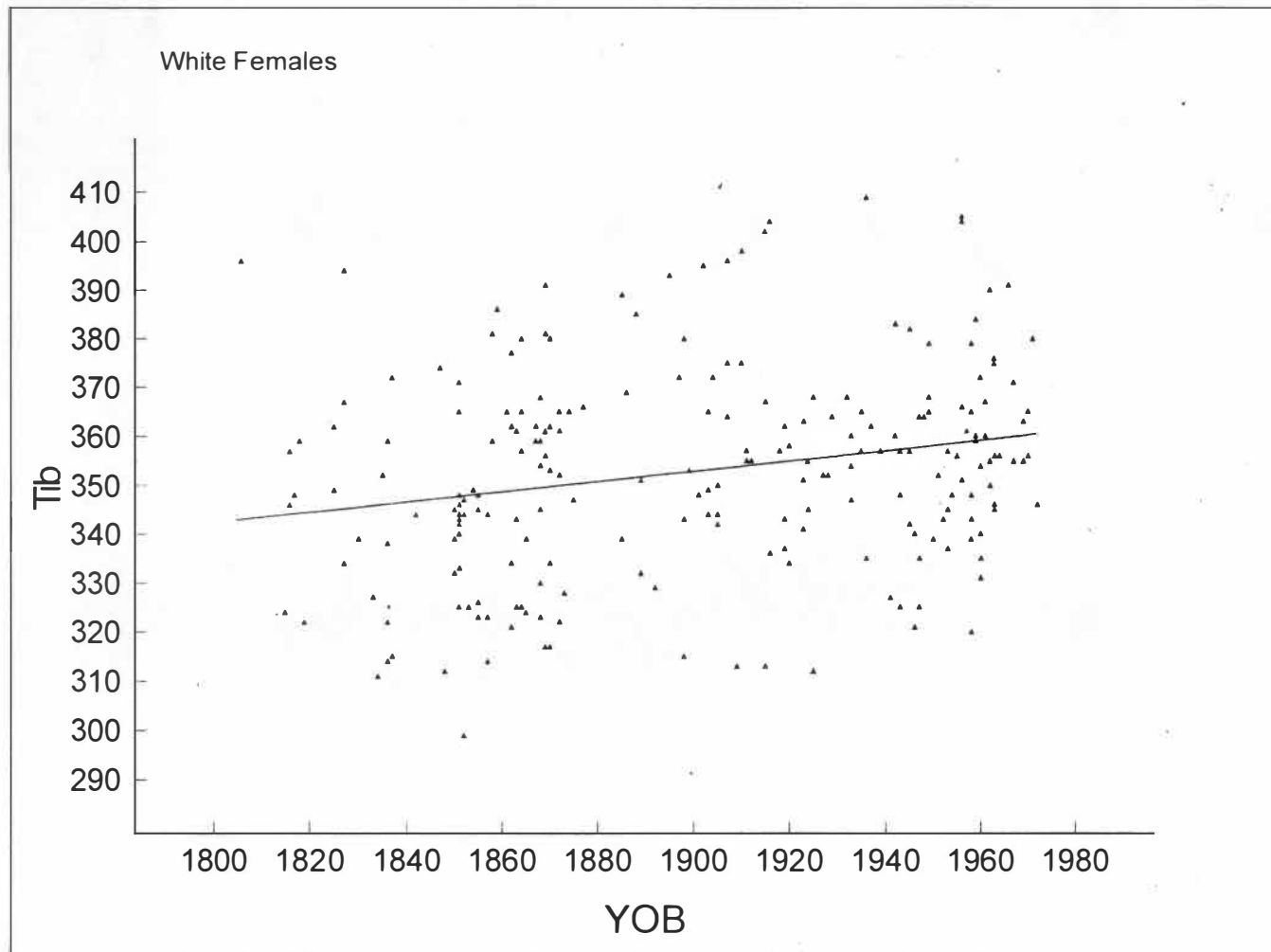


Figure 5.6. Plot of regression of tibia length (mm) onto year of birth for white females.

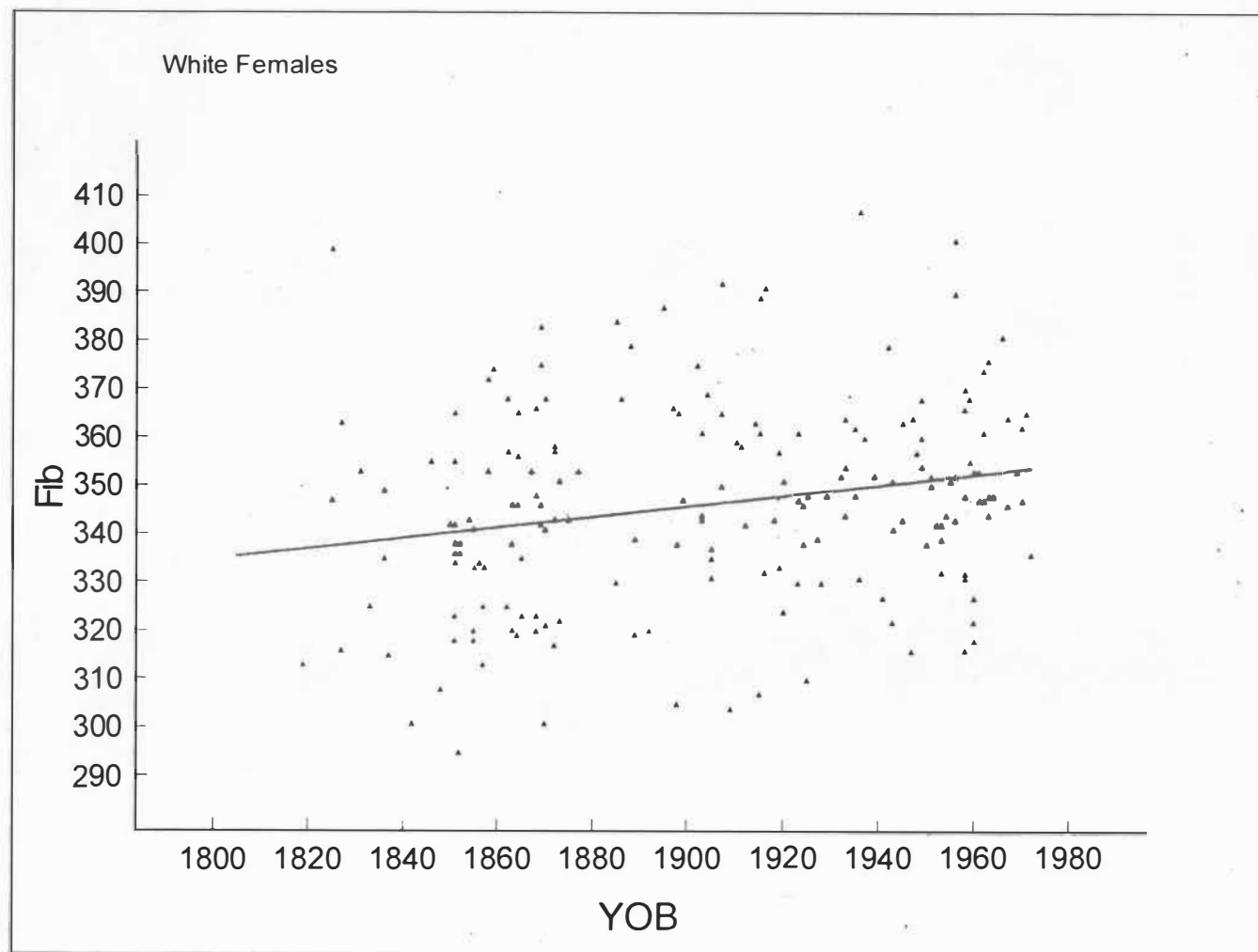


Figure 5.7. Plot of regression of fibula length (mm) onto year of birth for white females.

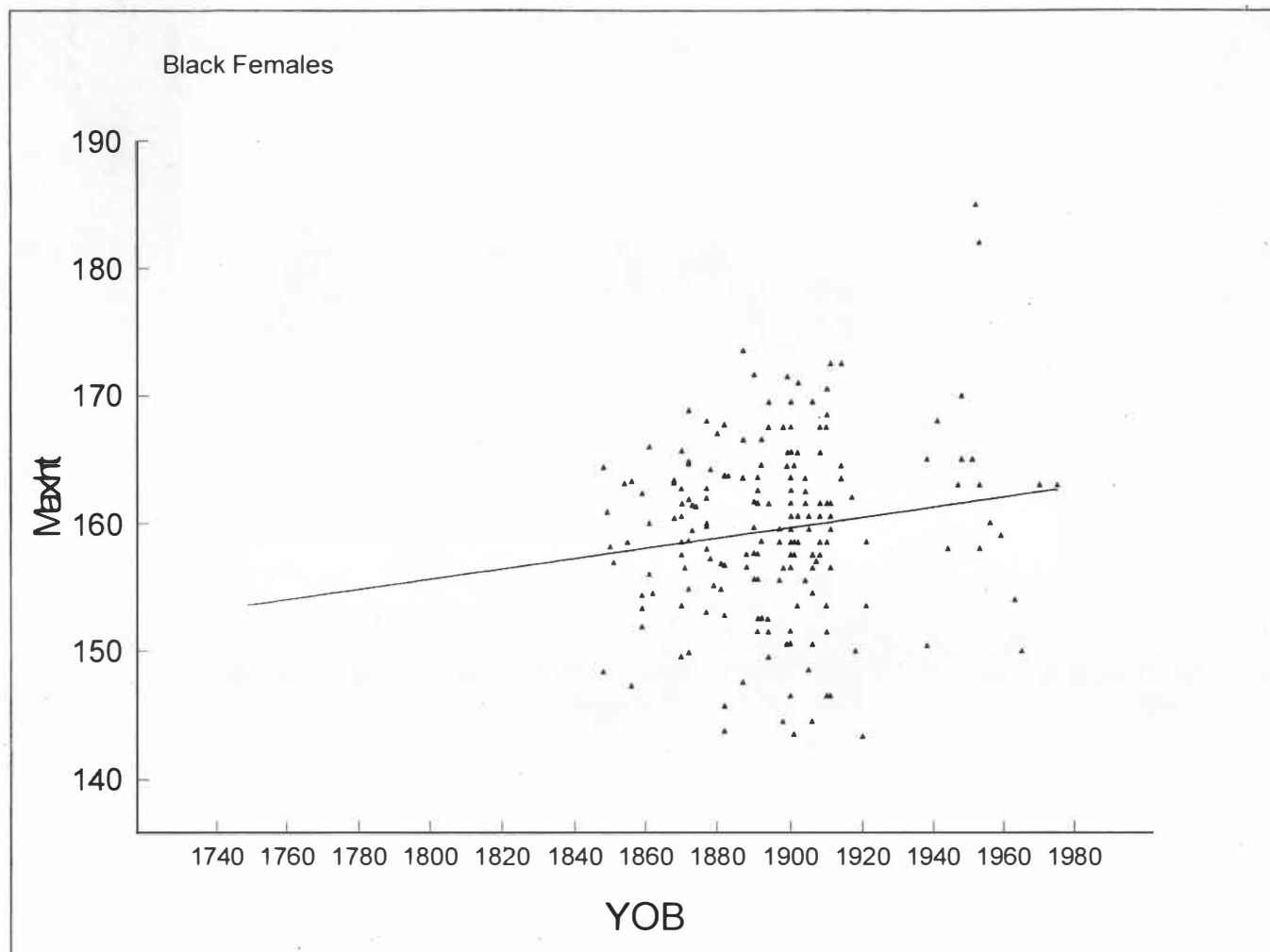


Figure 5.8. Plot of regression of maximum height (cm) onto year of birth for black females.

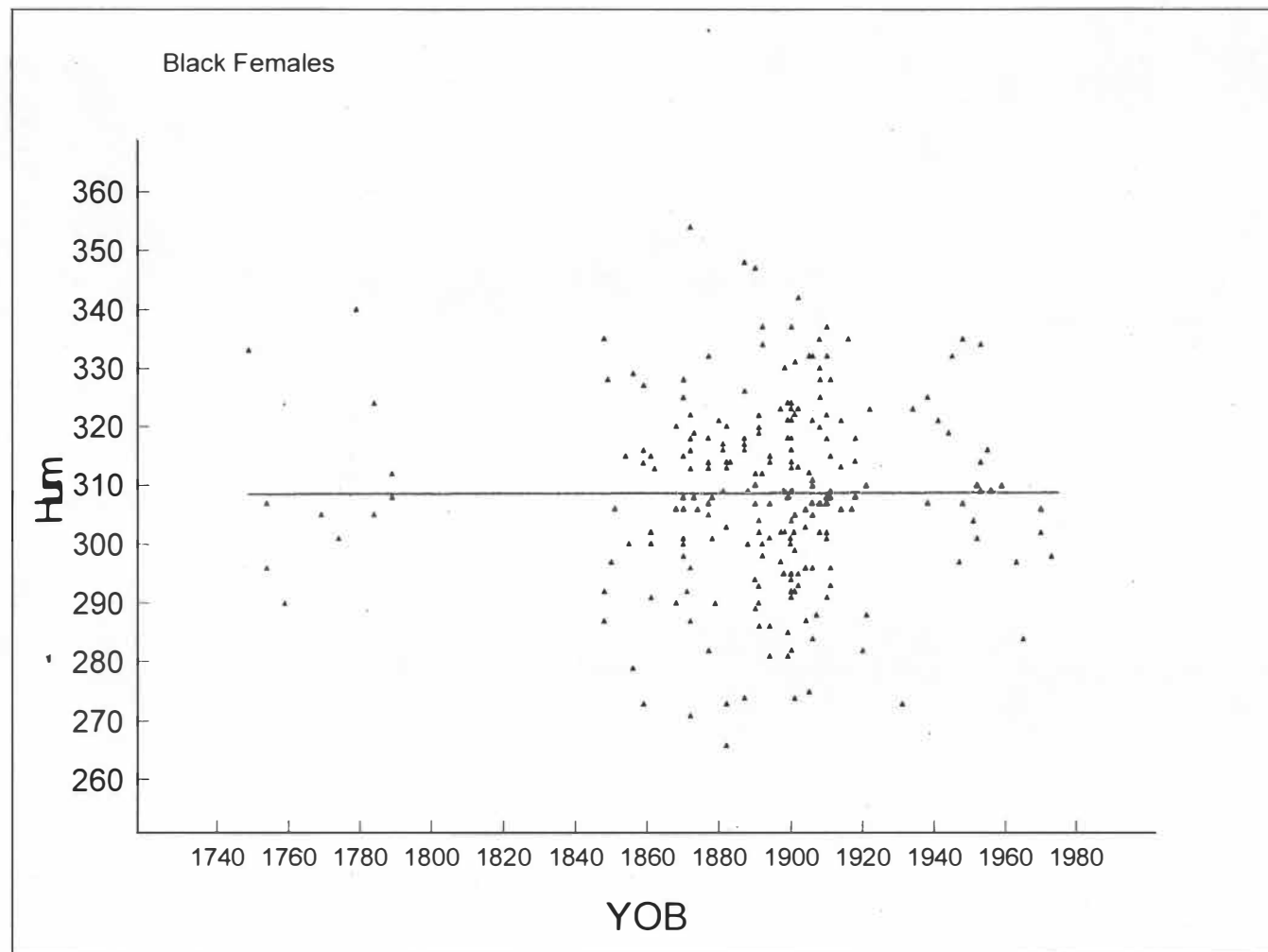


Figure 5.9. Plot of regression of humerus length (mm) onto year of birth for black females.

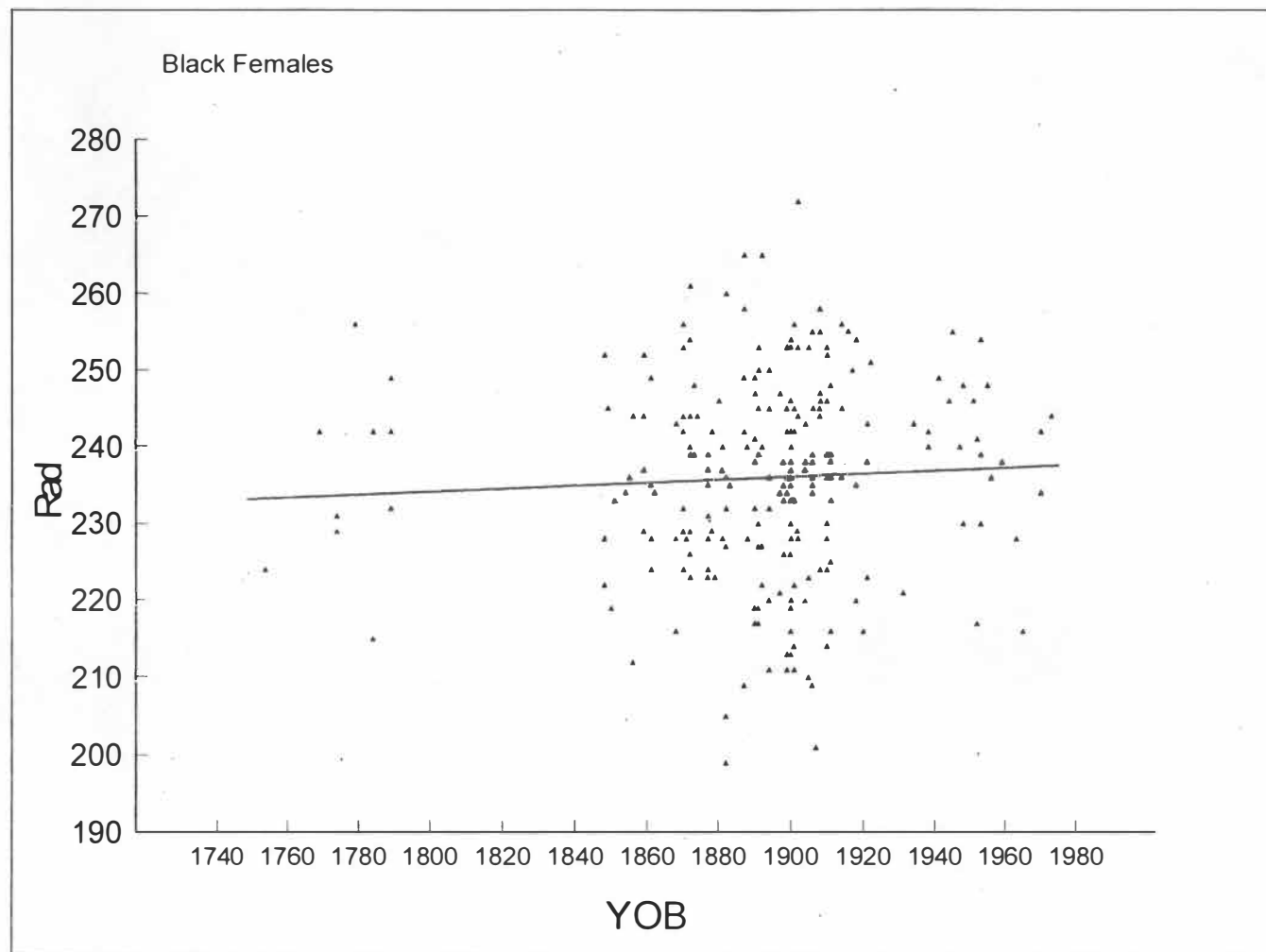


Figure 5.10. Plot of regression of radius length (mm) onto year of birth for black females.

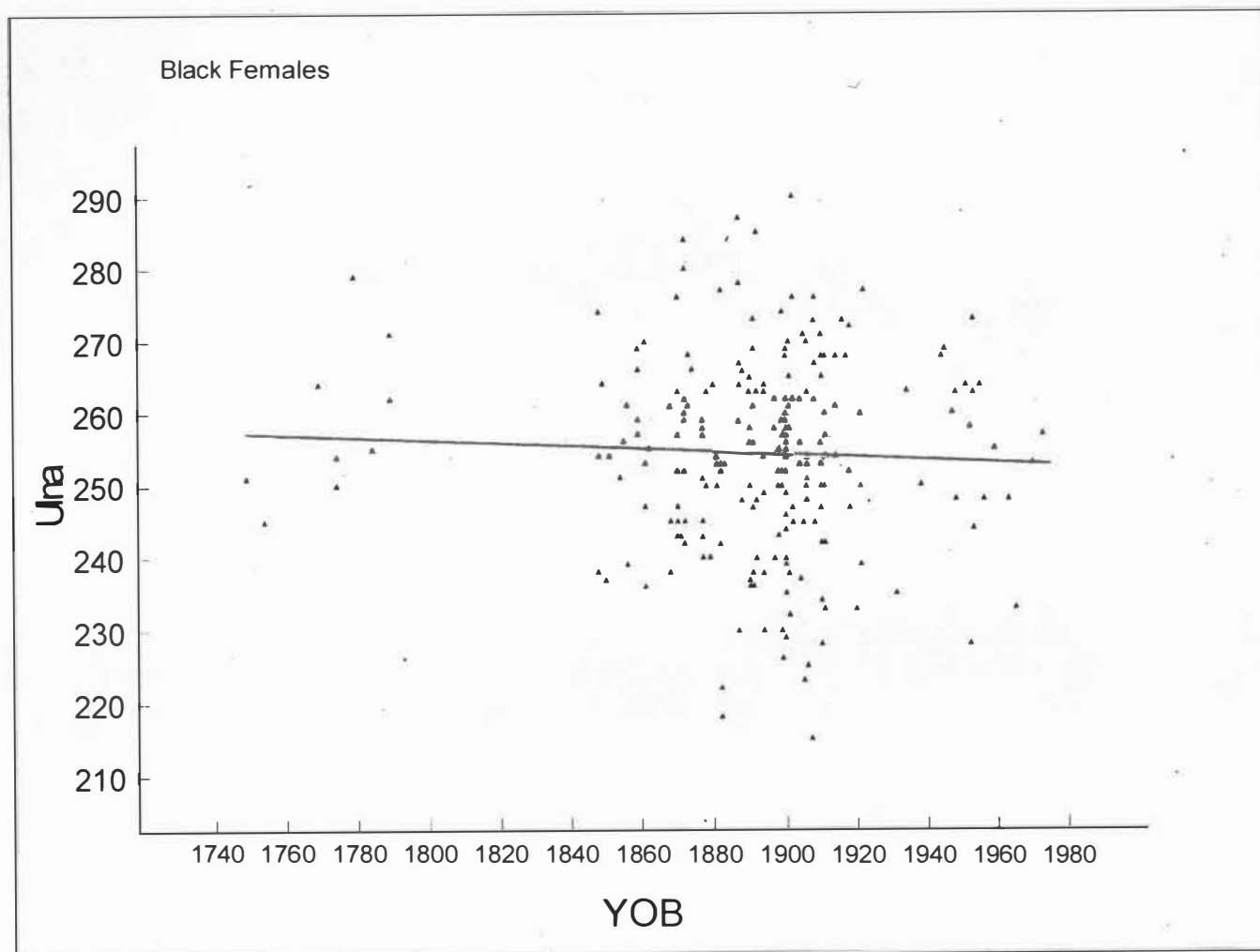


Figure 5.11. Plot of regression of ulna length (mm) onto year of birth for black females.

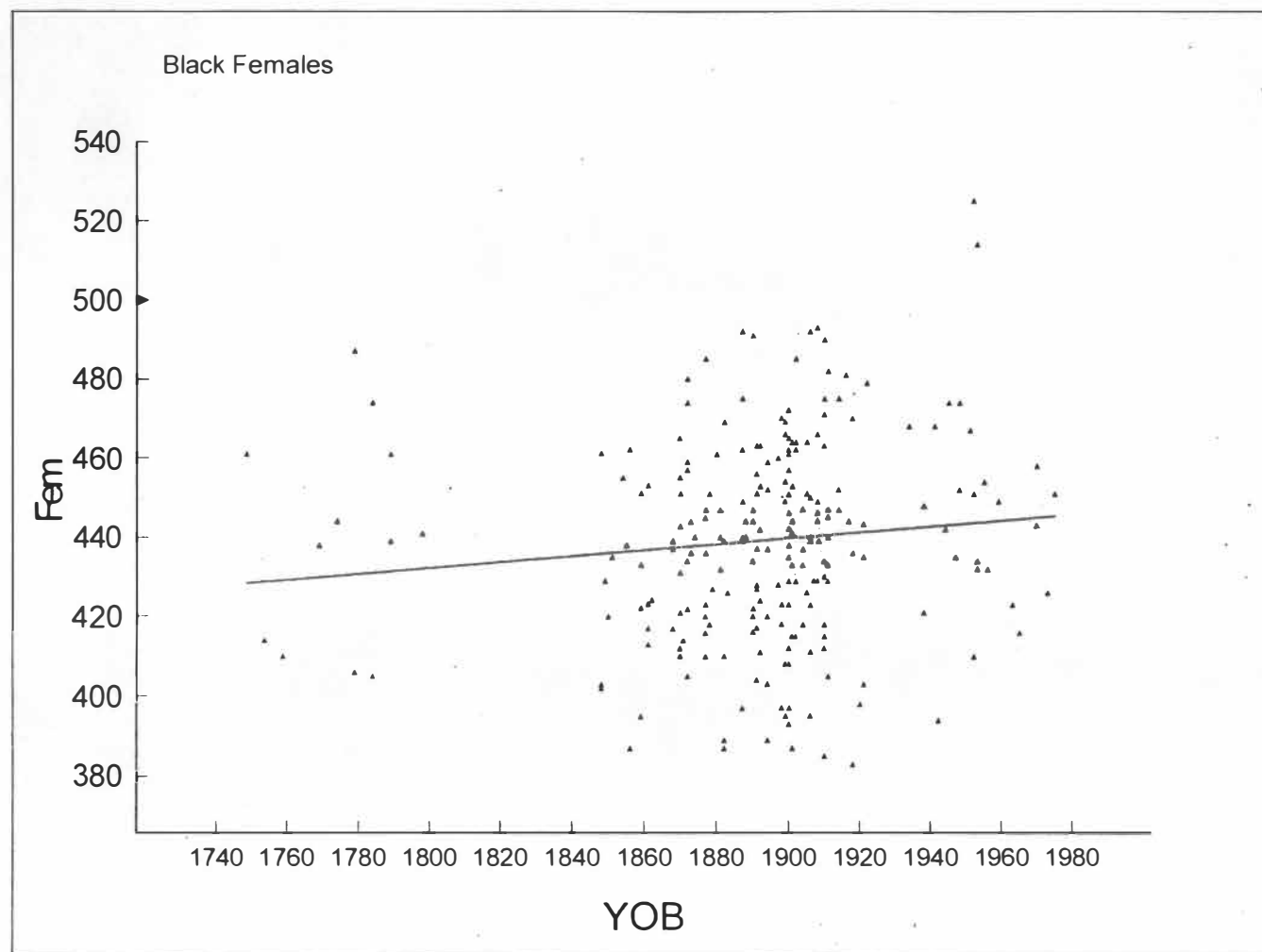


Figure 5.12. Plot of regression of femur length (mm) onto year of birth for black females.

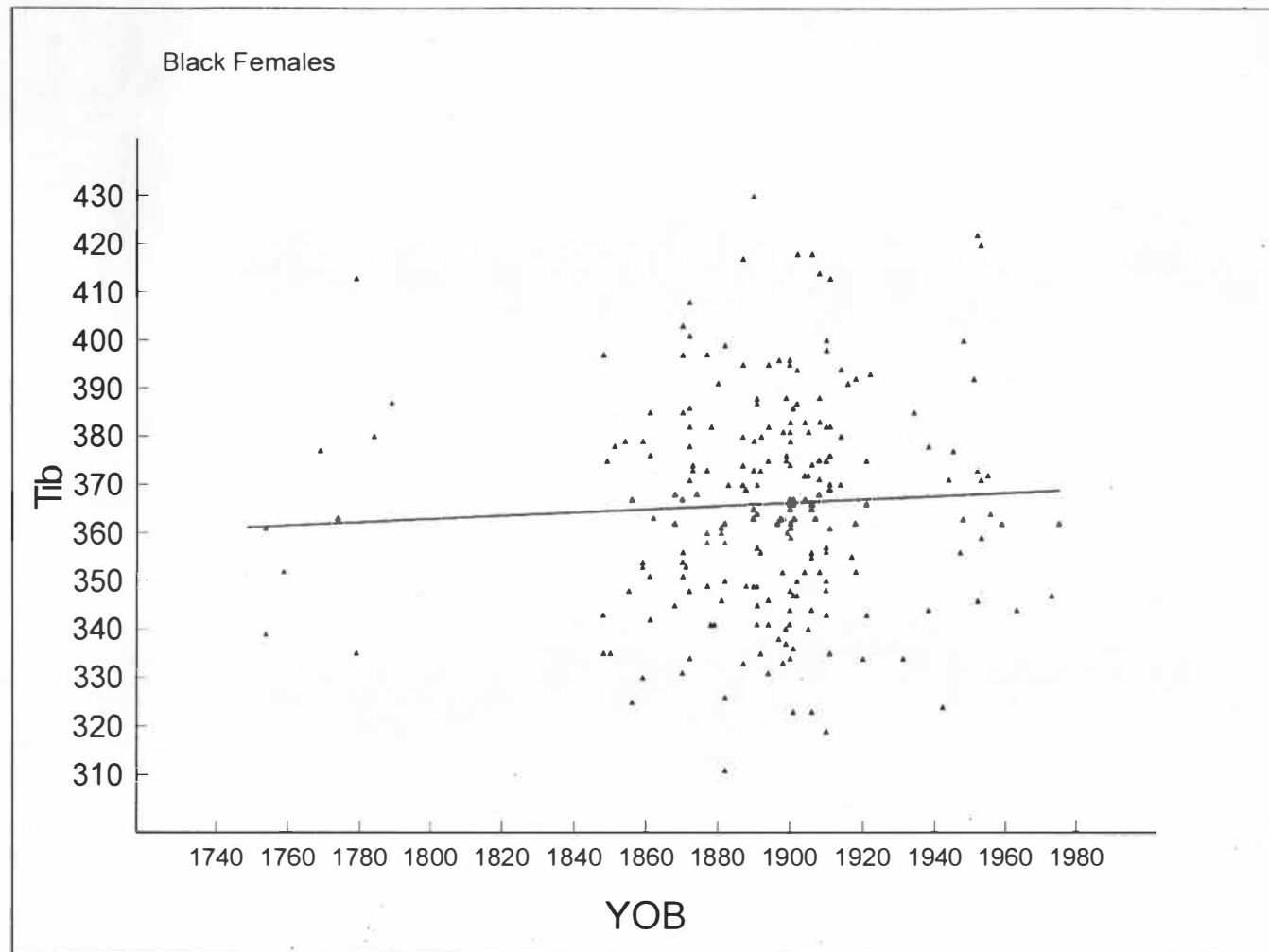


Figure 5.13. Plot of regression of tibia length (mm) onto year of birth for black females.

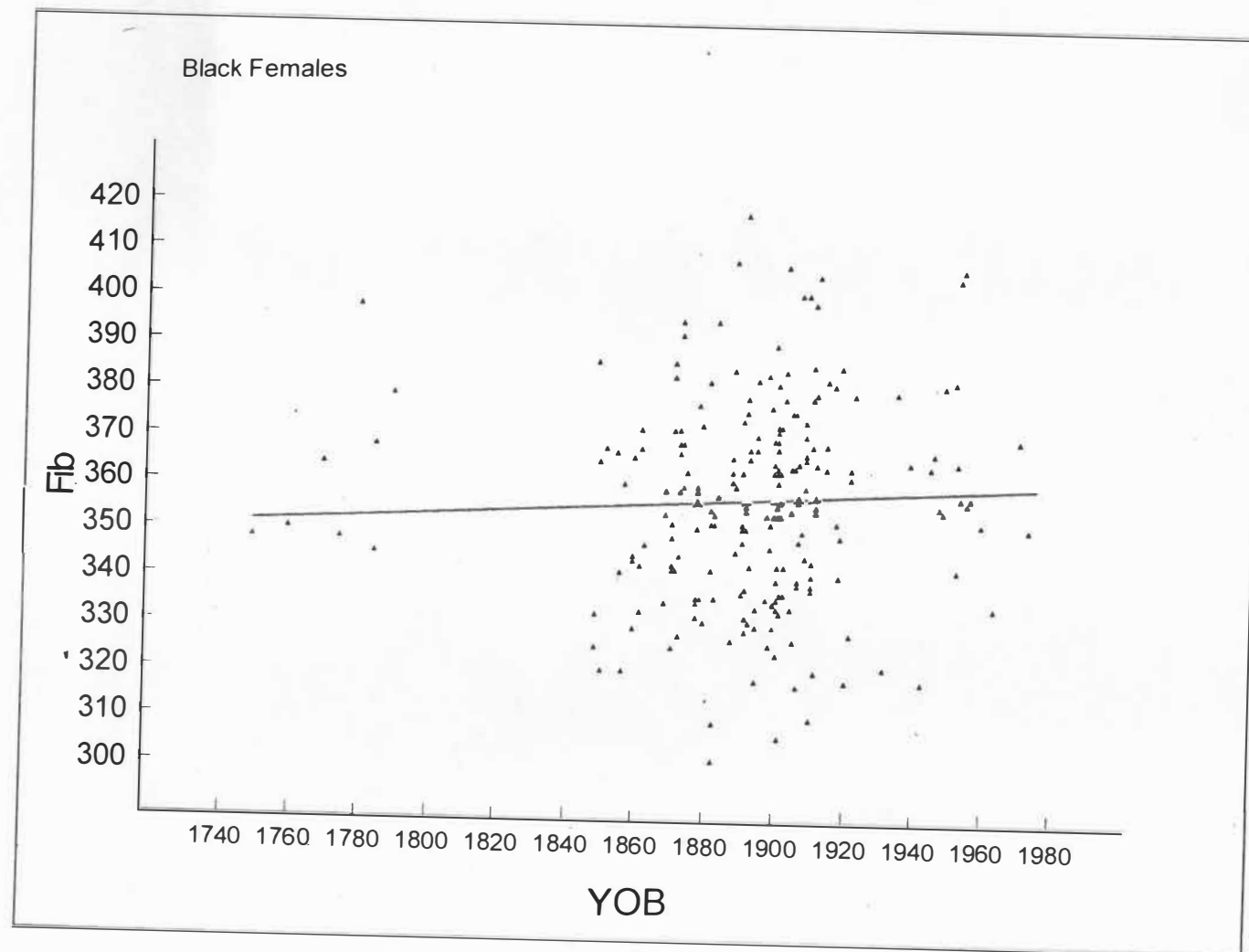


Figure 5.14. Plot of regression of fibula length (mm) onto year of birth for black females.

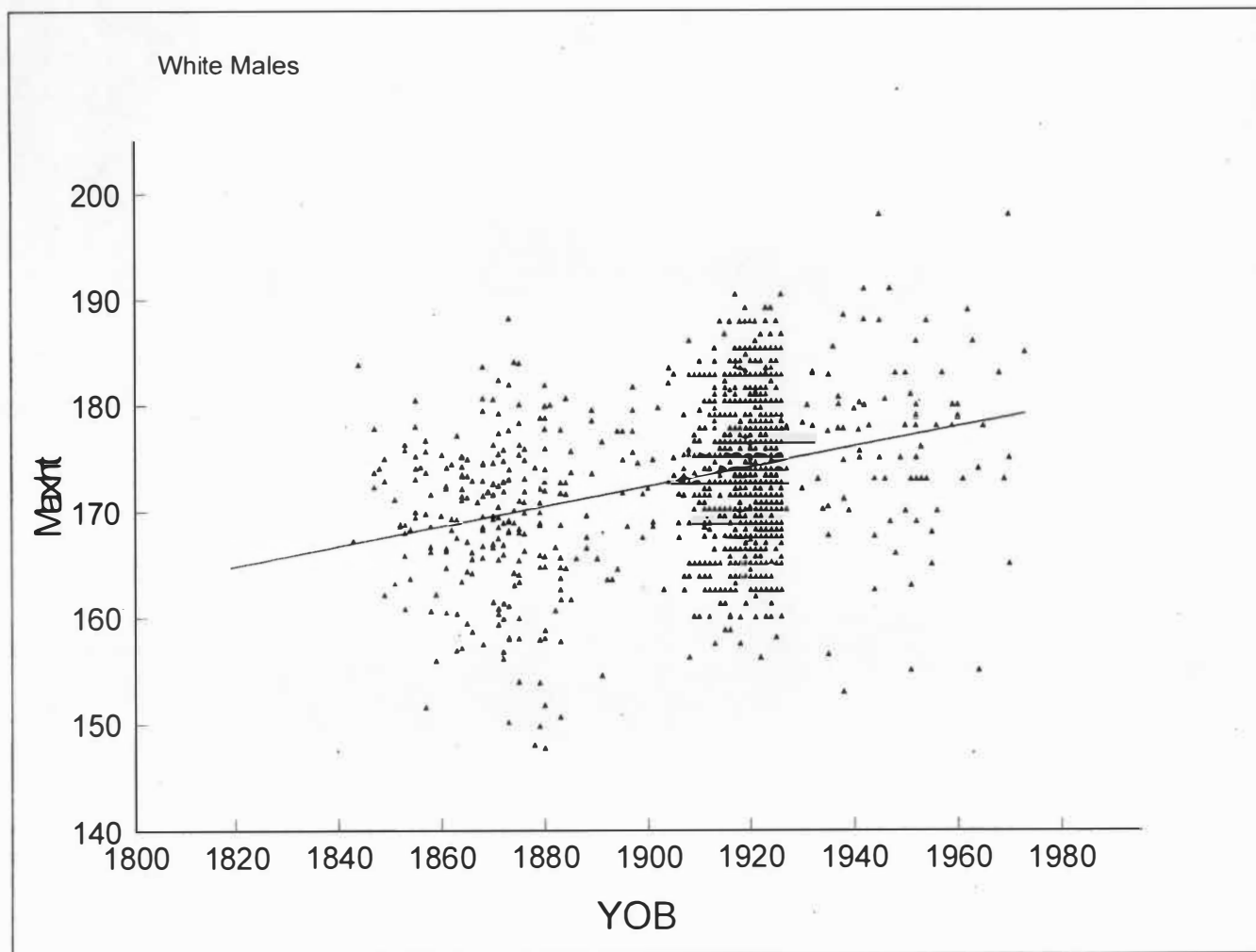


Figure 5.15. Plot of regression of maximum height (in cm) onto year of birth for white males.

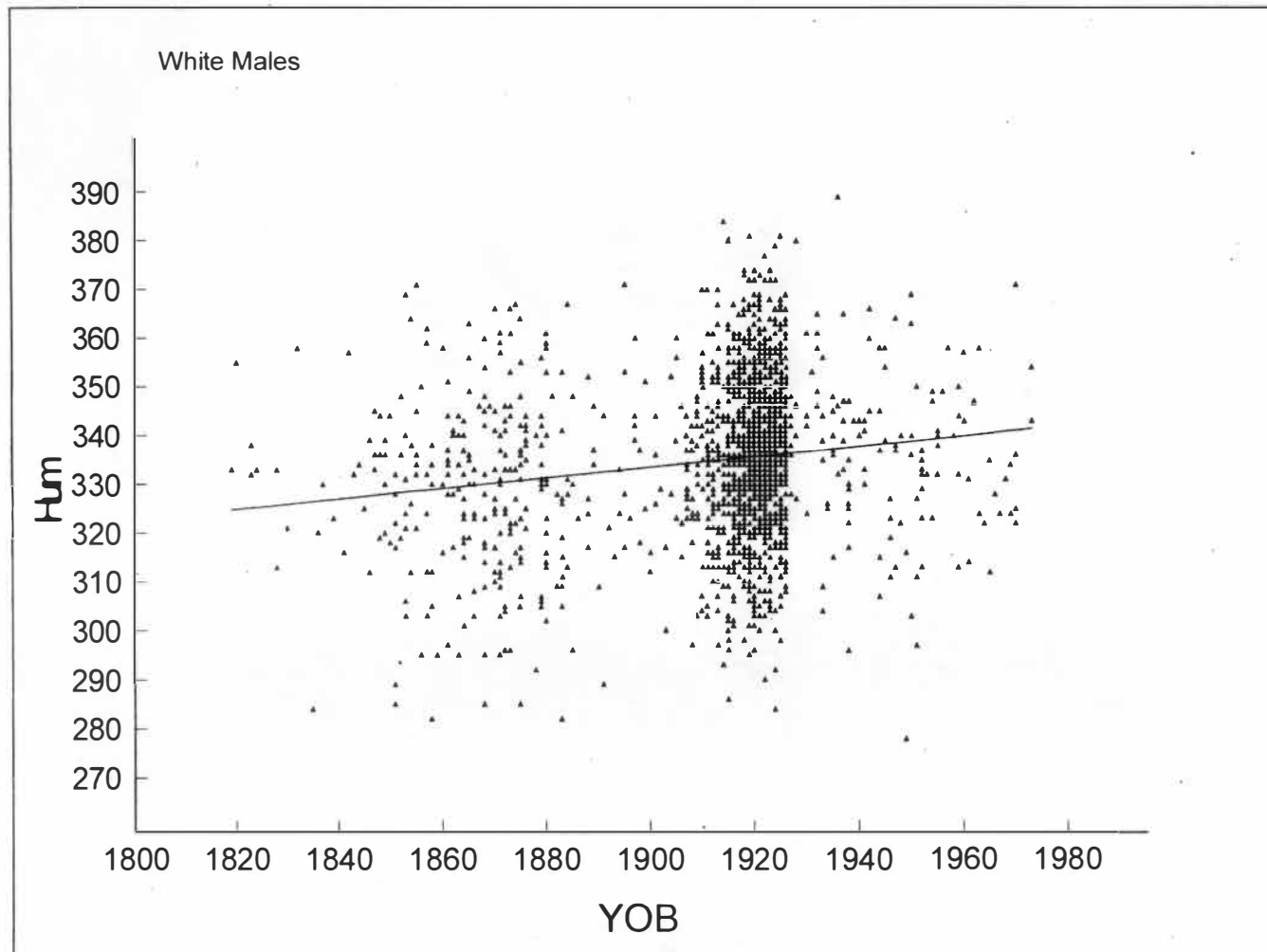


Figure 5.16. Plot of regression of humerus length (mm) onto year of birth for white males.

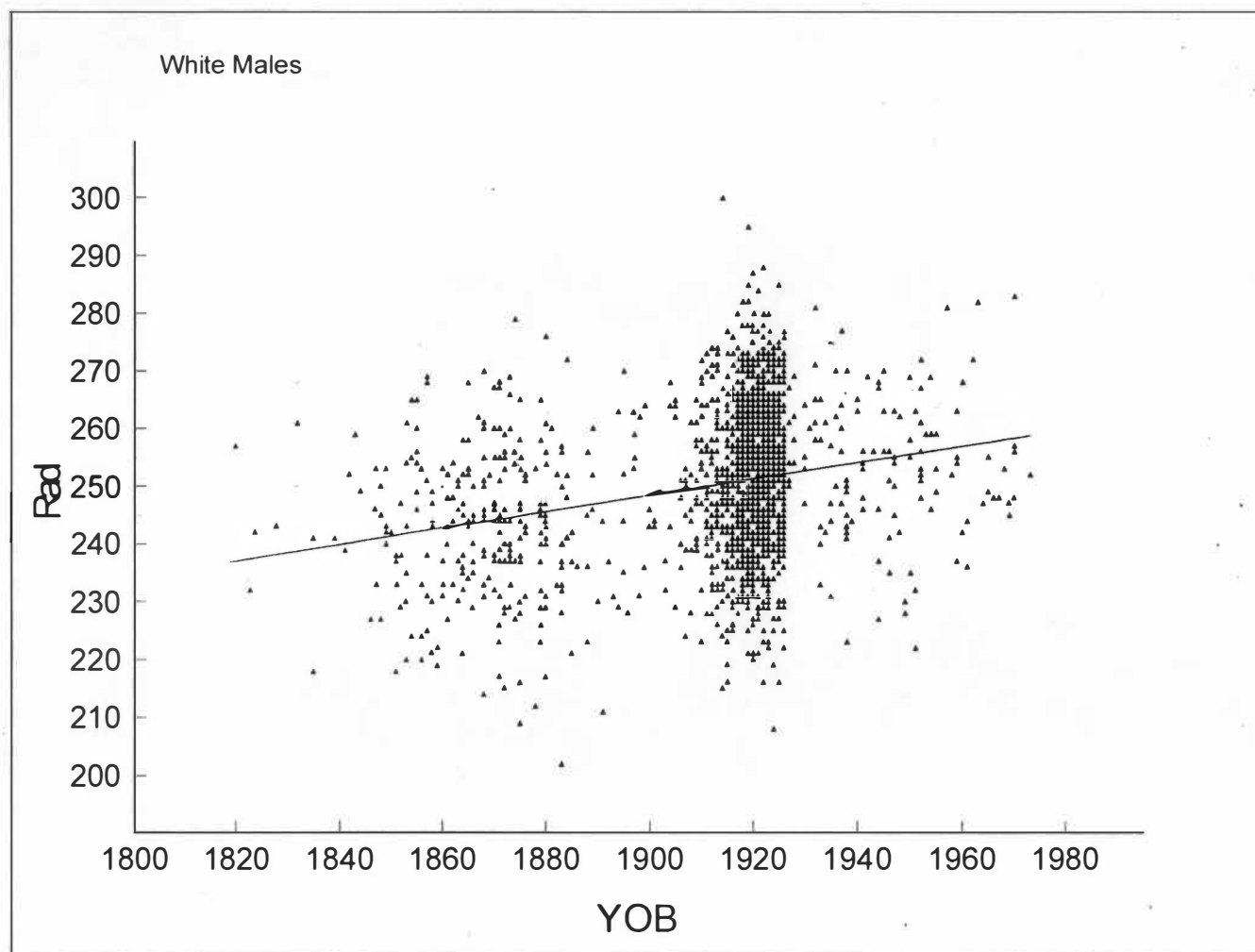


Figure 5.17. Plot of regression of radius length (mm) onto year of birth for white males.

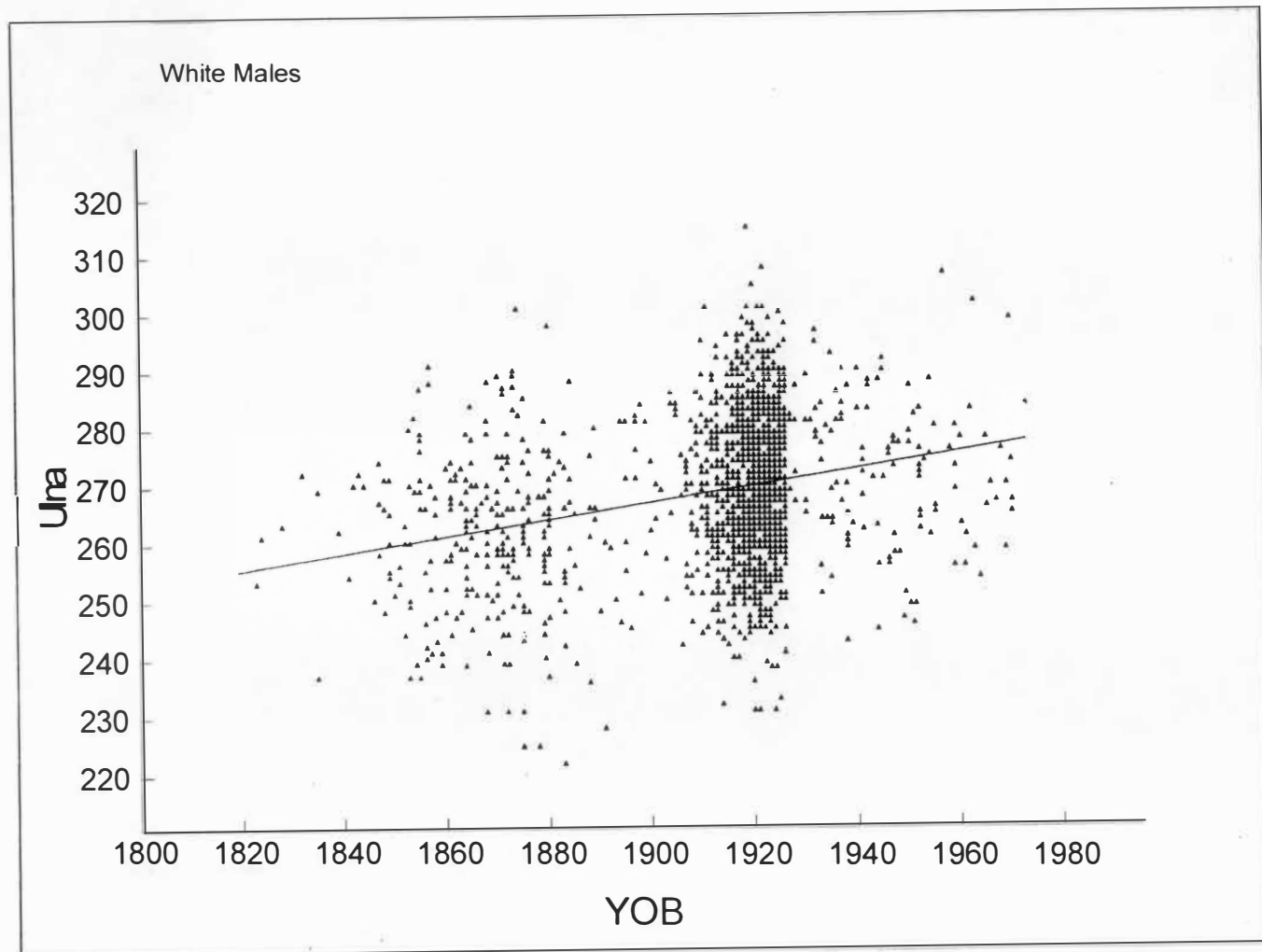


Figure 5.18. Plot of regression of ulna length (mm) onto year of birth for white females.

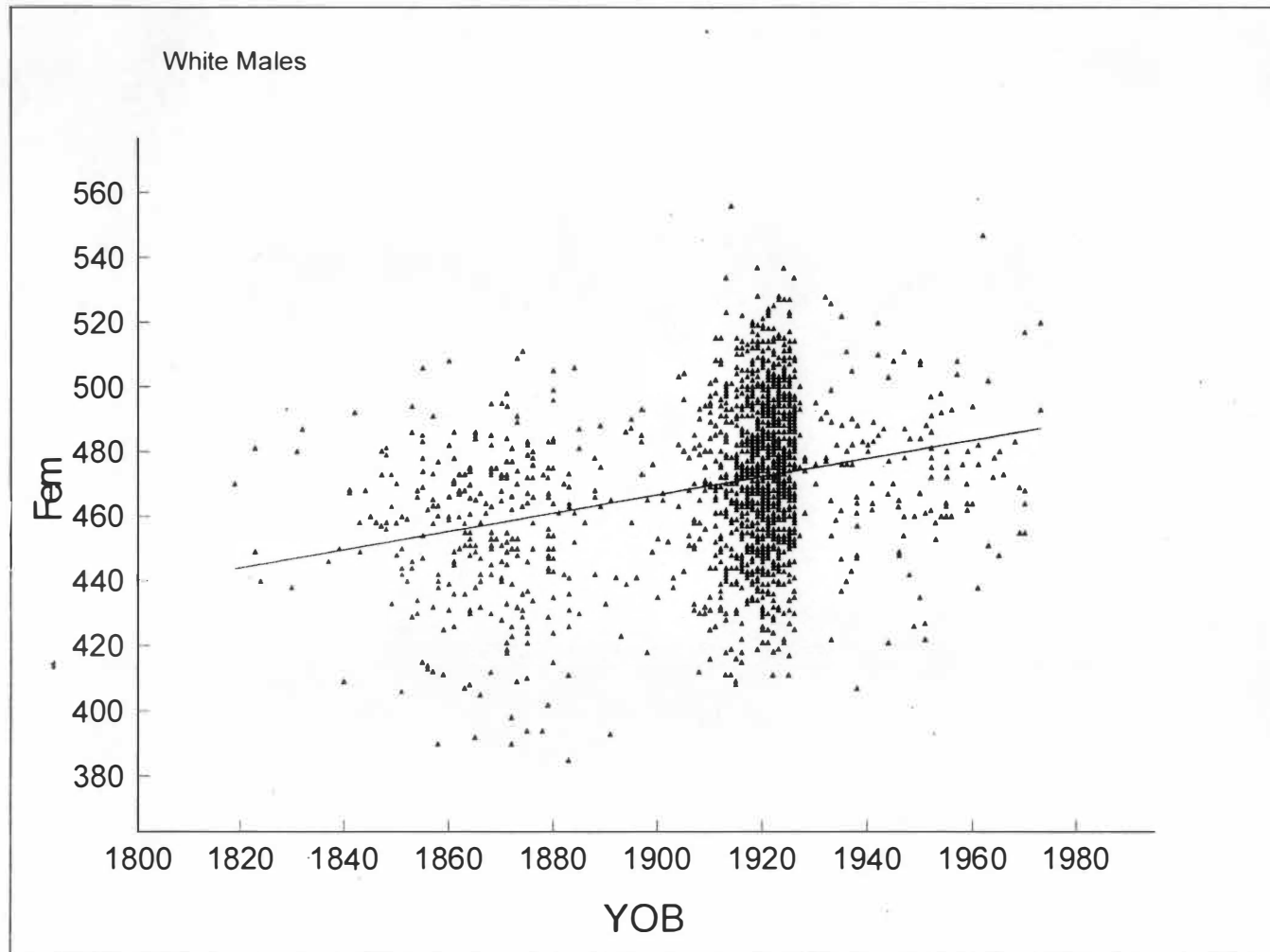


Figure 5.19. Plot of regression of femur length (mm) onto year of birth for white males.

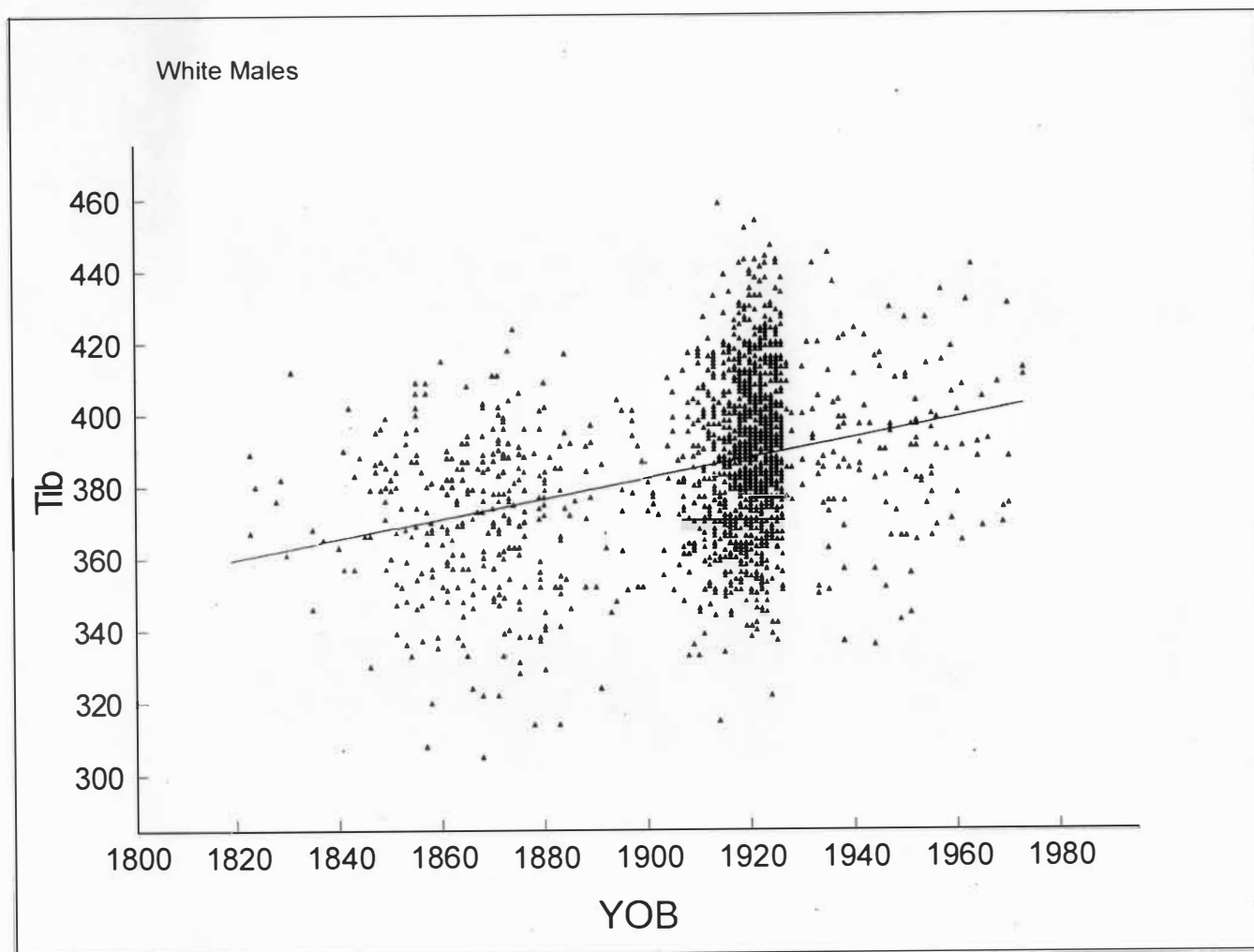


Figure 5.20. Plot of regression of tibia length (mm) onto year of birth for white males.

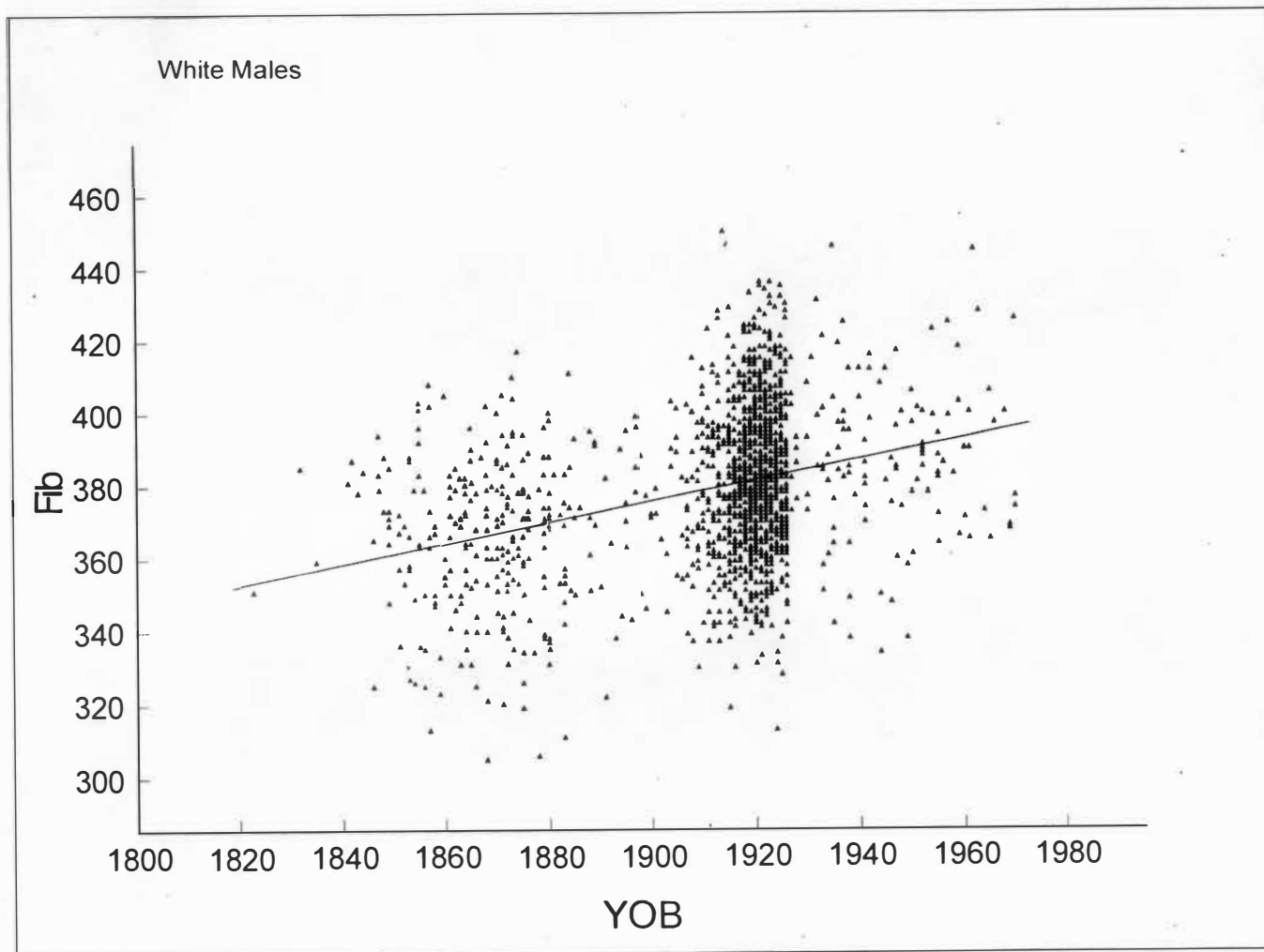


Figure 5.21. Plot of regression of fibula length (mm) onto year of birth for white males.

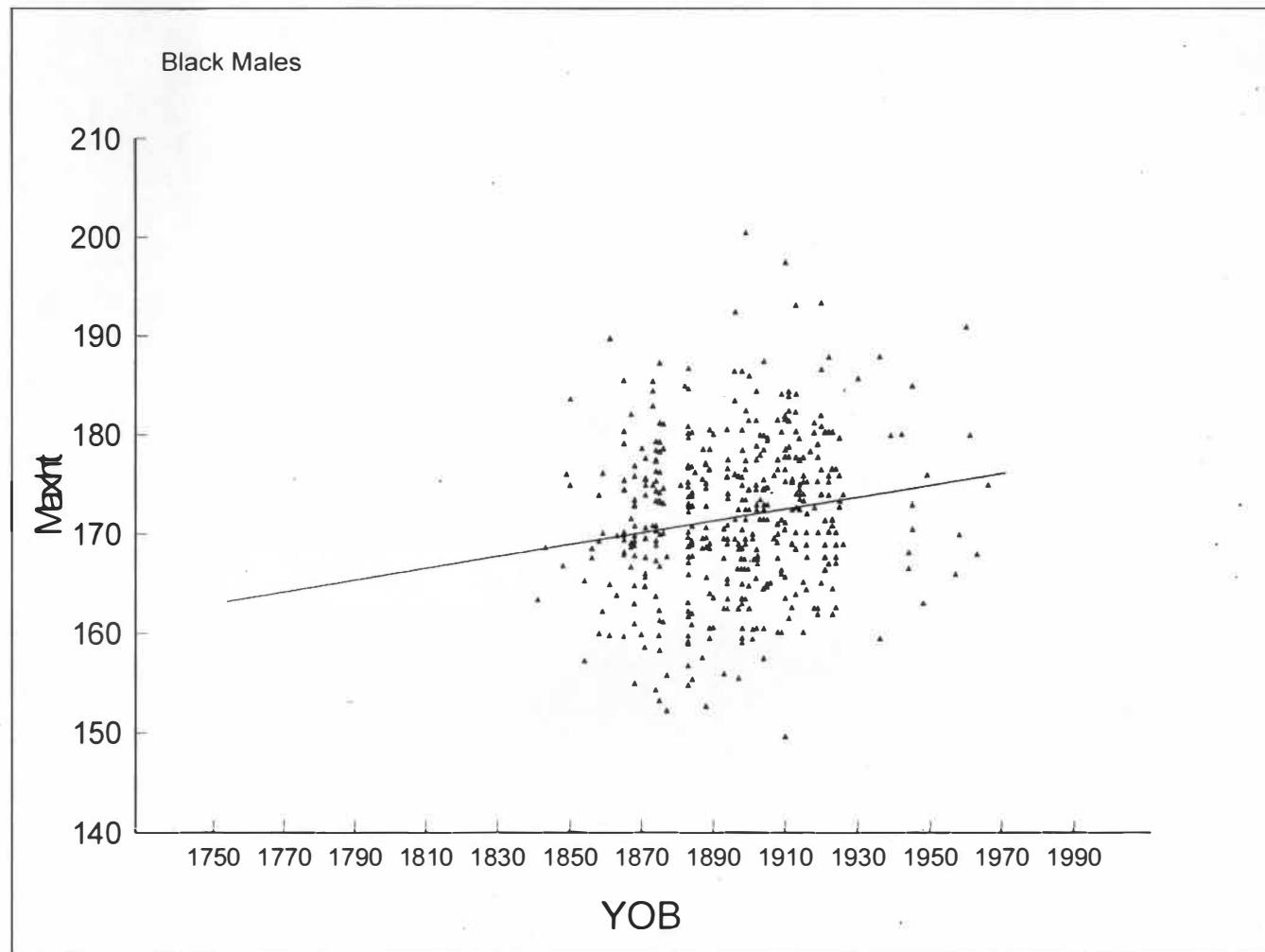


Figure 5.22. Plot of regression of maximum height (cm) onto year of birth for black males.

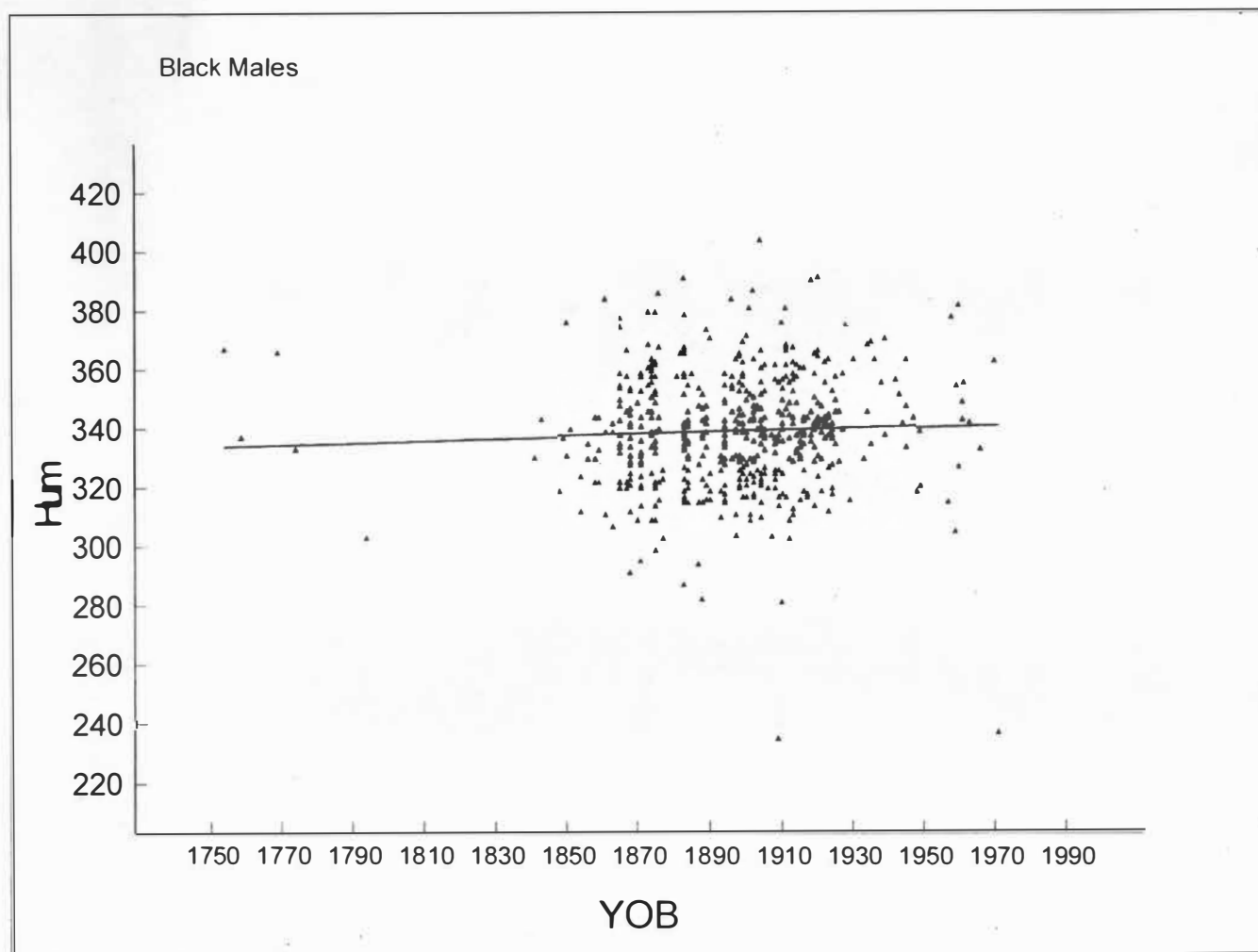


Figure 5.23. Plot of regression of humerus length (mm) onto year of birth for black males.

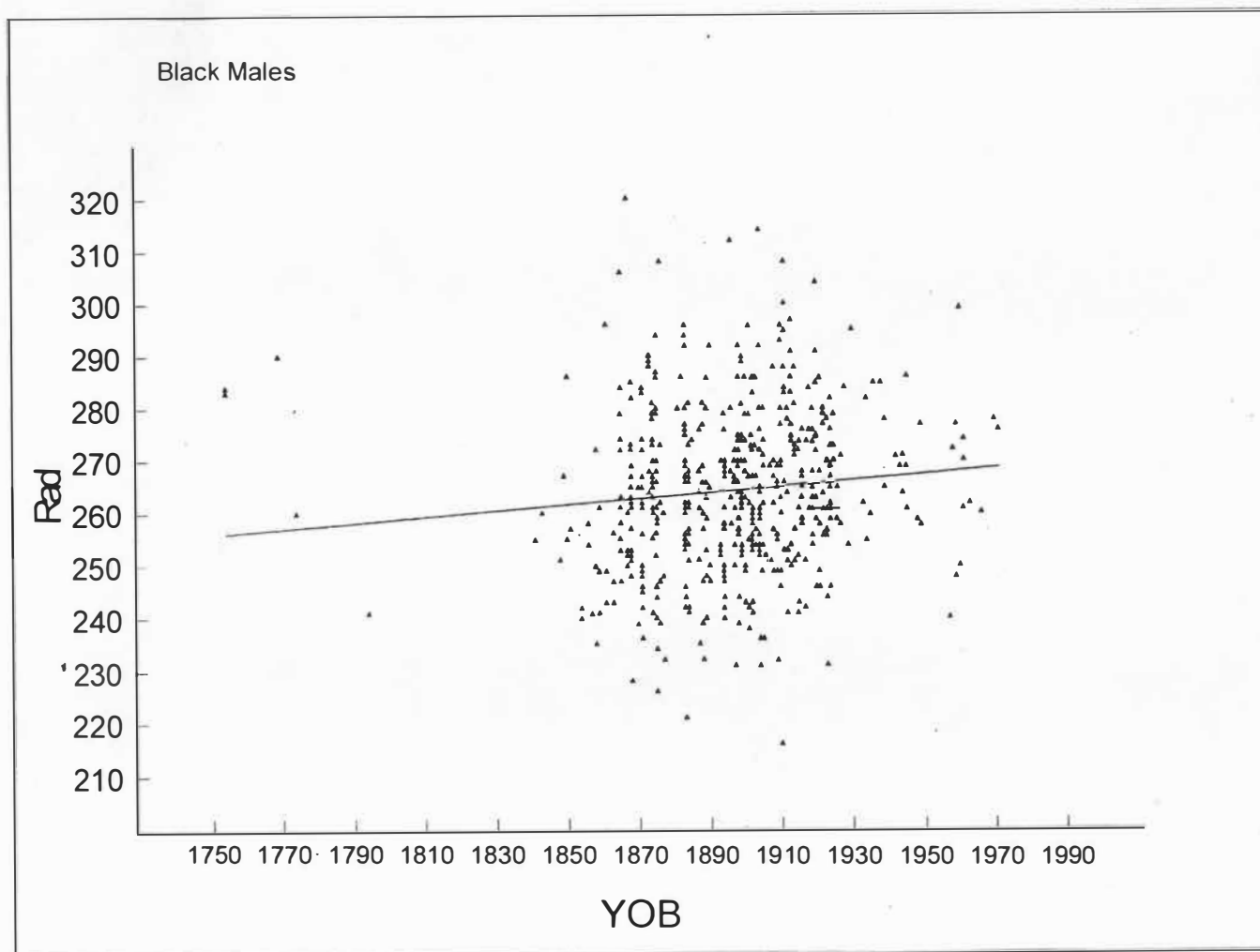


Figure 5.24. Plot of regression of radius length (mm) onto year of birth for black males.

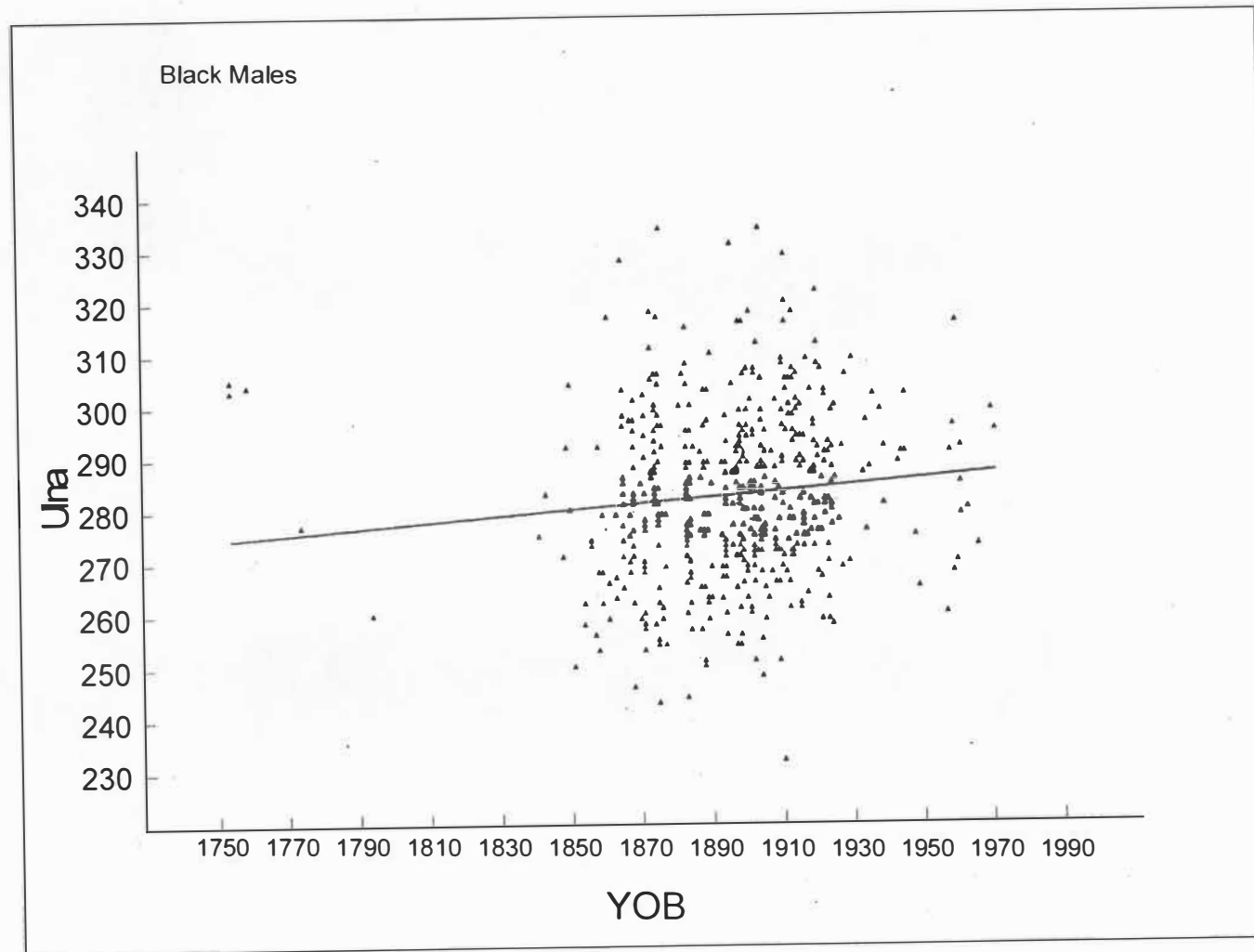


Figure 5.25. Plot of regression of ulna length (mm) onto year of birth for black males.

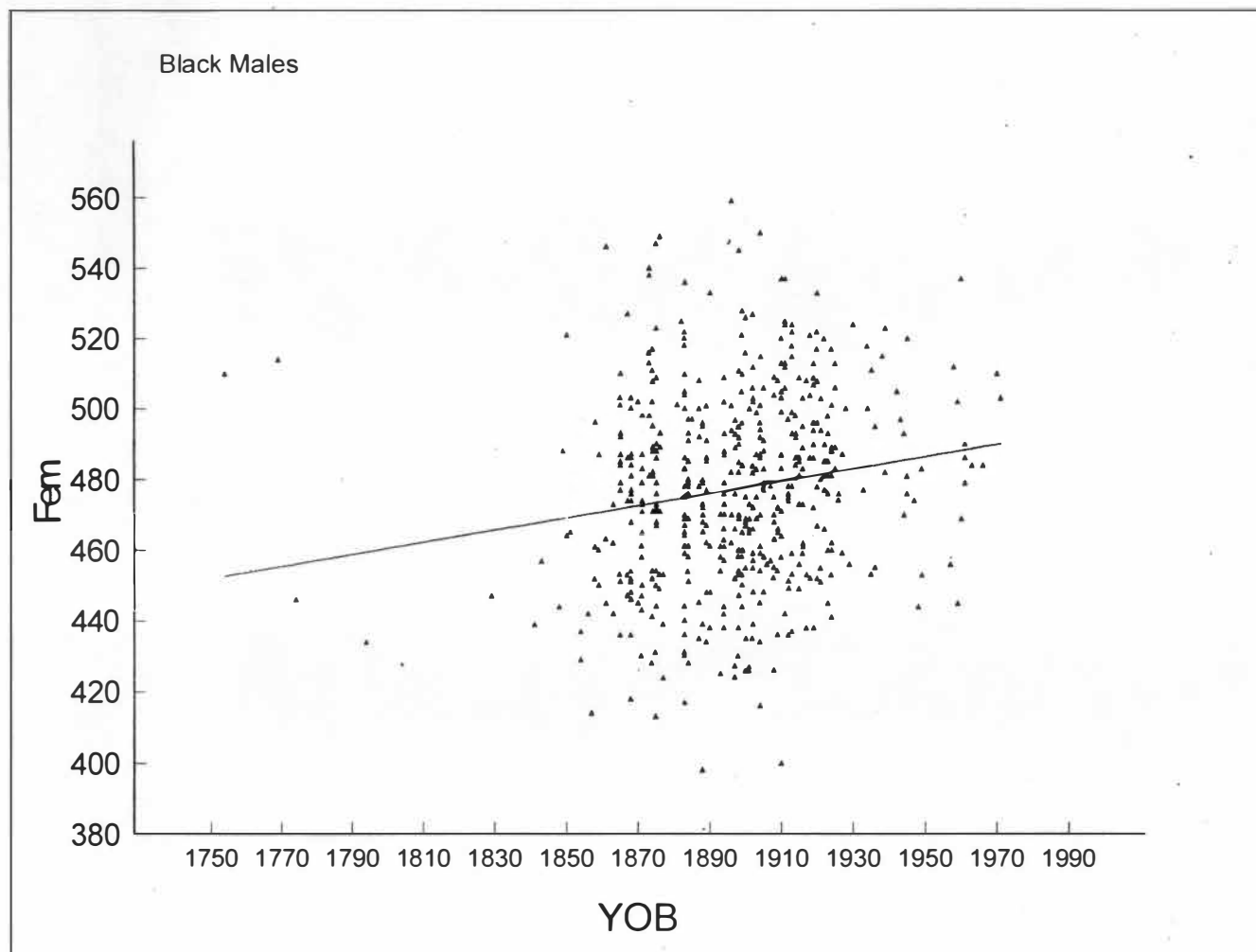


Figure 5.26. Plot of regression of femur length (mm) onto year of birth for black males.

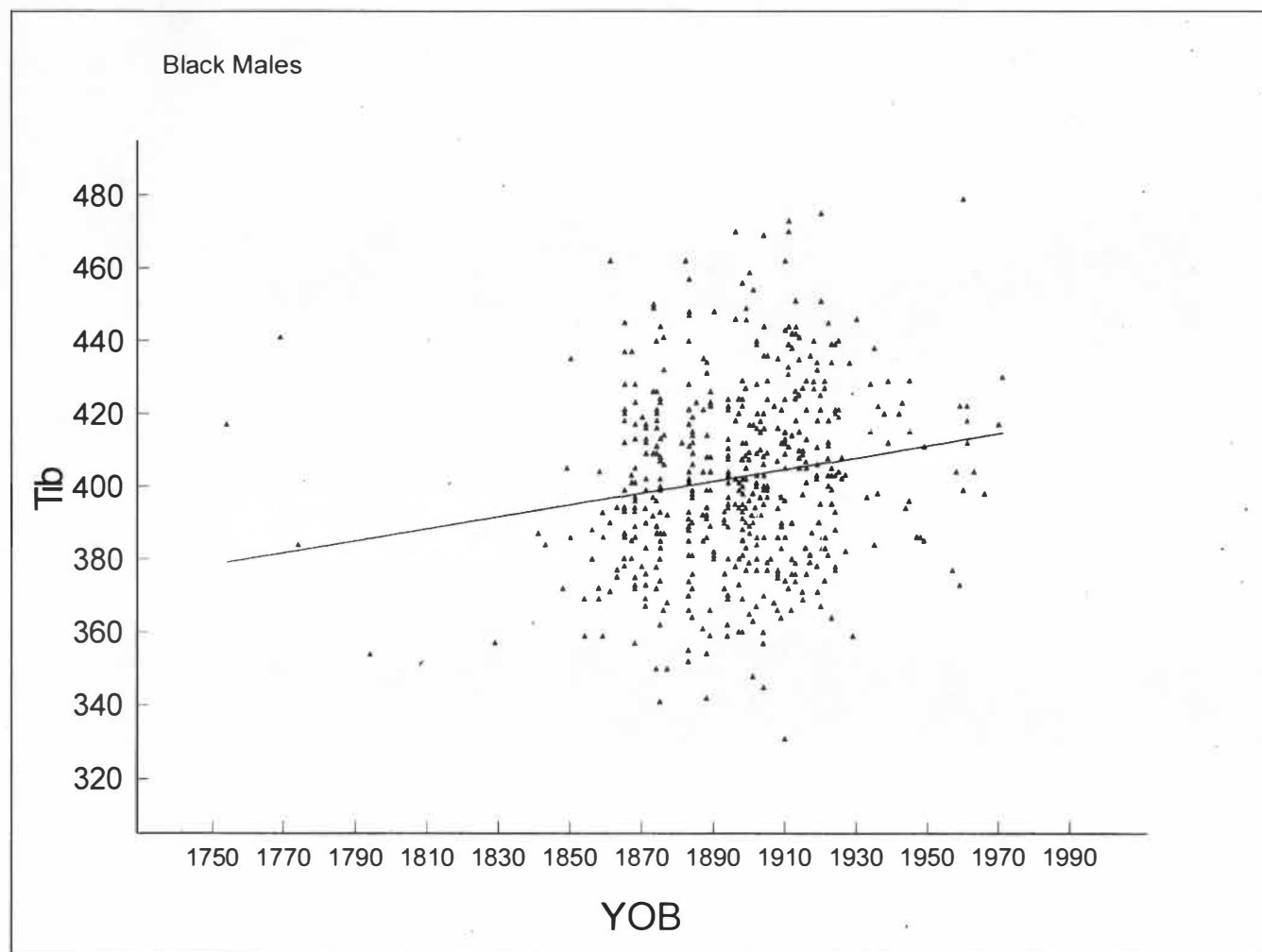


Figure 5.27. Plot of regression of tibia length (mm) onto year of birth for black males.

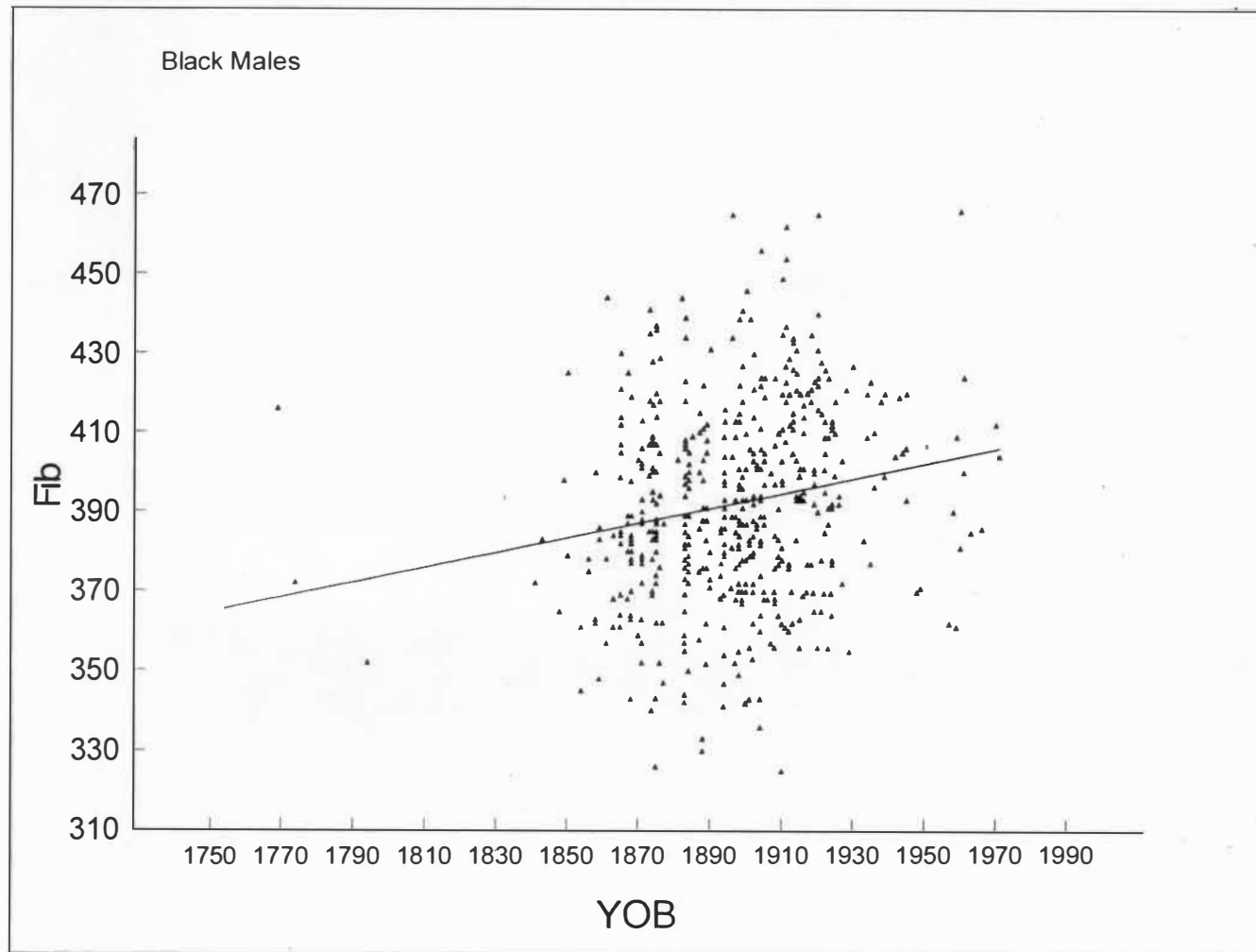


Figure 5.28. Plot of regression of fibula length (mm) onto year of birth for black males.

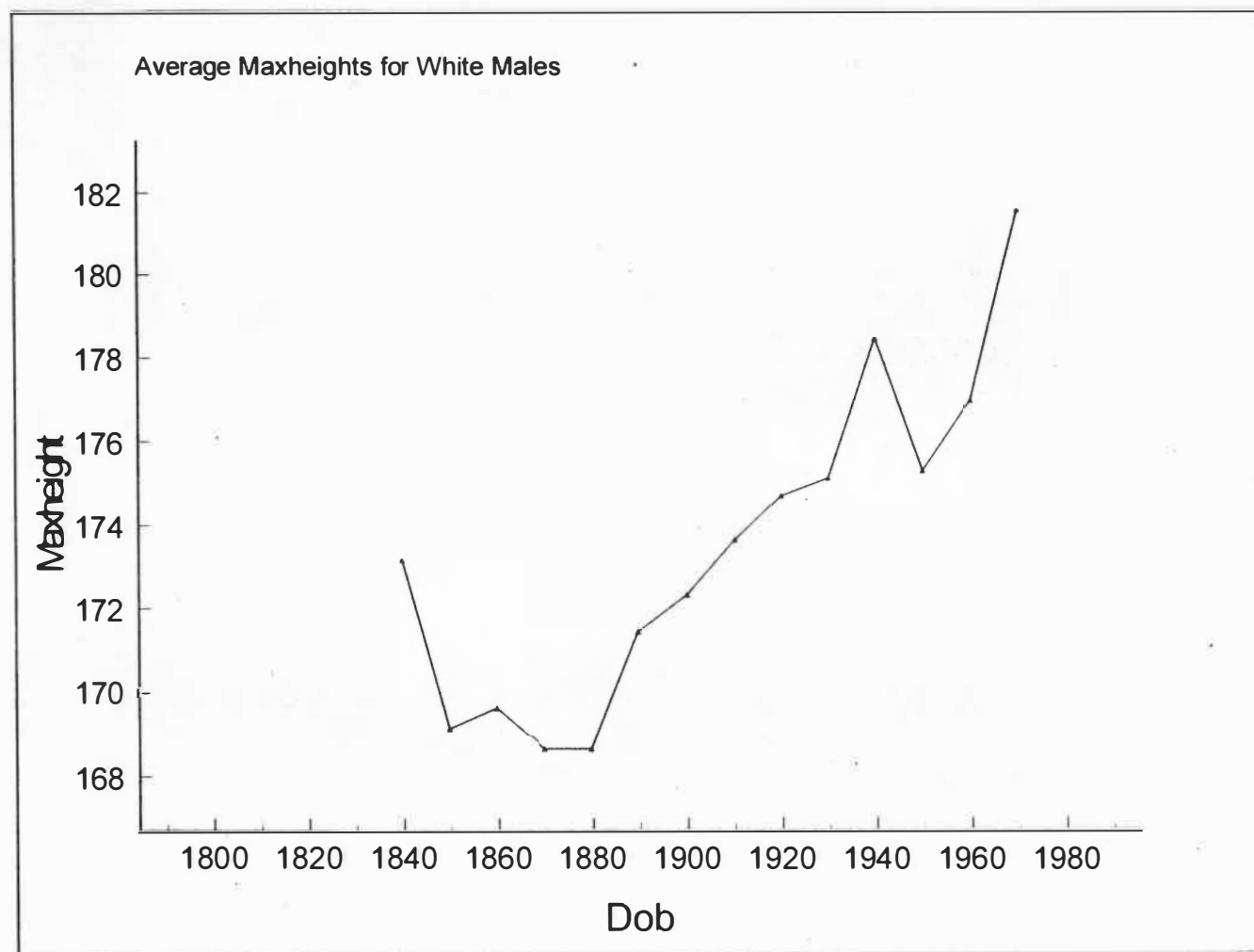


Figure 6.1. Decade means of maximum heights for white males.

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.