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**A FAMILIAL STUDY OF GROWTH AND HEALTH-RELATED FITNESS AMONG
CANADIANS OF ABORIGINAL AND EUROPEAN ANCESTRY**

By

Peter Todd Katzmarzyk

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ABSTRACT

A FAMILIAL STUDY OF GROWTH AND HEALTH-RELATED FITNESS AMONG CANADIANS OF ABORIGINAL AND EUROPEAN ANCESTRY

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The purpose of this study was to compare Canadians of First Nation (FN) and European ancestry (EA) in terms of body size, physique, and indicators of health-related fitness, and to determine the familial resemblance in these variables. A total of 624 subjects, 130 FN, 494 EA from the Northern Ontario communities of Temagami and Bear Island participated. The results indicated significant differences between FN and EA Canadians, and significant familial resemblance in body size, physique and health-related fitness. Generally, FN subjects were fatter and had a more central subcutaneous fat distribution than EA subjects. In both groups, males had less subcutaneous adiposity, but had a greater tendency to store proportionally more fat on the trunk than females. Few differences were evident for stature and skeletal dimensions between FN and EA subjects. The results also indicated that FN subjects were more endomorphic than EA subjects. The prevalence of obesity in FN was generally higher than in EA. Among males and females 5-19 years, the prevalence of obesity (≥ 85 th percentile age-specific NHANES II BMI) was 38.1% and 29.4% in FN males and females, respectively, and 21.3% and 16.9% in EA males and females, respectively. In FN adults 20-75 years, the prevalence of obesity (≥ 85 th percentile NHANES II BMI for 20-29 year old people) was 51.4% in FN males, 58.8% in FN females, 39.0% in EA males, and 35.0% in EA females. Analyses of secular changes indicated a positive secular trend for stature of 1.0 cm/decade in EA males. Estimated

secular changes in the other groups were not significant. Correlations between first degree relatives indicated significant familial resemblance in body size, physique, adiposity, relative fat distribution, grip strength and trunk flexibility. Spousal correlations showed little assortative mating in this sample. The results suggest that the increased prevalence of several metabolic diseases in FN Canadians may in part be explained by morphological characteristics which are associated with increased risk for disease, and that these differences are apparent in childhood.

For Brenda and Bradley

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CHAPTER I

INTRODUCTION AND CONCEPTUAL FRAMEWORK

Introduction

Studies of growth and health-related fitness, by design, are generally comparative. For example, growth status is often compared to reference data collected for a representative sample of the population. Alternatively, two subgroups of the population may be compared to each other in any of several growth and fitness parameters.

Aboriginal North Americans have a higher prevalence of obesity, diabetes and gall bladder disease than is observed in the general population. This syndrome of diseases, which falls under the rubric of the "New World Syndrome", is hypothesized to have a significant genetic component, as there is an apparent relationship between degree of Native American admixture and the syndrome (West, 1974; Gardner et al., 1984; Weiss et al., 1984; Szathmary, 1994). Among Aboriginal groups in Ontario, the estimated prevalence rates of diabetes are 6.1% for males and 9.2% for females (Young et al., 1990), which is considerably higher than national rates for Canada which have been reported at 1.7% (Statistics Canada, 1981) and 2.4% (Statistics Canada, 1987).

A question which is central to the study of the New World Syndrome is whether the high prevalence of diseases observed in Native groups is the result of a greater genetic susceptibility, or from a greater exposure to environmental stresses. Also of interest is the role of risk factors in the progression of degenerative diseases such as obesity and diabetes, and genetic and environmental influences on the risk factors. Obesity and the distribution of fat within the body are important risk factors

for disease (NIH, 1985; Ducimetiere et al., 1986; Ducimetiere and Richard, 1989; Després et al., 1990). Physique is also implicated as being associated with disease risk (Malina et al., 1997). Thus, the cause of high prevalence rates for metabolic diseases in North American Aboriginals is likely multifactorial, and a better understanding of risk factors such as obesity, relative fat distribution and physique may be important in understanding the etiology of the New World Syndrome among these groups.

In general, the growth of Native North Americans, and in particular, the Canadian First Nation groups, has not been extensively studied. Studies which have been done to date, with a few exceptions, have focused on the nutrition and health of the adult population, with little emphasis on growth. Since it is realized that diseases such as adult-onset diabetes and obesity have their roots in childhood and adolescence, it seems appropriate that emphasis be placed on studying the growth and health characteristics of Aboriginal children and youth. Thus, a study of growth in body size, physique, and indicators of health-related fitness among Canadians of First Nation and European ancestry may provide valuable insights into the observed prevalence rates of the New World Syndrome.

Given the proposed relationship between health-related fitness and health, outlined in Figure 1.1, an understanding of how much variation in health-related fitness is due to genetic and environmental factors is important. Studies concerned with estimating familial resemblance in fitness and motor performance phenotypes are confounded by the interrelationships between body dimensions and fitness. Typically studies have not taken into account the influence of body size on fitness when estimating the impact of familial factors on these traits. A key question which remains to be addressed is: given the relationship between anthropometry and fitness (Malina, 1975, 1994), what is the genetic contribution to health-related fitness once the effects of body size have been controlled?

Rationale and Purpose of the Study

The rationale for this study is three-fold. The first comes from the specific health concerns of First Nation people (Health and Welfare Canada, 1992). Perhaps the adult-onset diseases associated with the adoption of a westernized diet and lifestyle have their roots in childhood and adolescence, such that differences in body size and morphology (morphological fitness) between First Nation and European Canadians may be evident in this period of life. There are little data available describing relative fat distribution and physique in First Nation Canadians, which limits discussions of disease and risk factor prevention in these groups (Young, 1993).

The second rationale for this study stems from indications that secular trends in body size have occurred in Canada over the past 35 years. It is estimated that a national secular trend of about 1 cm/decade for stature has occurred from 1956 to 1986 (Shephard, 1986). Persistence of this secular trend limits interpretations of comparisons with reference data collected in 1970-72 (Health and Welfare Canada, 1980) and in 1981 (Fitness Canada, 1983, 1985, 1986).

The third rationale for this study is the need for a better understanding of the interrelationships among genetics, body morphology, and health-related fitness, as outlined in Figure 1.2. The interrelationships among body morphology and fitness phenotypes will be determined using correlational analyses. The family resemblance of body size and morphology will also be determined using correlation and regression techniques, as will the heritability of indicators of health-related fitness, taking into account body morphology as a covariate.

The purpose of this study is thus to (1) compare Canadians of European and First Nation ancestry in terms of body size, physique, and indicators of health-related fitness, (2) evaluate secular trends in body size in Canadians of European and First Nation ancestry, and (3) estimate familial resemblance in body size, physique, and indicators of health-related fitness in Canadians of European and First Nation ancestry.

Research Hypotheses

The specific research hypotheses are as follows:

- 1) There are significant differences between Canadians of First Nation (FN) and European ancestry (EA) in body size, physique, and indicators of health-related fitness.**
 - 1a) FN Canadians are heavier and demonstrate greater subcutaneous fatness than EA Canadians throughout childhood into adulthood.**
 - 1b) There are significant differences in relative fat distribution and physique between FN and EA Canadians.**
 - 1c) There are no differences in stature and other skeletal dimensions between FN and EA Canadians.**
- 2) Secular trends in body size are evident in FN and EA Canadians.**
 - 2a) There are significant secular increases in stature, mass and the BMI in FN and EA Canadians.**
- 3) There is significant familial resemblance in body size, physique and indicators of health-related fitness in FN and EA Canadians.**
 - 3a) There is significant familial resemblance in body size, physique and indicators of health-related fitness in FN and EA Canadians.**
 - 3b) Estimated heritabilities for strength and flexibility are greater after body morphology is factored into the analyses as a covariate.**

Limitations of Study

The study population is unique in that all participants are from the same small community in northern Ontario. This allows a certain control over environmental factors; however, it also limits the applicability of the results to other population groups. The results of this study carry significance for the residents of Temagami and Bear Island, but caution must be used when extrapolating the results to other communities. Given that regional data are not available from the national Canadian surveys (Health and Welfare Canada, 1980; Fitness Canada, 1983, 1985, 1986) for

comparison, the results from this study should not be considered representative of the general Canadian population.

This study was conducted over only the summer season, limiting the extension of results to other seasons. Anecdotal references by several subjects indicate that there is seasonal variation in body fatness and strength in this population between the summer and winter months. Subjects indicated that both FN and EA people are less active and may accumulate fat in the winter months; thus, the results of this study should be viewed as status during the summer months only.

Data on physical activity and dietary intake were not obtained, which limits interpretations about energy balance and speculations regarding differences in body size and fatness between EA and FN subjects.

The assignment of racial affinity was made by the participants themselves, such that concrete biological groupings were not possible. Difficulties arose in assigning hybrids with differing degrees of admixture to a specific group. Thus, results of comparisons between FN and EA subjects should be viewed as conservative, as the inclusion of hybrids may temper the results.

Significance of Study

This study has the potential of providing important information on the covariance among health-related phenotypes and the variation in these phenotypes which can be attributed to familial factors. In addition, the growth characteristics of FN children and youth are described and compared to national reference data, adding to the understanding of Aboriginal growth. Little data are available on relative fat distribution and physique in FN Canadians; thus, this study will provide important information on these characteristics. Although the results of this study may not be generalizable to the rest of Canada, the detailed observations from this region are valuable in and of themselves.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This study compares growth and adult morphology among groups of First Nation (FN) and European (EA) ancestry, while framing the data within a familial design which allows inferences about familial resemblance in parameters of growth and health-related fitness. Thus, the literature review is divided into two sections; the first examines body size, fatness, fat distribution, physique and secular trends among Aboriginal groups with comparisons to the general North American population, and the second reviews the current methodologies and understanding of the familial resemblance in body size and health-related fitness.

Section I: Growth and Adult Characteristics of Native North Americans

Introduction

Although there is considerable knowledge about the growth of children in general, there is a lack of data describing the growth characteristics of Native North Americans. Several anthropometric studies have been conducted; however, such studies have more often focused on the health and nutrition of adults rather than on the growth of children. Indeed, the first edition of Eveleth and Tanner's Worldwide Variation in Human Growth (1976) cites data from only four descriptive growth studies on Amerindian groups from North America. The subsequent edition (Eveleth and Tanner, 1990) includes growth data from only three more recent studies among Amerindians. This general lack of growth data represents a lacuna in understanding Amerindian health and variability.

The study of the growth of Amerindian children is important from several perspectives. First, growth studies are important to understand the nature of the growth process itself. This most basic rationale suggests that a knowledge of growth and maturation is important for understanding the findings of research within the clinical and scientific communities which work with children. Given the lack of data for Amerindian children, a growth study is important in its own right to provide basic information.

Second, there are a disproportionately high number of health problems among adult Native Americans compared to the general population which may perhaps be better explained in the context of growth and maturation. Diabetes, obesity, and gall bladder disease, which are particularly problematic for Amerindian groups (West, 1974; Weiss et al., 1984; Young, 1993), may have their origins in processes occurring during the growth period, beginning prenatally and extending through adolescence.

Third, a more theoretical approach to the study of human growth has been the association between patterns of growth and specific environmental influences, such as residence in cold climates or high altitudes, which may help to explain the origins of human variability (Leonard et al., 1994, 1995). Thus, the study of diverse ethnic groups is important for the formulation of evolutionary theories about human variability.

Fourth, the realization that growth parameters can serve as indicators of the quality of the physical environment has led many investigators to consider childhood growth as an important index of health and the standard of living for entire populations (Tanner, 1994). Such a rationale indicates that the health status of the Native American population may be reflected in the growth of children in these groups.

This review summarizes the available data on the growth of North American Aborigines and compares the data to reference data for Canada and the U.S. The reference data are derived largely from samples of European ancestry.

Growth Data

The available data on the growth of Aboriginal North Americans are largely limited to health studies in which the main focus is the health and nutritional status of the population. Considerably more data are available on the anthropometry of adult Natives than on children; however, the main focus of this review is the work completed with children and adolescents. Data on adults are presented for the purpose of comparing the end product of growth, i.e., adult morphology.

Descriptive growth studies have been conducted among the Navajo (Darby et al., 1956), Apache (Kraus, 1961), Gros Ventres and Assiniboin (ICNND, 1964b), Blackfeet (ICNND, 1964a), Nootka and Chilcotin (Birkbeck et al., 1971), Athapaskan (Lee and Birkbeck, 1977), Chippewa, Sioux and Winnebago (Johnston et al. 1978), and Cree (Coodin et al., 1980). The Alaskan Eskimos are among the most studied of the North American groups, and several studies have been published characterizing their growth (Heller et al., 1967; Jamison, 1970; Johnston et al., 1982; Rode and Shephard, 1994).

Body Size

Childhood and Adolescent Growth

Growth studies among Native North Americans generally demonstrate few differences in stature and body mass between children of Aboriginal and European ancestry. Comparisons of stature and body mass between the Navajo and a nationally represented Canadian sample revealed no significant differences between the groups (Darby et al., 1956). Similarly, a comparison of growth rates among the Apache, African Negroes, and American Whites (Irish ancestry) found no differences based on regression lines (Kraus, 1961). A study among Cherokee adolescents demonstrated that mean statures of youths 13-17 years were similar to National reference data; however, mean body masses were significantly greater than the reference data in both boys and girls (Story et al., 1986).

The United States Interdepartmental Committee on Nutrition for National Defense (ICNND, 1964a; 1964b) conducted nutrition surveys on the Indian reservations at Fort Belknap, Montana (Gros Ventres and Assiniboin) and the Blackfeet Reservation located to the west of Fort Belknap (Moore, 1972). Statures and body masses of children 6-11 years of age were compared to Iowa reference data. All of the children in both studies tended to be at or above the reference medians in stature and body mass. The Gros Ventres/Assiniboin boys tended to deviate the most in body mass from the reference children.

In a study of urbanization of Chippewa, Sioux, and Winnebago in Minneapolis, Johnston et al. (1978) noted that Native children were similar in stature to U.S. reference values until 12 years of age in boys, when the native sample began to lag behind. By 17 years of age, the reference mean was 6 cm taller than the Minneapolis Native boys sample. Body masses, however, showed a clear and consistent difference, with the Native boys and girls being heavier than the reference means beginning with age 2.

Data from Canadian Aboriginal groups parallel those from studies conducted in the United States. Coodin et al. (1980) reported that both the stature and body mass of Northern Manitoba Cree from birth to 6 years of age were similar to those reported for U.S. children; however, weight-for-height of the girls exceeded the reference. Studies among Athapaskan Aboriginals in British Columbia and the Yukon Territory indicated that they were shorter than Iowa reference values; however, all of the children were within 2 standard deviations of the reference (Birkbeck et al., 1971; Lee and Birkbeck, 1977). In some samples there was a tendency for the statures and body masses to lag, relative to the Iowa reference during adolescence (Lee and Birkbeck, 1977). The authors suggested that the results were consistent with moderate growth retardation during late adolescence; however, the biochemical data failed to reveal any signs of nutrient deficiencies.

Eskimo children are consistently shorter than other Aboriginal groups and nationally representative reference data. Heller et al. (1967) reported that the mean stature of the Eskimo children followed the 5th percentiles for White children until 16 years of age. Mass, however, was as great as that for White children until about 6 years of age; thereafter, Eskimo children weighed less. Similarly, St. Lawrence Island Eskimo children were shorter than both White and Black U.S. reference means, but body mass in the Eskimos was similar to U.S. reference values (Johnston et al., 1982). Jamison's (1970) analysis of the growth characteristics of a sample of Wainwright Eskimos indicated that adults were, on average, 12 cm shorter than North American Whites, and that they did not reach final adult height until they were in their mid-twenties.

The distribution of statures among Native North American groups generally overlaps those of the general Canadian population. Figures 2.1 and 2.2 illustrate growth in stature for Native American boys and girls, respectively, from age 4 to 18 years. The solid curves represent the 10th and 90th percentiles of Canadian children in the 1970s (Health and Welfare Canada, 1980). In both boys and girls, age-specific means fall between the 10th and 90th percentiles. Eskimos from Alaska (Heller et al., 1967) and specifically from Wainwright (Jamison, 1970) are among the shortest of the native groups; the Alaskan Eskimos fall below the 10th percentile in the older age groups in both boys and girls. The Gros Ventres/Assiniboin from Fort Belknap (ICNND, 1964b) are among the tallest of the groups depicted in the figures between the ages of 6 and 10 (the age range for that study), tracking between the 50th and 75th percentiles for both boys and girls (note: the 50th and 75th percentiles are not shown).

As with stature, there is considerable overlap in the mean body masses of Native groups. Figures 2.3 and 2.4 illustrate growth in body mass from 4 to 18 years in Amerindian boys and girls, respectively. The solid curves represent the 10th and 90th percentiles of Canadian children in the 1970s (Health and Welfare Canada, 1980).

All age-specific means fall between the 10th and 90th percentiles. The Gros Ventres/Assiniboin (ICNND, 1964b) and the Chippewa, Sioux and Winnebago (Johnston et al., 1978) are among the heaviest girls and boys in the older age groups. Among males, the Apache and Navajo are among the lightest groups at younger ages, whereas Alaskan Eskimos are the lightest at older ages. In girls, Alaskan Eskimos are the lightest group throughout the age range represented.

Adult Morphology

Considerable diversity in adult stature and body mass exists among selected Amerindian groups (Table 2.1). It is difficult to compare adult values to a nationally representative sample of Canadians (or to each other), as the age ranges vary and possible secular variation is not controlled (Jamison, 1970; Miller, 1970; Sugarman et al., 1990; Knowler et al., 1991; Rode and Shephard, 1994). Blackfeet men and women appear to be tallest, while the Eskimos are shortest. This difference appears to be quite real, as it is unlikely that a secular trend over one generation could have accounted for the observed difference of 11.1 cm in men and 9 cm in women between these two groups.

The Eskimo women measured by Jamison and Zegura (1970) in Wainwright, Alaska are the heaviest group; however, they are also the shortest. The heaviest men in are the Chilcotins from British Columbia, while the lightest are the Alaskan Eskimo men.

Fatness and Relative Fat Distribution

Fatness

Body fatness is generally estimated in anthropological studies from skinfolds or the BMI. The former indicates subcutaneous adipose tissue, while the latter is an indirect indicator of obesity. In the general adult population, the BMI is correlated with fatness (Roche et al., 1981) and is independent of stature, but its utility in children is limited since it is correlated with stature (Garn et al., 1986). However, the BMI is commonly used in children as it is simple to calculate from stature and body mass.

Childhood and Adolescent Growth

There are little data available on the BMI and subcutaneous fatness of Amerindian children and youth. Johnston et al. (1978) reported that among Minneapolis school children 6-17 years, urban Natives had greater weight-for-height indices than national reference data. Among Navajo schoolchildren 5-17 years, mean BMIs also exceeded national reference data (Sugarman et al., 1990). Similarly, Story et al. (1986) indicated that in Cherokee youth 13-17 years, mean BMIs were consistently greater than reference values in all age and sex groups.

Estimated BMIs were calculated from the stature and mass means presented in the previous section. Figures 2.5 and 2.6 present estimated BMIs for boys and girls, respectively, for ages 4 to 18 years. Solid lines represent the 5th and 95th percentiles for the BMI in U.S. children (Must et al., 1991). All age-specific estimates for the BMI fall between the 5th and 95th percentiles in both boys and girls. There is considerable overlap in the distributions among groups in both sexes. It is thus difficult to determine population differences based on these estimates.

The prevalence of obesity among Amerindian children and youth varies by geographic location and tribal affiliation. Malina (1993) examined prevalences of obesity in North American children and youth (defined as ≥ 85 th percentile NHANES II BMI) from 11% in Chippewa females to 78.3% in Southwestern Arizona Native females. There was also a trend over time, with older samples having lower estimated prevalences of obesity than more recent samples. These results are similar to those presented by Broussard et al. (1991), which indicated that the estimated prevalence of obesity among Native American schoolchildren varies considerably by region. The review demonstrated that the average prevalence of overweight among Native American adolescents was 24.5% in males and 25.0% in females. Compared to data from the Ten State Nutrition Study, prevalence rates of obesity in Cherokee youth (≥ 85 th

percentile triceps skinfold) were 49.7% in boys and 31.6% in girls 13-17 years (Story et al., 1986).

In a review of anthropometric variation among Amerindian groups, Johnston and Schell (1979) indicated that, in general, mean skinfold thicknesses tend to vary as does body mass. Compared to U.S. reference data, mean subscapular skinfold thicknesses in Chippewa males and females from infancy through 18 years of age were significantly greater than the reference medians, whereas in males, triceps skinfold thicknesses were significantly less than the reference medians below 6 years of age; thereafter, they were significantly greater than the reference medians (Johnston and Schell, 1979). Similarly, triceps skinfold thicknesses of Manitoba First Nation school children were well within the distribution for the general U.S. population (Coodin et al., 1980). Alternatively, Story et al. (1986) presented evidence that Cherokee youth demonstrated significantly greater means and medians for the triceps skinfold compared to U.S. reference data, indicating that these youngsters were somewhat fatter than the average American child.

Adult Morphology

There are more data on the BMI of adult Aboriginal groups than for children. Among selected samples of North American Aboriginals, Eskimo women have the highest BMI, while Nootka men are the heaviest for stature (Table 2.1). Although variable, there does not appear to be a clear pattern of variation in the BMI by geographic location.

There is consistent evidence that the prevalence of obesity, defined by the BMI, is greater in Aboriginal groups than the general population. In a survey of U.S. Native groups, Broussard et al. (1991) estimated prevalences of overweight (BMI ≥ 27.8 in males and BMI ≥ 27.3 in females) in adults ≥ 18 years at 33.7% in males and 40.3% in females, which were higher than national estimates for the U.S., 24.1% and 25% in males and females, respectively. Age specific prevalences of overweight (BMI ≥ 27.8

in males and BMI ≥ 27.3 in females) among the Pima ranged from 31% to 78% for males ≥ 20 years, and from 48% to 87% for females ≥ 20 years (Knowler et al., 1991). Navajo adults were also significantly overweight (Hall et al., 1991). The prevalence of overweight (BMI ≥ 27.8 in males and BMI ≥ 27.3 in females) was 30.3% in males and 50.0% in females.

Prevalence data for Canadian First Nation groups parallel those from the United States. The proportion of a Northwestern Ontario population of Cree and Ojibwa classified as obese (BMI ≥ 27 in males and BMI ≥ 25 in females), increased with age; 70% of women 35 to 64 years and 50% of men 35 to 44 years were obese (McIntyre and Shah, 1986). Similarly, Gittelsohn et al. (1996) estimated prevalences of obesity from 22.8 % to 50.0% in Ojibwa and Cree from Northwestern Ontario (BMI ≥ 30); and prevalences also increased with age. Young and Sevenhuysen (1989) surveyed four Northern Canadian First Nation communities. The data suggested that the prevalence of obesity was higher in Native groups compared to Canadian national averages; however, specific figures were not indicated.

Relative Fat Distribution

Relative fat distribution refers to the relative amount of fatness, subcutaneous or visceral, in different regions of the body (Malina, 1996). Two common indicators of relative fat distribution are the ratio of trunk/extremity skinfolds (TER) and the waist/hip circumference ratio (WHR). The TER is relatively simple and is useful when measuring large numbers of people; however, its use assumes that trunk and extremity subcutaneous fatness increase in a linear manner (Garn et al., 1982). The WHR is useful in adults, but its utility in children and youth has not been established (Malina, 1996).

Childhood and Adolescent Growth

A single study considered relative fat distribution among Native North American children (Johnston et al., 1978). Among urban Native schoolchildren,

triceps skinfolds were below reference medians for the first 5 years of life in males; thereafter, they were larger than the reference values. In contrast, subscapular skinfolds were consistently larger than the reference medians. In females of all ages, triceps skinfolds were consistently below, whereas subscapular skinfolds were consistently above reference medians. The data thus suggest that Native children accumulate proportionally more subcutaneous fat on the trunk than the extremities. Note, however, inference on relative subcutaneous fat distribution based on only two skinfolds must be made with caution (Malina, 1996).

Adult Morphology

There are little data available on relative fat distribution among Native North Americans. Young and Sevenhuysen (1989) indicated that the obesity among four Northern Canadian First Nation groups was primarily of the central type as gauged by the subscapular/triceps skinfold ratio and the WHR. Although raw data were not presented, the authors indicated that 36% of men and 11% of women had WHRs >0.99 , which corresponds to approximately the 95th and 99th percentiles of French reference data for men and women, respectively (Tichet et al., 1993). Also, 29.8% of men and 22.4% of women had subscapular/triceps ratios >1.64 . Among Canadian Eskimos, a truncal fat distribution (ratio of triceps/subscapular+suprailiac skinfolds) skinfolds was greater in women than men (Schaefer, 1977). A similar observation in women has been made in other cold adapted populations such as the Evenki reindeer herders of the central Siberian taiga (Leonard et al., 1994) and Mongolian pastoralists (Beall and Goldstein, 1992). It has been hypothesized that a central distribution of subcutaneous fat is an adaptation to the cold. Caution must be used when interpreting these results, however, as relative subcutaneous fat distribution is fat dependent. In other words, as overall fatness increases, the ratio of trunk/extremity fatness also increases (Garn et al., 1982; Malina, 1996). On the other hand, the subscapular/triceps

ratio among Canadian Inuit and Siberian nGanasan 17-49 years of age was higher in men than women (Rode and Shephard, 1995).

There is an apparent relationship between a truncal fat distribution and adult-onset diabetes (NIDDM) among Native groups. Among female Navajo, risk of NIDDM increased with an increase in the WHR. A similar nonsignificant trend was evident in the males. Mean WHRs were 0.96 for males ≥ 20 years and 0.90 for females ≥ 20 years. These values correspond to approximately the 75th and 95th percentiles of French reference data for males and females, respectively (Tichet et al., 1993). Szathmary and Holt (1983) used principal components analysis and hierarchical analysis of variance to examine the association between relative fat distribution and blood glucose levels among the Dogrib in the Northwest Territories. Although the analysis did not provide a measurable fat distribution phenotype, there was a significant association between truncal fat distribution (as assessed by principal components of subscapular, midaxillary, suprailiac, abdominal, triceps, forearm, and medial calf skinfold sites) and elevated blood glucose levels (Szathmary and Holt, 1983).

Physique

Physique refers to the configuration of the body as a whole. It is most often quantified as a somatotype, which characterizes physique or body build in three components: endomorphy, mesomorphy, and ectomorphy. Currently the Heath-Carter anthropometric protocol for estimating somatotype is most widely used (Carter and Heath, 1990).

There are very little data on the somatotypes of Native North Americans. A single study among Wainwright Alaska Eskimos 16-75 years of age, measured by Jamison and Zegura in 1958, using both the Heath-Carter anthropometric and photoscopic techniques (ratings by Heath) indicated that Eskimo men and women had a physique characterized by high endomorphy and mesomorphy, with many extreme mesomorphs (Carter and Heath, 1990).

Secular Trends

Secular trends in stature, body mass and fatness have been examined in Native North American populations (Jamison, 1970; Miller, 1970; Knowler et al., 1981, 1991; Sugarman et al., 1990; Rode and Shephard, 1994). Miller (1970) demonstrated a 1.3 cm increase in stature and a 5.9 kg increase in body mass between 1940 and 1967 (one generation) of Apache men; change per decade was not estimated. The change in stature was similar to the secular change which was occurring in military recruits over the same time frame; however, the secular change in body mass was quite dramatic. The secular change in body mass was attributed to shifts in dietary patterns as the Apache adopted a "westernized" diet with acculturation into American society. This dietary shift, in combination with a susceptible genotype, has been used to explain the increased incidence of diabetes and obesity in Native groups (Weiss et al., 1984).

The Pima Indians of Arizona are obese, on average, compared to national reference data for the United States (Knowler et al., 1991). Additionally, there has been a modest increase in the BMI among adult Pima over the last 25 years. In almost all age and sex groups, the mean BMI increased in the sampling periods 1965-72 to 1973-80 to 1981-88. The mean BMI of the youngest adult age groups were also higher than that of the older age groups (Knowler et al., 1991). Pima children 5 through 18 years may have undergone a secular trend in body mass since the turn of the century. Weights of Pima children, adjusted for height by linear regression, were 6 kg heavier than children of comparable height in measured in 1908 (Knowler et al., 1981).

Navajo schoolchildren were taller and heavier in 1989 than they were in 1955 (Sugarman et al., 1990). Compared to the data collected in 1955 (Darby et al., 1956), Navajo boys and girls in 1989 were 6.1% and 4.4% taller, respectively. Similarly, mean weights increased 28.8% and 18.7% in boys and girls respectively, from 1955 to 1989. No estimate of change per decade was given. The authors speculated that the

secular changes were the result of changes in nutrition, daily energy expenditure, and the availability of health care.

Eskimos of Wainwright, Alaska, and Northern Canada have also experienced secular changes in stature and body mass. Jamison (1970) noted that Wainwright Eskimos in 1969 were taller than those of 1955, and by using a regression approach on the birthdates, an increase of 4-6 cm between the years 1880 and 1940 was estimated.

A secular trend towards earlier maturation may have occurred among the Canadian Inuit, and this influences stature. Rode and Shephard (1994) published an update of their ongoing work with the Canadian Inuit of Igloolik in the Northwest Territories. The data suggested that at younger ages (10-12 years), children were taller in 1990 than in 1970 (+1.7%); however, in the older ages (17-19 years), there was a trend for shorter stature in 1990 than observed in 1970 (-2.2%). The trends were the same in both males and females. Estimates were a 1.1 cm/decade increase in the youngest students, and a -1.7 cm/decade decrease in 17-19 year olds. The authors suggested that the trend may be due to earlier maturation, but there are little data on which to base this assumption. An alternative hypothesis put forth by the authors was that high speed snowmobile driving causes vertebral compression in the older children, resulting in relatively shorter individuals in the older age groups. This hypothesis, however, has not been tested. The data showed no consistent trends in body mass over the three decades, but the sum of three skinfolds indicated that the 1990 sample was significantly fatter than previous samples from 1970 and 1980 (Rode and Shephard, 1994).

Since few studies of Amerindians provide estimates of change per decade, it is difficult to determine if secular changes are comparable to those in the general population. Positive secular trends have occurred in all socioeconomic groups in Europe, Japan and the United States (Malina, 1990). Tanner (1988) suggested that between 1880 and 1950, a secular change of approximately 1 cm/decade in adults had

occurred in Europe and the U.S. Given the ever-changing demographic composition of the U.S., it is difficult to estimate secular trends; however, data from several national surveys in the U.S. in the 1960's and 1970's indicate that the trend towards larger body size has ceased (Malina, 1990). Additionally, there is no consistent evidence for differences in secular increases between Black and White children. Comparisons of the BMI in Americans between 1960 and 1980 indicated no change in the BMI in males 18-34 years, but both Black and White females showed an increase over this span (Malina, 1990).

Summary

The data suggest that among Aboriginal groups, adult Eskimos are shortest in stature, while other groups such as the Gros Ventres/Assiniboin and Chippewa, Sioux and Winnebago are tallest. There are no clear trends in body mass; however, Eskimo women, as well as being the shortest, are also the heaviest.

The prevalence of obesity among Amerindian groups varies by geographic location and tribal affiliation. There is consistent evidence that the prevalence of obesity, defined by the BMI, is greater in Aboriginal groups than in the general North American population. Data on relative fat distribution among Native groups are limited, and results indicate that North American Aboriginals, particularly adults, have a more central or truncal fat distribution. Data are equivocal regarding sex differences in fat distribution.

Secular trends appear to have occurred in Native North Americans. The Pima are among the most obese of the Native groups, and the mean BMI appears to have increased over the last 25 years. A single study of secular change in Inuit children suggests that earlier maturation may be accounting for taller children at younger ages and shorter older children in 1990 than in 1970 within the same community. Estimated rates of change are rarely provided, which would aid in comparing studies.

Section II: Familial Aggregation of Body Size, Physique, and Indicators of Health-Related Fitness

Introduction

There is considerable interest in determining the familial resemblance in body size and components of health-related fitness. Fitness is generally defined as an individual's ability to withstand stress, and is usually defined in terms of health- and performance-related components (Caspersen et al., 1985). Performance-related fitness refers to the individual's ability to perform physical work optimally, whereas health-related fitness refers to those phenotypes which relate to health status. The definition of health-related fitness has recently been expanded to include five components (Table 2.2): morphological, muscular, motor, cardiorespiratory, and metabolic (Bouchard and Shephard, 1994).

This section outlines the types of studies which have been used to estimate the heritability of phenotypic characteristics as well as the evidence thus far accumulated to suggest a familial component in the observed variability in body size and health-related fitness. For the purpose of this review, morphological fitness phenotypes, such as the BMI, fatness, and relative fat distribution, will be considered in the section on fatness and relative fat distribution.

Types of Studies

Two major types of studies have been used to estimate the contribution of genetic factors to phenotypic variation. The first design is based on studying populations, while the second is based on studies of related individuals.

Population studies generally attempt to estimate the influence of genetic and environmental factors for a given characteristic (Bouchard and Malina, 1983). Anthropological studies of populations generally compare populations of similar ancestry living under different environmental conditions, or alternatively, compare populations of different ancestry living under similar environmental conditions

(Bouchard and Malina, 1983). Population studies are typically concerned with determining the extent to which genetic and environmental influences have impacted given characteristics within a given population; in other words, these are studies of adaptation and accommodation (Frisancho, 1993).

Studies of relatives have a long tradition in population genetic research. Studies of this type generally consider phenotypic variation among relatives. Basic designs may consider only relationships among nuclear family members, whereas other designs may involve extended pedigrees and complex statistical analyses aimed at investigating genetic mechanisms associated with a given trait, or genetic associations among traits (Bouchard and Malina, 1983; Rice et al., 1995).

Studies of relatives can generally be divided into two main types, family and twin. Family studies usually involve examining associations among all possible relatives, generally through the use of spouse, sibling, and parent-offspring correlations. More complex studies may include relationships among extended relatives (aunts, uncles, cousins, etc.). Examples of large family studies include the Québec Family Study (QFS, Bouchard et al., 1988), the Canada Fitness Survey (CFS, Pérusse et al., 1988), the Framingham Offspring Study (FOS, Heller et al., 1984), the Muscatine Ponderosity Family Study (MPFS, Moll et al., 1991), and the Nord-Trøndelag Norwegian National Health Screening Service Family Study (Tambs et al., 1991).

Study of adopted relatives is often useful in determining the influence of genetic and environmental factors on a particular trait. Examples of adoption studies include those utilizing the Montreal Adoption Survey (Annest et al., 1983; Biron et al., 1977) and the Danish Adoption Register (Sørensen et al., 1992a, 1992b).

Twin studies are specific investigations which examine variation within and among pairs of monozygotic (MZ) and dizygotic (DZ) twins. Although relatively simple in design, the twin method is more complex than originally thought (Bouchard

and Malina, 1983). Significant biases may result from (1) differences in means of twin types, and (2) associations between twin type and the phenotypic variance of the trait of interest (Bouchard and Malina, 1983). Twin studies generally provide higher estimates of heritability for a given phenotype than family studies, which should be taken into account when interpreting results from different studies.

Twin studies typically present associational data in the form of intrapair correlations for various phenotypes such as fatness, physical working capacity, and strength (Komi et al., 1973; Engström and Fischbein, 1977; Price et al., 1987). Twin studies have also been used to study genotype-environment interactions, especially with regard to changes in morphology following training and/or dietary manipulation (Poehlman et al., 1986, 1987; Bouchard et al., 1990). Examples of large twin studies include the Leuven Longitudinal Twin Study (Maes et al., 1993, 1996) and studies utilizing the Danish Twin Register (Herskind et al., 1996), the Finnish Twin Cohort (Korkeila et al., 1991), and the Swedish Twin Registry (Stunkard et al., 1990).

Body Size

This section focuses on familial resemblance in stature and body mass. In a review of 24 studies presenting parent-child correlations in stature and body mass, Mueller (1976) indicated that the heritability of stature in school aged children from 6 studies varied from 0.31 to 0.58 based on mid-parent regressions. Heritability approximations based on twice the parent-child correlation in the same 6 studies yielded higher estimates ranging from 0.44 to 0.88. However, the average parent-child combined correlation for stature from 20 studies demonstrated a heritability of 0.62. Body mass, based on parent child correlations from 9 studies had an average heritability of 0.52 (Mueller, 1976).

There is considerable variability in estimates of the familial resemblance in stature and body mass among family studies conducted since this early review in 1976 (Tables 2.3 and 2.4). Spousal correlations should theoretically approximate zero in the

absence of assortative mating, since spouses are biologically unrelated. However, spousal correlations for stature range from 0.06 in U.S. Blacks (Malina et al., 1976) to 0.43 in the CFS (Pérusse et al., 1988). Similarly, spousal correlations for body mass range from 0.15 in a sample of African Americans (Rotimi and Cooper, 1995) to 0.39 in a sample of Canadians from Montreal (Biron et al., 1977). These results indicate that assortative mating for stature and body mass occurred in some groups. In addition, shared lifestyles contribute to the spousal similarities in body mass (Ramirez, 1993).

Sibling and parent-offspring correlations indicate significant familial aggregation of stature and body mass (Tables 2.3 and 2.4). For stature, sibling correlations range from 0.14 to 0.67, whereas parent-offspring correlations range from 0.01 to 0.67. Similarly, sibling correlations for body mass range from 0.16 to 0.61 and parent-offspring correlations range from 0.16 to 0.52. Within studies, spousal correlations, with few exceptions, are generally lower than those for first-degree relatives, indicating that genetic factors may be contributing to the covariation among families. However, given that spousal correlations reach the strength of the association among first degree relatives in some cases, common environmental (household) effects may also be important.

It is difficult to infer genetic effects from familial correlations, since the effects of genetic factors cannot be distinguished from common environmental factors due to cohabitation. The purpose of most of the studies surveyed in Tables 2.3 and 2.4 was to examine familial resemblance in stature and body mass; however, three of the studies used additional analyses to estimate genetic and environmental contributions to stature and body mass.

Pérusse et al. (1988), using path analysis (TAU model), determined that transmissibility from parent to offspring (genetic and cultural) accounted for 27% and 28% of the variability in stature and body mass, respectively. Thus, non-transmissible

factors such as shared sibling environment, personal lifestyle, and variation due to unreliability of measurements accounted for over 70% of the variance in stature and body mass in this sample.

The role of the shared environment may not be the same for both stature and mass. Using maximum likelihood methods, Annett et al. (1983) determined that genetic factors made a highly significant contribution to the familial aggregation of both stature and mass, whereas common household effects contributed significantly to variation in stature, but not in body mass. A study of adopted and natural children and their parents indicated a significant genetic component of the variability in body mass (Biron et al., 1977). The correlation between natural parents and their children was significant ($r=0.31$, $p<.001$); however, the correlation between adoptive children and adoptive parents was not significant ($r=0.01$, $p=.85$). Similarly, the correlation among natural siblings was significant ($r=0.39$, $p<.001$) and the correlation among adoptive children was not significant ($r=0.01$, $p=.94$).

Circumferences and Skeletal Dimensions

Circumferences

Circumferences are heterogeneous measurements (Bouchard et al., 1997). A given circumference includes skin, adipose tissue, and various underlying tissues depending on the location of the measurement. Although simple to measure, data on the family resemblance in body circumferences are very limited.

Evidence indicates a significant familial component in the variance of several body circumferences (Table 2.5). Spousal correlations range from 0.04 to 0.31, indicating assortative mating in some groups. Sibling correlations for body circumferences are generally higher than parent-offspring correlations within studies, suggesting that shared environment is important in explaining variation in these traits. Sibling correlations range from 0.09 to 0.50 and parent-offspring correlations range from 0.14 to 0.53. In general, correlations are of similar strength among studies and

across all circumferences.

Family correlations vary with the age and sex of the subjects. Byard et al. (1983) indicated that sibling correlations for calf circumference varied with the age of the siblings, and that correlations decreased at 12-13 years of age in boys and at 11-12 years in girls. The decreases corresponded to periods of variable growth rates around the pubescent growth spurt in stature. The strength of correlations was also different when children and adult family members were compared.

Skeletal Dimensions

Familial resemblance in skeletal dimensions is supported by data from several studies (Table 2.6). Surprisingly, few studies report spousal correlations for skeletal dimensions, which makes it difficult to interpret sibling and parent-child correlations in explaining genetic and environmental influences. Sibling correlations range from -0.02 to 0.68, while parent-offspring correlations range from 0.07 to 0.49. Sibling and parent-offspring correlations are generally of similar magnitude within and among studies.

Few studies have attempted to estimate the genetic component of the variability in skeletal dimensions. Evidence indicates a genetic component to the variance in skeletal breadths (Clark, 1956; Vandenburg, 1962) as well as genetic pleiotropism such that genetic factors may work synergistically to influence the breadth and robusticity of the skeleton (Bouchard and Lortie, 1984). Note that many anthropometric skeletal dimensions are composites across several bones, e.g., sitting height, biacromial and bicristal breadths, etc. (Bouchard et al., 1997). Bouchard et al. (1980b) estimated heritabilities of 0.48 for sitting height, 0.62 for biacromial breadth, 0.22 for bicristal breadth, 0.50 for bicondylar breadth and 0.54 for biepicondylar breadth. These estimates were computed as two times the sibling correlation, controlling for seven socioeconomic familial indicators. Using twin data, Kramer et al. (1986) estimated the heritability of bicristal breadth as 0.51, which was higher than the estimate of Bouchard

et al. (1980b); however, twin studies generally generate higher heritability estimates than family studies.

Fatness and Relative Fat Distribution

The genetics of body fat and relative fat distribution have recently become of great concern, mostly because of the identification of obesity as an important risk factor for many diseases. Variables such as the BMI, percentage body fat, skinfolds, and trunk/extremity skinfold ratios have been utilized in several studies in an attempt to quantify the genetic contribution to fatness, obesity and relative fat distribution.

BMI

The most frequently studied index of obesity is the BMI (mass/stature²), although the BMI is actually a measure of heaviness, as it does not distinguish between lean and fat tissues. Any estimate of the genotypic variance of the BMI will thus be contaminated by the unknown genotypic effects on both fat and fat-free tissues (Bouchard, 1989).

There is considerable variability in estimates of familial resemblance in the BMI (Table 2.7). Spousal correlations indicate a small assortative mating effect, especially in an Indian sample ($r=0.37$, Nirmala et al., 1993). With this exception, spousal correlations for the BMI range from -0.05 to 0.19. The range of estimates probably represents different mating strategies among world populations and different contributions of the home environment to the BMI in different ethnic groups.

Correlations among first-degree relatives for the BMI are consistently higher than spousal correlations. Parent-offspring correlations range from 0.02 to 0.38; however, with the exception of two studies (Ramirez, 1993; Annett et al., 1983), estimates of heritability based on two times the parent-offspring correlation range from 0.36 to 0.76. This agrees well with the overview of Bouchard et al. (1997), suggesting that the heritability of the BMI derived from family studies is generally about 0.30 to 0.50. Further, twin studies tend to produce higher estimates of

heritability, while adoption studies yield lower estimates. Combining research strategies, the estimated heritability of the BMI is approximately 0.25 to 0.40 (Bouchard et al., 1997).

Body Fat

Studies investigating the genetics of direct assessments of body fatness are few (Bouchard and Pérusse, 1988). Ramirez (1993) estimated lean body mass using bioelectrical impedance and in turn percentage body fat. Sibling correlations were 0.21 (brother-brother) and 0.36 (sister-sister), and parent-offspring correlations ranged from 0.17 to 0.25, after adjusting for the effects of age and the BMI. Bouchard et al. (1988) considered percentage and total body fat estimated from densitometry in 1,698 relatives from the Québec Family Study. Interclass correlations were 0.23 for parent-offspring comparisons and 0.17 in siblings for percentage body fat. The results were consistent with an additive genetic effect explaining 25% of the variance, whereas approximately 55% was transmissible (cultural+genetic) (Bouchard et al., 1988).

Subcutaneous fatness (sum of skinfolds) also demonstrates aggregation within families (Table 2.8). Spousal correlations for skinfolds range from 0.02 to 0.46. As for the BMI, this variation may be explained by differential mating patterns and different contributions from the living environment. Parent-offspring and sibling correlations for the sum of skinfolds range from 0.13 to 0.68.

Fatness is a complex phenotype and is influenced by many environmental factors, such as energy intake and physical activity. However, the incorporation of activity levels and food intake into genetic models has only a small effect on parent-child similarities (Bouchard et al., 1989). Indicators of fatness still exhibit a significant genetic influence after physical activity and lifestyle variables were considered in an Indian population (Mitchell et al., 1993) and the Québec Family Study (Savard et al., 1983).

Relative Subcutaneous Fat Distribution

The distribution of adipose tissue within the body, both subcutaneously (external) and viscerally (internal), is as important a risk factor for many diseases as is the total amount of fat (Ducimetiere et al., 1986; Ducimetiere and Richard, 1989; Després et al., 1990). Evidence is available primarily for familial resemblance in subcutaneous fat distribution in contrast to internal vs external fat distribution, for which little data are available. Relative fat distribution shows familial aggregation (Table 2.8). Spousal correlations are generally similar to those reported for overall fatness, while correlations among first degree relatives vary among studies, ranging from 0.22 to 0.36 for TER and from 0.00 to 0.24 for the WHR. Fatness and relative fat distribution are multifactorial traits which exhibit high individual variability and change dramatically over the lifespan (Malina, 1996). The evidence indicates that there is a significant genetic component to variation in these complex phenotypes.

Physique

Several studies have investigated the familiarity of physique, as assessed by the Heath-Carter anthropometric somatotype. Somatotype is a three component descriptor of physique, the configuration of the body as a whole. Since the three components, endomorphy, mesomorphy, and ectomorphy, are intercorrelated, it is important to statistically control for the other two somatotype components in analyses (Song et al., 1993, 1994). Recent studies have used regression analyses to control for the other two components; however, earlier studies by Kovar (1977), Bouchard et al. (1980a) and Pérusse et al. (1988) did not control for the effects of the other two somatotype components.

There is considerable evidence for familial resemblance in somatotype (Table 2.9). Spousal correlations for specific components are generally low, ranging from -0.08 to 0.23, whereas sibling and parent-offspring correlations are of a higher magnitude. Sibling correlations range from 0.22 to 0.59 and parent-offspring

correlations range from -0.04 to 0.41. There are no apparent trends in correlations by somatotype component; however, mesomorphy appears to demonstrate a higher degree of familial resemblance than the other components (Song et al., 1993; Sánchez-Andrés, 1995). Since spousal correlations are generally lower than sibling and parent-offspring correlations, the transmission of somatotype is probably under some degree of genetic regulation. However, within studies, sibling correlations are generally greater than parent-offspring correlations, suggesting that the shared household environment may also be important in the familial resemblance.

Twin studies generally demonstrate higher sibling correlations than family studies (Kovar, 1977; Song et al., 1994). Intraclass correlations among pairs of MZ twins (0.51 to 0.90) are higher than correlations among DZ twins (0.15 to 0.64), indicating that genetic factors are contributing to the variance in somatotype.

Strength and Flexibility

Familial resemblance in grip strength and trunk flexibility is reviewed subsequently. For a more extensive review of the genetics of performance, the reader is referred to Bouchard et al. (1997).

Grip Strength

The available evidence suggests significant familial aggregation in grip strength (Table 2.10). Spousal correlations range from low to moderate, 0.01 to 0.26, whereas sibling correlations range from 0.10 to 0.55. Parent-offspring correlations are generally of lower magnitude than sibling correlations, ranging from -0.05 to 0.31. Although there is evidence for genetic effects, the role of the shared environment is also important in the familial resemblance in grip strength.

Trunk Flexibility

Flexibility appears to be highly heritable at least in the broad sense of transmissibility. Pérusse et al. (1988) demonstrated a heritability of 0.48 for the sit-and-reach in a stratified sample of the Canadian population, while Devor and Crawford

(1984) calculated a transmissibility of 0.66 for the same measure in a sample of Kansas Mennonites.

Correlations among family members indicate significant transmissibility of flexibility between parents and offspring, while the shared environment is also important in explaining the variance within and among families (Table 2.10). Using intraclass correlation within pairs of twins, Maes et al. (1993) indicated that MZ twins (0.82) had higher correlations than DZ twins (0.53), suggesting that trunk flexibility is in part genetically determined. The flexibility phenotype is largely a measure of the architecture of the joint and surrounding musculature (Bouchard et al., 1997), which may explain the high degree of concordance among studies. Flexibility is joint specific and heritability estimates of trunk flexibility may not be applicable to other joints.

Summary

The available evidence suggests significant familial aggregation in body size, adiposity, relative fat distribution and indicators of health-related fitness; however, the magnitude of the family effect varies among studies. Inferences regarding the genetics of the selected phenotypes are difficult to make based on correlational studies, but comparisons of the magnitude of parent-offspring, sibling and spousal correlations suggest the influence of genetic factors. Spousal correlations for all phenotypes indicate that assortative mating may occur in some groups, and that common environmental (household) effects may be important in explaining the familial component of the phenotypic variance.

CHAPTER III

METHODS

Introduction

The purpose of this study was to compare Canadians of First Nation and European ancestry in terms of body size, physique, and indicators of health-related fitness, and to determine the familial resemblance in these variables. The protocol, therefore, involved the collection of anthropometric and health-related fitness data in such a way as to allow statistical familial analyses. The most critical aspect for the analysis is the knowledge of the familial relationships among the subjects, which is why a family study approach was used.

Research Location and Study Population

The northern Ontario town of Temagami and the First Nation community of Bear Island were selected as the sites for study. The nearest city to these communities is North Bay (pop. 60,000), which is located 100 km south along a national highway. New Liskeard is a farming town of approximately 5,500 people, located 70 km north of Temagami (Figure 3.1).

Bear Island is approximately 24 km from Temagami, and can only be reached by water. Each community has a public school (K-8), with 130 children attending the Temagami Public School and 17 attending the Laura McKenzie Learning Centre on Bear Island at the time of the study. Many children are bussed to North Bay or New Liskeard for high school.

The exact population of the Temagami area is difficult to determine. According to Statistics Canada, Temagami had 1,030 residents in 1993, based on tax returns with

an address using the Temagami (P0H 2H0) postal code (Statistics Canada, 1995). According to the Corporation of The Township of Temagami, the total population of Temagami was 864 people in 1994 (Township of Temagami, 1994). These two sources provide different estimates of the population of Temagami; however, the area encompassed by the Statistics Canada report is larger than the Township of Temagami proper, as there are many people living outside of the township who get their mail delivered to Temagami. On the other hand, there are also people who are not full-time residents of Temagami who use this address for tax returns (students, seasonal workers, etc.). All things considered, it is likely that the true population of Temagami is between 864 and 1,030 people.

The Temagami First Nation has accurate records of the population of Bear Island. Each building on the Island is numbered and the occupants of each building are known. Based on the Band records, the community of Bear Island had 174 residents at the time of this study.

Ethnographic Background

Present day Temagami, Teme-augaming (the place of deep water), is inhabited by both Aboriginal and European Canadians. The history of each group in the area is unique. The Aboriginals of the area are the Teme-Augama Anishnabai (the people of the deep water) and are traditionally an Algonkian speaking group. The Teme-Augama Anishnabai have documented 6,000 years of occupation of their homeland, N'Daki Menan (Teme-Augama-Anishnabai, 1990). Their homeland at the time of European contact encompassed approximately 3,800 square miles around Lake Temagami; however, the band was small, numbering fewer than 200 people (Hodgins and Benidickson, 1989). The population of Temagami (Bear Island) in 1913 was 95 people (Speck, 1915). Because of the small population size, the Temagami people had a pattern of "migration" by intermarriage and spread outward through neighboring

tribes, thus leading to a distinctive grouping of Ojibwa, Cree and Algonquin settling in the area (Hodgins and Benidickson, 1989).

The archeological record reveals a long history of occupation in the Temagami area by prehistoric hunter-gatherers. Paleoenvironmental and geochronological studies indicate that paleo-Indian occupation as early as 10,500 BP is a distinct possibility; however, no sites this old have been found using current survey methods (Gordon, 1990). Evidence of human habitation at 5,030 $\pm$ 240 years BP at a site on the Montreal River is the earliest reliable date obtained from a reliable stratified context (Knight, 1977, as cited by Gordon, 1990).

Since deglaciation approximately 10,500 years ago, Temagami has undergone dramatic shifts in hydrology, vegetation, and climate (Gordon, 1990). Prehistoric groups inhabiting the area would have had to adapt to these environmental changes. Archeologists are interested in studying cultural adaptations to the changing environment over time using the archeological record; however, biological adaptations to the changing environment should also be considered.

The earliest European contacts in the Temagami area were through the fur trade, and by the late 1800s, the Hudson's Bay Company was established in the area (Mitchell, 1977). Following the fur trade, the late nineteenth century saw lumbermen, missionaries, prospectors, railwaymen, sportsmen and canoeists entering the area (Hodgins and Benidickson, 1989). From this point on, lumbering, mining and tourism became the chief industries of Temagami. A major blow to the recent economy of the area was the closure of Defasco Canada's Sherman Iron Mine and William Milne and Son's lumber mill in 1990. The main industry in Temagami is now tourism and the spin-off labor market (hospitality, commerce, construction).

Today, individuals of Aboriginal and European ancestry are living together in the same community: they attend the same churches, shop at the same stores, and work alongside one another in the area's limited industries. Given the differing periods of

habitation of the two groups, inferences about biological adaptation to the northern Ontario environment may be made by comparing First Nation and European Canadians in terms of growth and health-related fitness.

Study Design

The design of the study involved collecting anthropometric, performance, and health-related fitness data on a sample of subjects from two ethnically distinct populations inhabiting the same environment. The data were collected in an overarching framework of a family study, in which the purpose was to estimate the heritability of the anthropometric and health-related fitness variables.

Data were collected during the spring and summer of 1996 (May-August). All residents of Temagami and Bear Island from 5-75 years of age were eligible to participate in this study. Permission to undertake this study was obtained from the Township Council of Temagami, the Temagami First Nation, the Timiskaming Board of Education, and the University Committee for Research Involving Human Subjects (UCRIHS) at Michigan State University. Copies of letters of permission are in Appendix A. All adult subjects signed informed consent forms. In addition, parents were required to sign a consent form for their children (<18 years old) to participate in the study. Children gave their assent by signing the form along with their parents.

Subjects were recruited over the telephone and by going door to door (for adults), and using a letter sent home from the principal of the public school (for children 5-15 years). The majority of the children 5-15 years were measured at school, whereas adults were generally measured in their home. Reasons for non-participation included having other time commitments, not knowing about the study (away from home, could not be reached by phone, etc.), and not wanting to be measured. Given that non-participation included not getting measured, it is difficult to determine if there were differences between participants and non-participants in body morphology or health-related fitness which may have biased the results.

All subjects were measured for several anthropometric dimensions, grip strength and trunk flexibility. Additionally, children attending the public schools (5-15 years) completed an extended battery of motor fitness tests.

Sample

A total of 624 subjects, 130 First Nation (FN), 494 European ancestry (EA) participated in the study. The age and sex distribution of the sample is compared to population statistics for Temagami and Bear Island in Table 3.1. Approximately 50% of the total population of the area participated. Some FN people live on the mainland, and some EA people also live on Bear Island. It must be noted that the population statistics include all residents of the area; however, the present sample includes only those individuals 5 through 75 years of age. Thus, the study sample represents more than 50% of the individuals within this age range.

Subjects were assigned to either the FN or EA group based on self-ascribed ethnic status, and was not based on biological markers such as blood groupings or skin reflectance. Those who indicated admixture (hybrids) were assigned to the FN group if they had a parent or grandparent who was FN, or if they were classified as a Status Native by the federal government.

A higher participation rate was obtained in the public schools over the overall participation rate. Of 130 children attending the Temagami Public School, 108 participated (83%). Additionally, all 17 children attending the Laura McKenzie Learning Centre on Bear Island participated in the study (100%).

Anthropometry

Several anthropometric dimensions were taken on each subject: stature; sitting height; body mass; skinfolds at the biceps, triceps, subscapular, abdominal, suprailiac, supraspinale and medial calf sites; biacromial, bicristal, biepicondylar, and bicondylar breadths; and flexed and relaxed mid-arm, maximal calf, waist and hip circumferences. All bilateral measurements were taken on the right side of the body. Subischial length was estimated as stature minus sitting height, and arm muscle area was estimated from arm circumference and the triceps skinfold. Several indices were also derived: the body mass index (BMI), Heath-Carter anthropometric somatotype, the sitting height/stature ratio, hip/shoulder breadth ratio, sum of skinfolds, a trunk/extremity skinfold ratio, and the waist/hip circumference ratio. The procedures for the anthropometric dimensions were as follows (Lohman et al., 1988):

Body Size

Stature (cm) was measured using a field anthropometer (GPM, Switzerland) to the nearest mm with the subject in bare feet, standing on a flat surface with weight evenly distributed on both feet. The head was positioned in the Frankfort Horizontal Plane.

Sitting Height (cm) was measured using a field anthropometer to the nearest mm with the subject seated on a table with the legs hanging freely and hands resting on the thighs. The backs of the knees were close to but not touching the table. The subject was sitting as erect as possible with the head in the Frankfort Horizontal Plane.

Body Mass (kg) was assessed to the nearest 0.2 kilograms using a spring scale (Medixact Proshape, Sunbeam-Oster, Schaumburg, IL) resting on a hard flat surface. Although the standard technique involves the use of a beam scale, the use of a spring scale is recommended for field work when there is no practical alternative. Body mass was optimally measured with the subject wearing only light shorts and a t-shirt. In those cases where this was impossible, an adjustment for the mass of extra clothing was made based on weighing several individuals in shorts and then in heavy pants or

jeans (heavy pants or jeans = 0.90 kg adjustment in adults, 0.45 kg adjustment in children <18 yrs).

Skinfolds

Skinfolds were measured with Holtain (Holtain LTD, Crymych, U.K.) calipers to the nearest 0.2 mm.

Triceps skinfold (mm) was measured over the midline of the triceps muscle, midway between the lateral projection of the acromion process and the inferior margin of the olecranon process. The measurement was made 1 cm proximal to the marked level with the upper extremity hanging loosely with the palm facing forward.

Biceps skinfold (mm) was measured as the thickness of a vertical fold raised over the belly of the biceps muscle, 1 cm superior to the line marked for the measurement of the triceps skinfold. The upper extremity was relaxed at the side, palm pointing forward.

Subscapular skinfold (mm) was measured just below the inferior angle of the scapula on a diagonal, inclined infero-laterally, approximately 45 degrees to the horizontal plane in the natural cleavage lines of the skin.

Abdominal skinfold (mm) was measured as a horizontal skinfold 3 cm lateral to the umbilicus and 1 cm below it.

Suprailiac skinfold (mm) was measured in the midaxillary line immediately superior to the iliac crest. The arms hung loosely, or were slightly abducted to facilitate measurement. The skinfold was raised following the natural cleavage of the skin, approximately 45 degrees to horizontal.

Supraspinale skinfold (mm) was measured 5 cm superior to the anterior superior spine of the iliac crest along a 45 degree angle to the horizontal in the natural cleavage line of the skin.

Medial calf skinfold (mm) was measured with the subject sitting with the knee flexed 90 degrees and the sole of the foot on the floor. This measurement was made along the long axis of the medial aspect of the calf at the point of maximal calf girth.

Breadths and Circumferences

The following bony breadth measurements were made to the nearest mm by applying firm pressure with the upper end of the anthropometer.

Biacromial breadth (cm) was measured with the subject standing. The measurement was made from behind as the distance between the most lateral aspects of the acromial processes.

Bicristal breadth (cm) was measured with the subject standing with the feet about 5 cm apart and the arms folded across the chest. The measurement was made from behind at the widest biiliac breadth.

Bicondylar breadth (cm) was measured with the subject seated with the knee flexed 90 degrees. The distance between the lateral and medial condyles of the femurs was measured.

The following measurement was made to the nearest mm by applying firm pressure with a small sliding caliper (GPM, Switzerland).

Biepicondylar breadth (cm) was measured with the subject's arm raised to the horizontal, and the elbow flexed 90 degrees. The measurement was made between the lateral and medial epicondyles of the humerus.

The following measurements were made to the nearest mm with a GrafcO flexible fiberglass tape.

Relaxed mid-arm circumference (cm) was measured with the subject standing with arms hanging at the sides, palms facing the thighs. This measurement was made at the midpoint between the acromion process of the scapula and the inferior margin of the olecranon process of the ulna.

Flexed mid-arm circumference (cm) was measured with the subject standing. The subject was instructed to flex the biceps or to "make a muscle" with the right arm. This measurement was made at the point of maximal circumference of the flexed arm.

Maximal calf circumference (cm) was measured with the subject standing and weight evenly distributed on both feet. The tape was placed around the calf and moved up or down to locate the maximal girth, at which point the measurement was recorded.

Waist circumference (cm) was measured with the subject standing and weight distributed evenly on both feet, arms at the sides and abdomen relaxed. This measurement was made over one layer of light clothing (t-shirt, dress) at the natural waist, which is the narrowest part of the torso. In obese subjects it was necessary to move the tape up and down and record the smallest horizontal circumference between the ribs and the iliac crest.

Hip (buttocks) circumference (cm) was measured with the subject standing erect with arms at the sides and feet together. The measurement was taken at the level of maximum extension of the buttocks in a horizontal plane. This measurement was taken through one layer of clothing.

Anthropometric Indices

The derived indices were as follows:

Subischial length (SIL), or estimated leg length was estimated as stature minus sitting height.

Arm Muscle Area (AMA) was estimated using the following formula (Frisancho, 1990):

$$\text{AMA (cm}^2\text{)} = \frac{[C - (\pi \text{TSF})]^2}{4\pi}$$

where C is arm circumference (cm) and TSF is the triceps skinfold (cm).

Body mass index (BMI) was calculated as body mass/stature² (kg/m²).

Sitting height/stature ratio (SSR) was calculated as sitting height/stature x 100.

Hip/shoulder ratio (HSR) was calculated as bicristal breadth/biacromial breadth x 100.

Sum of trunk skinfolds (TRUNK) was calculated as the sum of 3 trunk skinfolds (subscapular, abdominal, and suprailiac).

Sum of extremity skinfolds (EXTREMITY) was calculated as the sum of 3 extremity skinfolds (biceps, triceps, and medial calf).

Sum of skinfolds (SUM) was calculated as the sum of 6 skinfolds (subscapular, abdominal, suprailiac, biceps, triceps, and medial calf).

Trunk/extremity ratio (TER) was calculated as the ratio of the sum of the subscapular, abdominal, and suprailiac skinfolds to the sum of the biceps, triceps, and medial calf skinfolds.

Waist/hip ratio (WHR) was calculated as the ratio of waist circumference to hip circumference.

Somatotype

Somatotype was derived using the equations of Carter and Heath (1990).

Endomorphy

$$\text{Endomorphy} = -0.7182 + 0.1451 (A) - 0.00068 (A^2) + 0.0000014 (A^3)$$

where $A = [(triceps \text{ (mm)} + subscapular \text{ (mm)} + supraspinale \text{ (mm)} \text{ skinfolds}) \times (1701.8 / stature \text{ (cm)})]$

Mesomorphy

$$\text{Mesomorphy} = [0.858 \times biepicondylar \text{ breadth (cm)}] + [0.601 \times bicondylar \text{ breadth (cm)}] + [0.188 \times CAG] + [0.161 \times CCG] - [stature \text{ (cm)} \times 0.131] + 4.50$$

where CAG = corrected arm girth = flexed arm circumference (cm) minus triceps skinfold (cm), and CCG = corrected calf girth = maximal calf circumference (cm) - medial calf skinfold (cm)

Ectomorphy

If $SMR \geq 40.75$,

$$\text{Ectomorphy} = SMR \times 0.0732 - 28.58$$

If $SMR < 40.75$ but > 38.25 ,

$$\text{Ectomorphy} = SMR \times 0.0463 - 17.63$$

If $SMR \leq 38.25$,

$$\text{Ectomorphy} = 0.1$$

$$\text{where } SMR = \text{stature mass ratio} = \frac{\text{stature (cm)}}{\sqrt[3]{\text{mass (kg)}}}$$

If any somatotype component is zero or negative, a value of 0.1 is assigned (Carter and Heath, 1990).

Strength, Flexibility, and Motor Fitness

Adolescents and Adults (16-75 yrs)

Each adolescent and adult performed a strength test and flexibility test.

Left and right grip strength of the hand was measured with a Stoelting adjustable dynamometer (Stoelting Co., Chicago, IL) to the nearest 0.5 kg following the procedures of the Canadian Standardized Test of Fitness (Fitness Canada, 1986). The subject held the dynamometer in line with the forearm at the level of the thigh. The dynamometer was then squeezed vigorously so as to exert maximum force. Three trials were allowed with each hand, the best one being retained in the analysis.

Trunk flexibility was assessed using a sit-and-reach exercise following the procedures of the AAHPERD Physical Best manual (1988). The subject was seated with the legs fully extended and feet pressed up against the test apparatus. The subject extended forward with the hands placed on top of one another to perform the test. Each participant was allowed three trials in which they had to hold the position for at least one second. Flexibility was measured to the nearest 0.5 cm. A measurement of 23 cm corresponds to touching the toes.

Children (5-15 years)

Children were tested on a larger number of items than adults. The following additional fitness tests were administered during regular class time at the Temagami Public School and the Laura McKenzie Learning Centre on Bear Island: right and left grip strength, trunk flexibility, flexed arm hang, sit-ups, standing long jump, and 35-meter dash.

Only children with signed parental consent forms participated in this study. All items in the battery of fitness tests were repeated 3 times and the best performance was retained for analysis.

Right and left grip strength was assessed as in adults.

Trunk flexibility was assessed as in adults.

A **Flexed arm hang** was conducted on a bar parallel to the ground, following the protocol of the Leuven Growth Study of Flemish Girls (Claessens et al., 1990).

Hands were in the pronated position, and the time was stopped when the eyes dropped below the level of the bar. Time was recorded to the nearest second.

Sit-ups were assessed following the protocol of the Canadian Standardized Test of Fitness (Fitness Canada, 1986). The subject was in a supine position with legs flexed 90 degrees at the knee. The researcher held the subject's ankles to assure that the heels remained in contact with the floor. With hands placed beside the head with fingers over the ears, the subject touched the knees with the elbows and returned to the starting position as many times as possible in 60 seconds.

The **Standing long jump** was assessed by having the subject jump as far as possible from the standing position into a jumping sand pit. Distance from take-off to the back of the heels on landing was measured to the nearest 0.01 m.

A **35-meter dash** was conducted from a stationary start position and was measured to the nearest 0.1 second.

Measurement Variability and Reliability

In order to estimate measurement variability and demonstrate reliability, several considerations were made in devising the protocol for this study.

Measurement Variability of Anthropometry

Replicate anthropometric dimensions were taken on a subsample of approximately 10% of the study sample (64 subjects). The replicate measurements were made at least 1 day apart and no more than 2 months apart (mean 10 days). The intra-observer technical error of measurement was calculated using the following formula (Malina et al., 1973):

$$TEM = \sqrt{(d^2) / 2n}$$

where d^2 is the sum of the squared differences of replicate measurements and $2n$ represents twice the number of pairs. Additionally, reliability coefficients (intra-class correlation coefficients) were calculated for the anthropometric measurements. One-way analysis of variance was used to obtain the mean square among subjects (MS_A) and the mean square within subjects (MS_W). The formula for the intraclass correlation coefficient is as follows (Baumgartner and Jackson, 1991):

$$r_{\text{intra}} = (MS_A - MS_W) / MS_A$$

The closer the intraclass correlation coefficient is to one, the smaller the error introduced by the observer. Table 3.2 presents the age and sex distribution of the subsample used in this analysis. The average age of the sample was 25.4 years, ranging from 4.4 to 75.3 years. Descriptive statistics are not presented due to the wide range of ages represented in the subsample.

The mean differences between replicate measures are presented with the intra-observer TEMs and intraclass correlation coefficients in Table 3.3. Table 3.4 compares the intra-observer TEMs with those from selected studies (Malina, 1995). The intra-observer error in this study is similar to that of the Hispanic Health and Nutrition Examination Survey (Chumlea et al., 1990) and the National Health and Nutrition

Examination Survey (Johnston et al., 1972; Malina et al., 1973). The TEMs reported by Siegel (1995) and Klika (1995) are quite low; however these studies involved athletic subjects within a small age-range. The sample of the present study is comparable in age range to the national surveys described above; thus the intra-observer TEM is of similar magnitude. The technical errors of measurement for the somatotype components were ≤ 0.2 somatotype components, which compare to those reported for the Quebec Family Study (≤ 0.3 somatotype units; Bouchard, 1985).

Reliability of Strength, Flexibility and Motor Fitness

Within day reliabilities of the fitness tests were estimated using intraclass correlation coefficients (r_{intra}) between the best versus the second best trial of the three trials which were achieved for each test (Baumgartner and Jackson, 1991).

Intraclass correlations for the strength, flexibility and motor fitness variables are presented in Table 3.5 along with the sample sizes used for the calculation of each correlation. Intraclass reliability coefficients are compared to selected studies in Table 3.6. The fitness tests in the present study are very reliable, demonstrating intraclass correlations greater than or equal to 0.99 for all variables. Given that the intraclass correlations were calculated over a large age range, it is not surprising that they appear higher than those of the other studies, which use single year age groups.

Data Management

Each subject was identified by an ID number and data were entered into a database management system (Dbase III). A file was created which contained the subject id number, parental id numbers, sex, ethnicity, birth and observation dates, and all anthropometric and performance data collected on each subject.

All data were double entered into a second Dbase III file, which was merged with the original file using SPSS procedures (SPSS, 1990). An SPSS program was written to compare the two Dbase III files and flag discrepant values. Errors were corrected in the Dbase III files until no discrepant values were found.

The corrected Dbase III file containing all anthropometric and performance data was converted into an SPSS system file which was retained for further analysis. SPSS programs were written to compute fractional ages and anthropometric indices based on existing data.

Missing data were coded as system missing values with the exception of single skinfolds. For individuals who were missing a single skinfold, this value was predicted using multiple regression from the subject's age, sex and the remaining six skinfolds. This procedure resulted in increasing the sample size for anthropometric indices which have skinfolds as a component. A total of 25 individual skinfolds were predicted in adults, none in children. Table 3.7 demonstrates the prediction equations and the standard errors of the estimates for the predicted skinfolds (abdominal, subscapular, and medial calf).

For the purpose of identifying outliers, examining distributions for normality, and adjusting values for age, the sample was split into four groups based on age and sex. The groups were as follows: males ≥ 19.50 , males ≤ 19.49 years, females ≥ 19.50 years, and females ≤ 19.49 years. Frequency distributions for all variables were examined for normality, and those variables significantly skewed were $\log_{10}$ transformed where appropriate. The variables demonstrating skewed distributions and

their associated skewness statistics are presented in Table 3.8. For the comparative analyses between EA and FN samples, the $\log_{10}$ transformed values were used in place of the raw data.

Outliers were considered to be values falling beyond 4 standard deviations of each age group mean (see above) and were eliminated from further analysis. The elimination of outliers resulted in the loss of 29 values from 11 subjects.

Regression analyses were used to adjust raw data for the effects of age within each of the age/sex groups defined above for the purpose of the familial aggregation analyses. Scores were adjusted by applying the following multiple regression:

$$Y = \text{age} + \text{age}^2 + \text{age}^3$$

The residuals of the multiple regression were retained for further analysis, and were considered to be adjusted for the effects of age and sex. Since somatotype is a three component descriptor, each somatotype component was further adjusted for the effects of the other two components by regression procedures (Song et al., 1993). Tables 3.9 and 3.10 present the variability in the original variables which was accounted for by the adjustment procedures.

For the purpose of the familial aggregation analyses, the data were reorganized into parent and offspring samples. A total of 266 nuclear families were differentiated following the reorganization. Variables were then z-standardized within generations which served to normalize the distributions of several skewed variables. The offspring generation was further reorganized into sibships based on parental id numbers. The distribution of sibship size is presented in Table 3.11.

Statistical Analyses

The analyses for the specific hypotheses are as follows:

Hypothesis 1

There are significant differences between Canadians of First Nation (FN) and European ancestry (EA) in body size, physique, and indicators of health-related fitness.

Hypothesis 1a) FN Canadians are heavier and demonstrate greater subcutaneous fatness than EA Canadians throughout childhood into adulthood.

Analyses:

Within age/sex groups, indicators of heaviness (body mass, BMI) and subcutaneous fatness (SUM, TRUNK, EXTREMITY) were compared between FN and EA subjects using ANCOVA with age as a covariate. Individual anthropometric z-scores were calculated for body mass, the BMI, triceps and subscapular skinfolds, and AMA using the following equation (Gibson, 1990; 251):

$$z \text{ score} = \frac{\text{individual's value} - \text{median value of reference population}}{\text{standard deviation value of reference population}}$$

The reference data used for body mass were from Health and Welfare Canada (1980), while data for the BMI, and triceps and subscapular skinfolds were from the NHANES II for the U.S. population (Najjar and Rowland, 1987). AMA was z-standardized using the reference data of Frisancho (1990) for U.S. Whites based on NHANES I and NHANES II. Additionally, z-scores for body mass in FN subjects were also calculated using First Nation reference data from Health and Welfare Canada (1980). Since the conversion of data into z-scores theoretically eliminates the function of age, independent samples t-tests were used to make comparisons among FN and EA subjects, and between males and females in terms of z-transformed variables.

Prevalence rates for obesity were calculated for FN and EA samples by age and sex group. Two indicators of obesity were used: the BMI and the triceps skinfold (TSF). For subjects 5-19 years of age, the criteria for obesity based on the BMI and

TSF was greater than or equal to the respective age- and sex-specific 85th percentiles of NHANES II data (Najjar and Rowland, 1987). For subjects 20-75 years of age, the criteria for BMI obesity was $\geq$ 85th percentile NHANES II data for 20-29 year old people ($\text{BMI} \geq 27.8$ in males and $\text{BMI} \geq 27.3$ in females) and the criteria for TSF obesity was $\geq$ 85th percentile NHANES II data for 18-24 year old people ($\text{TSF} \geq 17.5$ mm in males and $\text{TSF} \geq 29.5$ mm in females).

Subjects were classified as obese by both the BMI and TSF independently. Additionally, subjects were classified as obese by the BMI only (BMI Obese), TSF only (TSF Obese), or both the BMI and TSF together (BMI+TSF Obese). This classification is based on Malina et al. (1989), which generally corresponds to the scheme of Van Italie and Abraham (1985): “overweight not obese” - high BMI, low skinfolds, “obese not overweight” - high skinfolds, low BMI, and “overweight and obese” - high BMI, high skinfolds. Characteristics of subjects in each classification of obese were compared in terms of selected bony dimensions, relative fat distribution, and somatotype.

Hypothesis 1b) There are significant differences in relative fat distribution and physique between FN and EA Canadians.

Analyses:

Within age/sex groups, the TER, an indicator of relative subcutaneous fat distribution, and the WHR, an indicator of central/peripheral fat distribution, were compared between FN and EA subjects within age/sex groups using ANCOVA, with age as a covariate.

Heath-Carter anthropometric somatotypes were compared using the protocol of Cressie et al. (1986), which involves three steps. Since somatotype is a three component index, each component should not be considered as a separate variable. The first step in the analysis was to perform an overall MANCOVA between the groups with age as a covariate. For those comparisons demonstrating a significant

MANCOVA, univariate F-tests were performed to determine which components were contributing to the significant difference. Finally, for those groups demonstrating a significant MANCOVA, a forward discriminant function analysis was performed to determine which somatotype components best distinguish between the two groups.

1c) There are no differences in stature and other skeletal dimensions between FN and EA Canadians.

Analyses:

Stature, sitting height, the SSR, the HSR, and skeletal dimensions were compared between FN and EA subjects within age/sex groups using ANCOVA, with age as the covariate.

Anthropometric z-scores were calculated for stature and the SSR using reference data from Health and Welfare Canada (1980). Additionally, z-scores were calculated for stature and the SSR among FN subjects using First Nation reference data from Health and Welfare Canada (1980). Differences in anthropometric z-scores between FN and EA subjects, and between males and females were assessed using independent samples t-tests.

Hypothesis 2

Secular trends in body size are evident in FN and EA Canadians.

Hypothesis 2a) There are significant secular increases in stature, mass and the BMI in FN and EA Canadians.

Analyses:

This hypothesis was tested two ways. First, comparisons of stature among several samples collected in Canada over the last 35 years were made. Second, the approach of Himes and Mueller (1977a) was used for an internal analysis of statural changes within the FN and EA samples. The technique of Himes and Mueller involves two steps. The first step was to estimate statural losses due to aging, which was accomplished by regressing stature on age, controlling for subischial length (SIL). The

partial regression coefficient was retained as the shrinkage factor. Stature of all individuals aged 30 years and older was adjusted by the shrinkage factor. Age 30 was chosen as the age representing maximal stature as some growth may occur into the mid-twenties, especially in males (Trotter and Gleser, 1951; Hertzog et al., 1969). The second step was to regress the adjusted stature estimates on age, and then to use the regression coefficient as an estimate of the secular change.

An internal secular trend analysis of body mass and the BMI was not possible due to the natural tendency for these variables to increase with age. This hypothesis was tested by comparison of body mass and the BMI among several samples in Canada over the last 35 years.

Hypothesis 3

There is significant familial resemblance in body size, physique and indicators of health-related fitness in FN and EA Canadians.

Hypothesis 3a) There is significant familial resemblance in body size, physique and indicators of health-related fitness in FN and EA Canadians.

Analyses:

The assessment of familial resemblance in the traits of interest was approached using correlation and regression analyses. The following four approaches were used:

1) Intraclass sibling correlations were computed using the ANOVA procedures of Donner and Koval (1980, see also Donner and Eliasziw, 1991). This analysis was limited to 106 sibships with at least 2 siblings. The following summarizes the ANOVA:

Source	df	Sum of Squares	Mean Squares	F
Between Sibships	n - 1	SSB	MSB	MSB/MSW
Within Sibships	k - n	SSW	MSW	

where

n is the number of sibships,

$$k = \sum_{i=1}^n k_i, \text{ the total number of observations.}$$

The ANOVA estimator of the sibling correlations is defined as:

$$r_{\text{ms}} = \frac{\text{MSB} - \text{MSW}}{\text{MSB} + (k_0 - 1) \text{MSW}},$$

where

$$k_0 = \frac{1}{n-1} \left(k - \frac{1}{k} \sum_{i=1}^n k_i^2 \right).$$

2) Pearson interclass spousal correlations were computed between each set of parents.

3) Pearson interclass parent-offspring correlations were computed between each parent and offspring in the following combinations: father-son, father-daughter, father-offspring, mother-son, mother-daughter, and mother-offspring using the pairwise estimator method (Donner, 1979).

4) The regression of offspring on mid-parent (mother + father / 2) values was done to estimate heritability (h^2). Using this approach the regression coefficient is the estimator of h^2 . It must be noted that the regression coefficient obtained is not directly comparable to the correlation coefficients obtained using the previous approaches.

Hypothesis 3b) Estimated heritabilities for strength and flexibility are greater after body morphology is factored into the analyses as a covariate.

Analyses:

Estimates of familial aggregation for grip strength and heritability were computed as described above. Age-adjusted grip strength and flexibility scores were then adjusted for body mass, stature, and the BMI independently using regression procedures. The amount of variability accounted for by age, body mass, stature, and the BMI on grip strength and flexibility using regression techniques is presented in Table 3.12. The four estimates of familial aggregation were then recalculated using the values adjusted for body size.

CHAPTER IV

RESULTS

Introduction

The results are presented in two sections. The first section presents descriptive statistics for the sample and comparisons with reference data, while the subsequent section presents results of analyses related to specific hypotheses.

For descriptive purposes, the sample was divided into the following sex-specific age groups: 5-9, 10-14, 15-19, 20-29, 30-39, 40-49, 50-59, 60-69, and 70-75 yrs. The age groups were chosen to correspond with those used in national Canadian surveys (Health and Welfare Canada, 1980; Fitness Canada, 1983, 1985, 1986). However, for the statistical analyses, the sample could not be broken down into the same age categories due to insufficient numbers in the First Nation group. The age groups used in the analyses were 5-19 years and 20-75 years and age was incorporated into each analysis as a covariate.

Descriptive Statistics

Tables 4.1 through 4.7 present descriptive anthropometric data for all variables measured and derived. Tables 4.8 and 4.9 present sample sizes, means and standard deviations for the health-related fitness measures. These data are presented for descriptive purposes and are compared to the most recently available reference data for Canada, and at times to U.S. data when there are no corresponding reference data for Canadians.

Stature

Stature was compared to Canadian reference data from the Canada Fitness Survey (Fitness Canada, 1985, 1986). Stature of EA and FN males 5-19 years is presented in Figures 4.1 and 4.2. Stature is between the 10th and 90th percentiles until about ages 10-12 years, when it appears to increase relative to the reference values in EA males, and approximates the median in FN males. 5-year age group means approximate the reference medians (Figure 4.3 and 4.4).

Stature of EA and FN males reaches a peak between ages 20-25 and then slowly declines throughout adulthood (Figures 4.5 and 4.6). Adult 10-year age group means fall between the 50th and 90th percentiles. Mean stature of EA and FN females track at the 50th percentile throughout adulthood, and the distribution of statures overlaps the reference data (Figures 4.7 and 4.8).

Body Mass

Body mass was compared to Canadian reference data from the Canada Fitness Survey (Fitness Canada, 1985, 1986). Body mass in EA males 5-19 years follows the same pattern as stature (Figure 4.9). It approximates the 50th percentile until about age 10-12 and then begins to climb relative to the reference data. FN males are heavy relative to the reference data throughout childhood (Figure 4.10).

The body mass of EA and FN females 5-19 years (Figures 4.11 and 4.12) generally approximates the 50th percentile in EA females until about age 10-12 when variability increases. Body mass in FN females generally falls between the 10th and 90th percentiles.

Body mass remains high throughout adulthood in EA and FN males, with 10-year age group means generally between the 50th and 90th percentiles of the reference data (Figures 4.13 and 4.14). Similarly, 10-year age group means for body mass in EA females track between the 50th and 90th percentiles (Figure 4.15). The body

masses of FN females are high relative to the reference data, with 10-year age group means approximating the 90th percentiles throughout adulthood (Figure 4.16).

Sitting Height

Sitting height was compared to reference data from the U.S. for children and youth (Hamill et al., 1973; Malina et al., 1974) and from the Nutrition Canada Survey for adults (Health and Welfare Canada, 1980). Sitting height in EA and FN males 5-19 years follows the same trend as stature (Figures 4.17 and 4.18). The 5-year age group means generally approximate the reference medians, but sitting height increases relative to the reference in EA males after about age 12. Sitting height of EA females 5-19 years follows reference medians, whereas 5-year age group means in FN females 5-19 years are between the 50th and 90th percentiles (Figures 4.19 and 4.20).

The distribution of sitting heights in adult EA and FN males overlaps the distribution of the reference data, and values decrease throughout adulthood (Figures 4.21 and 4.22). Similarly, sitting height in adult EA and FN females approximates the reference medians (Figures 4.23 and 4.24).

Subischial Length

Estimated leg length (SIL) was compared to reference data from the U.S. for children and youth (Hamill et al., 1973; Malina et al., 1974). In all age and sex groups, SIL approximates the reference medians throughout childhood and adolescence, but in EA males, SIL climbs relative to the reference in late adolescence (Figures 4.25 through 4.28).

Sitting Height/Stature Ratio

The sitting height/stature ratio (SSR) was compared to reference data from the U.S. for children and youth (Hamill et al., 1973; Malina et al., 1974) and from the Nutrition Canada Survey for adults (Health and Welfare Canada, 1980). A significant number of EA and FN males 5-19 years fall below the 10th percentile for SSR, indicating that they are relatively long-legged compared to the reference (Figures 4.29

and 4.30). The 5-year age group means fall between the 10th and 50th percentiles. Figures 4.31 and 4.32 present corresponding data for the SSR in EA and FN females 5-19 years. In EA females, 5-year age group means are between the 10th and 50th percentiles, and they are slightly higher in FN females, although there is considerable variability in the data.

Throughout adulthood, 10-year age group means for SSR are below the 50th percentile in EA males (Figure 4.33). There is considerable variability in the SSR of FN males 20-75 years; however, 10-year age group means approximate the median (Figure 4.34). The 10-year age group means for SSR in EA and FN females tend to fall between the 10th and 50th percentiles throughout adulthood, although the distributions overlap the reference data (Figures 4.35 and 4.36).

Arm Muscle Area

Estimated arm muscle area (AMA) was compared to U.S. reference data for Whites from NHANES I and II (Frisancho, 1990). AMA in EA and FN males 5-19 years approximates the reference medians (Figures 4.37 and 4.38). Similarly, 5-year AMA means in EA and FN females 5-19 years also approximate the medians (Figures 4.39 and 4.40).

The AMA of adults is presented in Figures 4.41 through 4.44. In all sex/ethnic groups, the distribution of AMAs overlaps the distribution of the reference data. Similarly, 10-year age group means in all sex/ethnic groups approximate the reference medians.

BMI

The BMI was compared to U.S. reference data from NHANES II (Najjar and Rowland, 1987). In EA males 5-19 years, the distribution of the BMI is bimodal, with many subjects between the 10th and 50th percentiles, and many individuals at the upper extreme of the distribution, >90th percentile (Figure 4.45). Similarly, the BMI of FN males 5-19 years is generally between the 10th and 90th percentiles, with some subjects

exceeding the 90th percentile (Figure 4.46). With few exceptions, the BMI of EA females 5-19 years falls between the 10th and 90th percentiles of the reference data, and 5-year age group means approximate the median (Figure 4.47). FN females 5-19 years also demonstrate a distribution of the BMI that extends from the 10th percentile to >90th percentile (Figure 4.48).

There are a significant number of EA males 20-75 years with a BMI >90th percentile throughout the age range (Figure 4.49). FN 20-75 years are also heavy, with 10-year age group means falling between the 50th and 90th percentiles (Figure 4.50). The BMI of adult EA females follows the same pattern as adult EA males; 10-year age group means are between the 50th and 90th percentiles, and there are a large number of people with a BMI >90th percentile (Figure 4.51). Similarly, FN females 20-75 years are also heavy, with 10-year age group means falling between the 50th and 90th percentiles (Figure 4.52).

Triceps Skinfold

The triceps skinfold was compared to U.S. reference data from NHANES II (Najjar and Rowland, 1987). The distribution of the triceps skinfold in EA males 5-19 years overlaps that of the reference data, with values ranging from <10th to >90th percentile. Similarly, 5-year age group means fall between the 50th and 90th percentiles (Figure 4.53). FN males 5-19 years also have triceps skinfolds which generally fall between the 10th and 90th percentiles for ages 5-19 years (Figure 4.54). Note that the 10th and 50th percentiles of the reference data are relatively stable; however, the 90th percentiles vary with age in males 5-19 years. As in males, the distribution of the triceps skinfold in EA females approximates the distribution of the reference data, and those of FN females are generally within the 10th and 90th percentiles (Figures 4.55 and 4.56).

Adult 10-year age-group means for the triceps skinfold approximate the reference medians throughout adulthood in EA males and females (Figures 4.57 and

4.59). Although the distribution of the triceps skinfold of FN males and females overlaps the reference distribution, 10-year age group means tend to fall above the medians (Figures 4.58 and 4.60).

Subscapular Skinfold

The subscapular skinfold was compared to U.S. reference data from NHANES II (Najjar and Rowland, 1987). The distribution of the subscapular skinfold in both EA and FN males is bimodal in the 5-19 year age group, with most of the sample falling between the 10th and 90th percentiles, and another group falling above the 90th percentile (Figures 4.61 and 4.62). The distribution of subscapular skinfolds in EA females is similar to that of EA males, such that it is skewed towards the upper extremes (Figure 4.63). The subscapular skinfolds of FN females generally fall between the 10th and 90th percentiles of the reference data (Figure 4.64).

In adulthood, 10-year age group means for the subscapular skinfold are between the 50th and 90th percentiles for EA and FN males, with a large number of subjects above the 90th percentile (Figures 4.65 and 4.66). Although the distributions of the subscapular skinfold overlap the reference distributions, adult EA and FN female 10-year age group means are between the 50th and 90th percentiles of the reference data (Figures 4.67 and 4.68).

Grip Strength

Combined grip strength (right+left grip) was compared to reference data from the Canada Fitness Survey (Fitness Canada, 1985, 1986). There is a linear relationship between grip strength and age in males and females 5-19 years, and no apparent differences between EA and FN children. Values approximate the medians of the reference data in all sex/ethnic groups (Figures 4.69 through 4.72).

Among adults, 10-year age group means in EA males are above the 50th percentile, whereas corresponding means of FN males are below the 50th percentile, with the exception of the 20-29 year age group (Figures 4.73 and 4.74). In contrast,

means for EA and FN adult females are above the 50th percentile and the distributions overlap considerably (Figures 4.75 and 4.76).

Trunk Flexibility

Trunk flexibility was compared to reference data from the Canada Fitness Survey (Fitness Canada, 1985, 1986). There is no apparent relationship of flexibility with age, and values generally fall between the 10th and 90th percentiles of the reference data for children 5-19 years (Figures 4.77 through 4.80).

The distributions of trunk flexibility in adults overlap the distributions of the reference data, and both EA and FN 10-year age group means approximate the 50th percentile throughout adulthood (Figures 4.81 through 4.84). There are no apparent differences in the distribution of flexibility scores among EA and FN groups.

Sit-ups

The number of sit-ups performed in 60 seconds was compared to reference data from the Canada Fitness Survey (Fitness Canada, 1985, 1986). The number of sit-ups increases with age in both males and females, and the distributions of EA and FN children overlap considerably (Figures 4.85 through 4.88). Compared to the reference data, EA and FN children perform poorly, with 5-year age group means falling between the 10th and 50th percentiles in all sex/ethnic groups.

Flexed Arm Hang

The timed flexed arm hang was compared to data from the Michigan State University Motor Performance Study (Haubenstricker et al., 1991). Performance increases with age in EA males (Figure 4.89), but does not show a linear trend with age in FN males (Figure 4.90). In females, the age related increase in the reference data is not as marked as in the males (Figures 4.91 through 4.92). The distribution of values in EA and FN females overlaps the distributions of the reference data, and the distributions of EA and FN children overlap considerably. Although low, the values of EA and FN children fall within the range for U.S. (Michigan) children.

35-meter Dash

Running speed (m/s) in the 35 meter dash was compared to running speed (m/s) for a 27.5 meter dash in the Michigan State University Motor Performance Study (Haubenstricker et al., 1991). Running speed increases linearly with age in boys and girls (Figures 4.93 through 4.96). There are no apparent differences between EA and FN children in speed; however, mean running speed is at or below the 10th percentile of the reference data in both EA and FN boys and girls.

Standing Long Jump

The standing long jump was also compared to data from the Michigan State University Motor Performance Study (Haubenstricker et al., 1991). Performance increases linearly with age in EA and FN boys and girls, but the slopes vary (Figures 4.97 through 4.100). There are no apparent differences between EA and FN children. Relative to U.S. (Michigan) children, performance of the EA and FN children generally falls between the 10th and 50th percentiles.

Anthropometric Z-Score Analysis

Anthropometric z-scores indicate that both EA and FN males are tall and heavy relative to Canadian reference data (Health and Welfare Canada, 1980). Mean z-scores for stature in males range from 0.42 to 0.98, and those for mass in males range from 0.68 to 1.44 (Table 4.10). Relative to U.S. NHANES II data (Najjar and Rowland, 1987), male BMIs are also greater, demonstrating mean z-scores ranging from 0.40 to 0.82. Mean z-scores for stature in females are consistently positive and similar in magnitude as males, ranging from 0.41 to 0.75. Female z-scores for mass are more variable among age and ethnic groups, ranging from -0.43 in EA females 20-75 years to 1.11 in FN females 5-19 years. Female BMI z-scores are also similar in direction and magnitude as males. BMI z-scores range from 0.26 to 0.99 in females. Table 4.10 demonstrates that the SSR is consistently lower than Canadian reference data in all age and ethnic groups, values ranging from -0.10 to -0.73, indicating that the subjects have relatively long lower extremities compared to the reference.

Subcutaneous fatness shows considerable variability in distribution of z-scores of the triceps and subscapular skinfolds. Triceps skinfold z-scores are similar to those for the BMI in 5-19 year males (EA 0.45, FN 0.80). In males 20-75 years, triceps z-scores are lower than in the younger age group (EA 0.13, FN 0.31). Subscapular skinfold z-scores are also positive in males, ranging from 0.44 in EA 5-19 year males to 1.47 in FN 5-19 year old males. Among females, triceps skinfold z-scores are low and positive, whereas subscapular z-scores are positive and greater in magnitude within each age/sex group.

There are significant ethnic differences in anthropometric z-scores within age groups. In 5-19 year old males, FN boys are significantly taller, heavier and demonstrate greater subscapular skinfolds relative to the reference values ($p \leq 0.05$). In 20-75 year old females, the FN sample demonstrates a significantly higher mass, BMI,

triceps and subscapular skinfolds, and AMA than the EA sample relative to the reference ($p \leq 0.05$).

There are also significant sex differences in anthropometric z-scores within age groups. In the 5-19 year old EA sample, males are significantly taller than females relative to the reference ($p \leq 0.05$). In 5-19 year old FN subjects, males have significantly greater triceps and subscapular skinfolds than females relative to the reference ($p \leq 0.05$). In the 20-75 year old EA and FN samples, males are significantly heavier than females relative to the reference ($p \leq 0.05$).

Anthropometric z-scores of FN adults standardized against Canadian FN reference data (Health and Welfare Canada, 1980) are presented in Table 4.11. Mean z-stature in FN males is 0.70 standard deviations above the Canadian national reference. Similarly, mass in FN males is 1.38 standard deviations above the reference. In FN females, z-scores for stature and mass are also positive (z-stature=0.98, z-mass=0.69). The mean z-score for mass in males is significantly greater than in females ($p \leq 0.05$). There are no sex differences in FN SSR z-scores, which are zero and negative in both males and females, respectively (males 0.01, females -0.37).

Caution must be used in interpreting z-scores derived from reference data from various sources such as above. Secular trends may have occurred between studies which make interpretation of the absolute values of z-scores difficult. Given that comparisons within a given trait were made using the same reference, the temporal trends in the reference data do not play a role in interpreting the results.

Secular Trend Analysis for Stature

The regression of stature on age in adults 20-75 years indicates a significant decrease in stature with age in EA males and females (Table 4.12). Estimated rates of decrease are 0.21 cm/year in EA males ($p<0.001$) and 0.10 cm/year in EA females ($p=0.002$). The regression coefficients for FN adults, in contrast, are not significant, suggesting no secular change in stature.

Based on partial regression coefficients for stature on age, controlling for SIL, shrinkage estimates are significant in EA males and females. Statural loss due to aging is estimated at 0.12 cm/year in males ($p<0.001$) and 0.06 cm/year in females ($p<0.001$),

After adjustment for shrinkage due to aging, a significant secular trend for stature is apparent in EA males. Estimated secular increases in stature adjusted for age-related shrinkage are 1.0 cm/decade in EA males ($p<0.005$) and 0.4 cm/decade in EA females ($p=0.19$, ns).

Stature, Skeletal Dimensions and Circumferences

Ethnic Differences

Table 4.13 presents results of the ANCOVAs for differences in stature, skeletal dimensions and AMA between EA and FN. There are few differences in stature and skeletal dimensions. Stature, the SSR and AMA are not different in any age and sex group. Among males 5-19 years, the FN sample demonstrates significantly greater biacromial breadth and HSR ($p \leq 0.03$). In males 20-75 years, the only significant difference is biepicondylar breadth, which is greater in the FN sample ($p = 0.05$).

Among females, only the 20-75 year age group demonstrates significant differences in skeletal dimensions. Bicondylar, biepicondylar, biacromial, and bicristal breadths, as well as the HSR are greater in FN females ($p \leq 0.02$).

Sex Differences

Males are significantly taller in all age and ethnic groups, except for the 5-19 year FN subjects, where the difference is not significant (Table 4.14). Females demonstrate higher SSRs than males in all groups; however, only the 20-75 year EA sample shows a significant difference in the SSR ($p < 0.001$). In all age and ethnic groups, males have significantly greater biepicondylar, bicondylar and biacromial breadths than females ($p \leq 0.05$). Bicristal breadth is only greater in males in the 20-75 year EA sample ($p = 0.003$). In all age and ethnic groups, females have a higher HSR than males, and males have greater estimated AMA ($p \leq 0.05$).

Familial Resemblance

Stature, skeletal dimensions, circumferences, and AMA were examined for familial resemblance. Intraclass sibling correlations for stature are 0.53 in the total sample, 0.66 in the EA sample, and 0.79 in the FN sample ($p < 0.001$), indicating significant aggregation of stature within sibships (Table 4.15). Similarly, sibling correlations for sitting height, SSR, SIL, biacromial breadth, and AMA also demonstrate significant aggregation within sibships in the EA, FN, and total sample

($p < 0.05$). Sibling correlations are also significant for all of the other skeletal breadths and circumferences in the EA and total samples, but not the FN sample (Table 4.15). The non-significant results in the FN group are probably related to the small samples.

There is no evidence for assortative mating for stature, skeletal dimensions, circumferences or AMA in this Northern Ontario population. Spousal correlations are low and generally not significant in both ethnic groups (Table 4.16). Interclass correlations between parents and offspring are also presented in Table 4.16. In the EA sample, stature correlations range from 0.29 to 0.43 ($p \leq 0.05$). The correlations for stature in the total sample are somewhat lower, and the father-son correlation is not significant. Familial correlations for stature in the FN sample are low and generally not significant except for mother-daughter ($r = 0.51$, $p \leq 0.05$) and mother-offspring ($r = 0.29$, $p \leq 0.05$) pairs.

Patterns of familial correlations indicate significant familial resemblance in all skeletal breadths, circumferences and AMA. Significant correlations vary with sample sizes, as larger correlations are required to reach significance in small samples. This probably explains the large number of non-significant correlations in the FN sample.

Estimates of heritability based on mid-parent regression indicate that stature, skeletal breadths, and circumferences are significantly heritable in the EA and total samples, but not in the FN sample (Table 4.17). AMA does not show significant heritability in any group. Estimated heritabilities for stature are 0.68 ($p < 0.001$) in the EA sample and 0.40 ($p < 0.001$) in the total sample. Significant heritabilities range from 0.25 to 0.59 in the total sample for these measurements.

Body Mass, Fatness and Relative Fat Distribution

Ethnic Differences

Table 4.18 presents the results of ANCOVAs for differences in body mass, fatness and fat distribution between EA and FN samples within age and sex groups. There are several significant differences. In the 5-19 year males, the FN sample has significantly higher means for SUM, TRUNK, EXTREMITY, TER, and WHR ($p \leq 0.05$), indicating that they have greater subcutaneous fatness and relatively more truncal or central subcutaneous fat.

In males 20-75 years, EXTREMITY, TER and WHR are significantly higher in the FN sample. Other indicators of fatness are also higher in the FN sample; however, they are not statistically significant due to a large amount of variability and small sample sizes in the FN sample. The results suggest that FN adult men have a greater propensity to store subcutaneous fat on the trunk.

In females 5-19 years, FN subjects have a significantly higher TER, indicating that they store relatively more fat on the trunk than EA females ($p = 0.006$). Adult FN females differ from EA females in every indicator of fatness and relative fat distribution. Body mass, BMI, SUM, TRUNK, EXTREMITY, TER and WHR are significantly higher in FN females than in EA females 20-75 years ($p \leq 0.05$). The results indicate that FN females 20-75 years have more subcutaneous fatness and a more central pattern of subcutaneous fat distribution than EA females.

Sex Differences

Table 4.19 presents the results of the ANCOVAs for differences in body mass, fatness, and relative fat distribution between males and females within age and ethnic groups. In the 5-19 year EA sample, females have significantly higher means for EXTREMITY and SUM, indicating that they are storing more subcutaneous fat than males, possibly due to adolescent loss of fatness on the extremities in males.

EA males 20-75 years are heavier and have a greater BMI than females; however, females have higher values for SUM, EXTREMITY and TRUNK, indicating greater subcutaneous fatness. Similarly, FN females 20-75 years are lighter than males, and they have higher means for SUM, TRUNK and EXTREMITY ($p \leq 0.002$).

In every age and ethnic group, males have significantly higher TERs and WHRs than females. The results indicate that males accumulate proportionally more subcutaneous fat on the trunk than the extremities than females.

Familial Resemblance

There is significant aggregation of fatness and relative fat distribution within sibships (Table 4.20). In the EA and total samples, significant intraclass sibling correlations are evident for all indicators of fatness and relative fat distribution. Correlations range from 0.40 to 0.57 in the EA sample, and from 0.13 to 0.38 in the total sample. In the FN group, indicators of fatness do not aggregate within sibships; however, indicators of relative fat distribution show significant intraclass correlations, 0.25 for the TER and 0.50 for the WHR ($p \leq 0.05$).

There is also significant familial resemblance in fatness and relative fat distribution between generations (Table 4.21). There does not appear to be assortative mating for body mass, fatness or relative fat distribution in this sample. Spousal correlations are low and not significant for all variables. Significant parent-offspring correlations range from 0.20 to 0.57. All variables, with the exception of the WHR, demonstrate significant father-offspring and mother-offspring correlations in the EA sample, and with the exception of TRUNK and WHR in the father-offspring correlations, all correlations are significant for father-offspring and mother-offspring in the total sample. Correlations in the FN sample are low and rarely reach significance probably due to small sample sizes. It appears as though there are several spurious negative correlations, particularly in the father-son category which has only 10 pairs of FN subjects.

Heritability estimates from regression of offspring on mid-parent values are presented in Table 4.22. The estimates in the FN sample are generally low and none are significant. With the exception of the WHR, all heritability estimates are significant in the EA and total samples ($p \leq 0.003$). Estimates of h^2 range from 0.30 to 0.45 in the EA sample and from 0.25 to 0.42 in the total sample.

Prevalence of Obesity

The prevalence of obesity using the BMI and triceps skinfold as criteria are presented in Table 4.23. Prevalence of obesity using the BMI is higher in FN subjects of all age and sex groups, ranging from 29.4% in FN females 5-19 years to 58.8% in FN females 20-75 years. However, the prevalence of obesity using the BMI is also high in the EA sample, ranging from 16.9% in EA females 5-19 years to 39.0% in EA males 20-75 years. The prevalence of obesity, based on the triceps skinfold, is highest in females 20-75 years. Prevalences of obesity based on the triceps skinfold range from 11.8% in FN females 5-19 years to 47.1% in FN females 20-75 years.

The prevalences of obesity based on the triceps alone (TSF Obese), the BMI alone (BMI Obese), and the triceps and BMI together (TSF+BMI Obese) are also presented in Table 4.23. Estimated prevalences of TSF Obesity range from 0.0% in FN females 5-19 years to 8.5% in EA females 5-19 years. In contrast, the estimated prevalences of BMI Obesity range from 2.7% in EA males 5-19 years to 40.0% in FN males 20-75 years. Estimated prevalences of TSF+BMI Obesity range from 10.2% in EA females to 43.1% in FN females 20-75 years.

Prevalences of obesity differ significantly between EA and FN females 20-75 years. The estimated prevalences are higher in the FN sample ($p \leq 0.05$) for triceps independently, the BMI independently, and TSF+BMI Obese (Table 4.23).

Differences between adult subjects classified as BMI Obese and TSF+BMI Obese are presented in Table 4.24. There were insufficient numbers in the 5-19 year old groups to make comparisons. Also, there were too few subjects classified as TSF

Obese to compare to the other groups. In all sex and ethnic groups except EA females, BMI Obese subjects have greater TERs than the TSF+BMI Obese ($p \leq 0.05$). In all groups, except FN males, there were significant somatotype differences between the groups classified as obese by different criteria. In general, endomorphy is greater in the TSF+BMI Obese group, and in the EA sample, mesomorphy is greater and ectomorphy is lower in the TSF+BMI Obese sample. In EA males, the TSF+BMI Obese group has a greater mean biepicondylar breadth, while both EA male and female TSF+BMI Obese have greater bicondylar breadths.

Physique

Ethnic Differences

There are significant differences in Heath-Carter anthropometric somatotypes between FN and EA subjects (Table 4.25). Significant MANCOVAs, with age as the covariate, are apparent for males 5-19 years ($p=0.002$), and 20-75 years ($p=0.04$), and for females 20-75 years ($p<0.001$). The MANCOVA for females 5-19 years is not significant ($p=0.10$).

Results of the univariate somatotype component F-tests for pairwise comparisons are also presented in Table 4.25. In males 5-19 years, FN subjects are significantly more endomorphic than the EA subjects ($p=0.004$). In males 20-75 years, endomorphy ($p=0.03$) is significantly greater and ectomorphy ($p=0.01$) is significantly lower in the FN sample. In 20-75 year old females, endomorphy ($p<0.001$) and mesomorphy ($p=0.001$) are significantly greater, and ectomorphy ($p<0.001$) is significantly less in the FN sample. Although not significant, somatotype differences between EA and FN females 5-19 years are in the same direction as in the other age and sex groups (greater endomorphy).

Forward discriminant function analyses indicate that endomorphy is the most important discriminator between FN and EA subjects in all age and sex groups, entering the analysis first in all groups (Table 4.26). In males 5-19 years and females 20-75 years, ectomorphy enters the analysis as the second most important discriminator, followed by mesomorphy. In males 20-75 years and females 5-19 years, mesomorphy enters second, followed by ectomorphy.

Sex Differences

Somatotypes of males and females differ in both the EA and FN samples. Table 4.27 presents the results of the overall MANCOVAs for sex differences, which are determined for all age and ethnic groups ($p\leq 0.004$). Table 4.27 also presents the results of pairwise comparisons for somatotype component differences between males

and females. EA males 5-19 years and 20-75 years are significantly less endomorphic and significantly more mesomorphic than females ($p \leq 0.003$). FN males 5-19 years are significantly more mesomorphic than females ($p = 0.02$), and FN females 20-75 years are significantly more endomorphic than males ($p < 0.001$).

The results of forward discriminant function analyses for discriminating between males and females are presented in Table 4.28. In the EA sample, endomorphy is the most important discriminator, followed by mesomorphy and ectomorphy in both age groups. Similar results are evident in the 20-75 year FN sample; however, in the 5-19 year age group, the best discriminator is mesomorphy, followed by endomorphy and ectomorphy.

Familial Resemblance

Intraclass sibling correlations indicate significant aggregation of somatotype within sibships (Table 4.29). The EA sample demonstrates significant correlations for mesomorphy ($r_{\text{intra}} = 0.57$, $p < 0.001$) and ectomorphy ($r_{\text{intra}} = 0.55$, $p < 0.001$), whereas the correlation for endomorphy is not significant ($r_{\text{intra}} = 0.07$, $p = 0.374$). The total sample follows a similar pattern; $r_{\text{intra}} = 0.29$ for mesomorphy ($p < 0.001$) and $r_{\text{intra}} = 0.27$ for ectomorphy ($p < 0.001$), and $r_{\text{intra}} = 0.07$ for endomorphy ($p = 0.171$). The FN correlations are lower in magnitude and not significant.

Spousal and parent-offspring interclass correlations for somatotype are presented in Table 4.30. Spousal correlations are low and not significant, indicating no assortative mating for somatotype. Only 8, 2, and 9 of 18 parent-offspring correlations are significant in the EA, FN and total samples, respectively. Significant correlations range from 0.20 to 0.49 across all samples. Correlations in the FN sample are generally of the same magnitude as in the EA sample; however, correlations are not significant due to small samples (9-34 pairs). Significant correlations do not follow an apparent pattern.

Heritability estimates based on mid-parent regression indicate significant familial resemblance in somatotype in the EA and total samples (Table 4.31). Heritability estimates in the FN sample are low and not significant, probably due to small sample sizes. For endomorphy, $h^2=0.27$ in the EA sample ($p=0.027$) and $h^2=0.26$ in the total sample ($p=0.022$). Similarly, $h^2=0.34$ in the EA sample ($p=0.001$) and $h^2=0.24$ in the total sample ($p=0.012$) for mesomorphy. Heritability estimates for ectomorphy are slightly lower and not significant.

Grip Strength, Trunk Flexibility and Motor Fitness

Ethnic Differences

There are few differences between EA and FN subjects in grip strength, trunk flexibility and motor fitness (Table 4.32). The only age and sex group which shows significant differences is males 20-75 years. Adult EA males are stronger in both right and left grip strength, and are more flexible in the lower trunk than FN males ($p \leq 0.02$).

Sex Differences

Males and females of European and FN ancestry consistently differ in grip strength and flexibility (Table 4.33). Males in all age and ethnic groups are significantly stronger than females in grip strength ($p \leq 0.03$). On the other hand, EA and FN males 20-75 years are not as flexible as females of the same age ($p \leq 0.05$).

Familial Resemblance

Intraclass sibling correlations for strength and flexibility are presented in Table 4.34. With the exception of flexibility in the EA sample, all variables demonstrate significant aggregation within sibships. Sibling correlations for right grip strength are 0.36, 0.30 and 0.28 in the EA, FN and total samples, respectively ($p \leq 0.02$).

Similarly, sibling correlations for left grip strength are 0.49, 0.26, and 0.25 in the EA, FN and total samples, respectively ($p \leq 0.04$). Sibling correlations for flexibility are 0.27 and 0.15 in the FN and total samples ($p \leq 0.03$). The correlation is of similar magnitude in the EA sample ($r_{\text{intra}} = 0.16$); however, it was not significant ($p = 0.21$).

Spousal correlations for grip strength and flexibility are low and not significant (Table 4.35), indicating no assortative mating for these variables. Generally, parent-offspring correlations indicate significant familial resemblance between generations for grip strength and flexibility (Table 4.35). In the total sample, 16 of 18 correlations are significant and range from 0.00 to 0.48. There is no apparent pattern to the correlations; however, due to small sample sizes in the FN group, few correlations are significant.

Table 4.36 presents heritability estimates based on regression of offspring on mid-parent values. Grip strength and flexibility are significantly heritable in all samples. Estimates of h^2 for right grip are 0.28, 0.62, and 0.34 for the EA, FN and total samples, respectively ($p \leq 0.03$). For left grip, h^2 estimates are 0.29, 0.57 and 0.36 for the EA, FN and total samples respectively ($p \leq 0.03$). Heritabilities for flexibility are 0.49, 0.38 and 0.49 for the EA, FN and total samples, respectively ($p < 0.001$).

Interrelationships Among Body Size, Fatness, Physique and Health-Related Fitness

Body Size, Fatness and Health-Related Fitness

Table 4.37 presents first order partial correlations between indicators of body size and fatness, and motor fitness, controlling for age. In all age groups, body size (stature, mass and the BMI) is positively associated with right and left grip strength; larger people are stronger. SUM is consistently positively related to right and left grip strength, but the association only reaches statistical significance in 20-75 year males and 5-19 year females ($p \leq 0.05$). Correlations between body size, fatness and flexibility are generally negative, and are significant in females 20-75 years.

Correlations among body size, fatness and motor fitness in males and females 5-19 years are variable in magnitude and follow few patterns. In males, all indicators of body size and fatness are negatively associated with the flexed arm hang but correlations in females are not consistent. In both sexes, SUM is negatively related to distance covered in the standing long jump ($p \leq 0.05$). Body mass, the BMI and the TER are also negatively related to the standing long jump in females ($p \leq 0.05$). Correlations for the 35-meter dash show different results for males and females. Indicators of fatness and relative fat distribution are negatively related to time to cover 35 meters, i.e., positively related to performance in males. In females, indicators of fatness and relative fat distribution are significantly positively related to the time to cover 35 meters, i.e., negatively related to performance.

Physique and Health-Related Fitness

Third-order partial correlations between somatotype components and fitness measures, controlling for age and the other two somatotype components are given in Table 4.38. Significant correlations appear only sporadically in the table, with few patterns apparent. Mesomorphy is positively related to right and left grip strength in all age and sex groups, with correlations ranging from 0.20 to 0.35 ($p \leq 0.05$).

Endomorphy is negatively related to flexibility, demonstrating significant correlations in three of the four age and sex groups. Correlations between endomorphy and flexibility are -0.17 (ns) in males 5-19 years, -0.20 ($p \leq 0.05$) in males 20-75 years, -0.37 ($p \leq 0.05$) in females 5-19 years, and -0.30 ($p \leq 0.05$) in females 20-75 years. Endomorphy is also negatively related to right and left grip strength in females 20-75 years, $r = -0.17$ and $r = -0.15$, respectively ($p \leq 0.05$).

In the 5-19 year group, endomorphy is negatively related to the number of sit-ups performed in 60 seconds. Correlations between endomorphy and sit-ups are -0.31 in males and -0.35 in girls ($p \leq 0.05$). There are no other trends apparent in the analysis of motor fitness.

Body size and Familial Resemblance in Grip Strength and Flexibility

Table 4.39 presents the results of analyses aimed at investigating the effect of incorporating body size into familial analyses of grip strength and flexibility. Intraclass sibling correlations do not increase once the effects of body size (mass, stature or BMI) are controlled using regression techniques. In the case of flexibility, the intraclass correlations decrease below the level of significance once body size is accounted for. An examination of parent-offspring correlations reveals that incorporating body size into the analyses has little effect on the magnitude of the familial resemblance. Similarly, heritability estimates based on regression of offspring on mid-parent values are not improved by the incorporation of body size in the regression.

CHAPTER V

DISCUSSION

Introduction

The results indicated significant differences between Canadians of First Nation (FN) and European (EA) ancestry, and significant familial resemblance in body size and indicators of health-related fitness. This chapter discusses the results in terms of stature and skeletal dimensions; fatness and relative fat distribution; physique; grip strength and flexibility, and the interrelationships among body size, fatness, physique and familial resemblance in health-related fitness. Due to small numbers in the FN sample, familial correlations were generally not significant for most variables. Likewise, differences in familial resemblance between EA and FN could not be determined due to small numbers in the FN group, although there did not appear to be any differences in EA and FN correlations. Therefore, the discussion focuses on familial resemblance in the total combined sample of EA and FN.

Stature and Skeletal Dimensions

Phenotypic Comparisons

Stature did not differ among EA and FN subjects within age and sex groups. Also, z-scores for stature indicated no differences between EA and FN subjects relative to reference data. An examination of the distribution of stature by age in males and females did not demonstrate any apparent differences between EA and FN groups; however, the stature of EA males and females increased relative to the reference data in late adolescence into early adulthood. As expected, males of all age and ethnic groups were significantly taller than females. The results are consistent with the findings of

several studies which indicate that stature of Aboriginal North Americans is not significantly different from the general population (Table 2.1).

There were few differences in skeletal dimensions between EA and FN subjects. The exception is the 20-75 year old females who had significantly greater biacromial, bicristal, bicondylar, and biepicondylar breadths than EA females (Table 4.13), indicating that there were ethnic differences in skeletal robusticity. Perhaps the greater adiposity and BMI of the FN females has had an effect on the skeleton. Adult FN females Males generally had greater skeletal breadths than females who had significantly greater HSRs than males of all ages. Additionally, there were no significant sex differences in bicristal breadth, with the exception of EA adults, in whom males had a greater mean than females (Table 4.14). These results are consistent with findings that males have broader shoulders than females, relative to the hips, but absolute hip breadths are not different between the sexes (Malina and Bouchard, 1991).

Familial Resemblance

Several studies have indicated significant positive assortative mating for stature based on spousal correlations (Tables 2.3 and 2.4). However, spousal correlations were low and not significant in the present study (Table 4.16). Spousal correlations for stature in the CFS were 0.43 (Pérusse et al., 1988), while in a sample from Montreal, spousal correlations were 0.25 (Annest et al., 1983). Correlations of a similar magnitude have been reported for samples from the U.S. (Ramirez, 1993; Rotimi and Cooper, 1995; Heller et al., 1984; Malina et al., 1976). The spousal correlation for stature in the present sample ($r=-0.01$) is similar in magnitude to the value of 0.06 reported for Black Americans from Philadelphia (Malina et al., 1976).

The pattern of correlations among relatives indicates that both genetic and environmental factors are important in explaining familial resemblance in stature. The intraclass sibling correlation for stature is higher ($r=0.53$) than parent-offspring correlations, which range from 0.16 to 0.37 (Tables 4.15 and 4.16), indicating that the

shared family environment is important in the familial aggregation of stature. The estimated heritability based on offspring-midparent regression is 0.40, while the parent-offspring correlations are significant (with the exception of father-son), indicating that genetic factors are also probably important.

Spousal similarities in skeletal dimensions and circumferences are rarely reported; however, sibling and parent-offspring correlations suggest genetic factors are important in explaining the phenotypic variability in these traits (Tables 2.5 and 2.6). The sibling correlation for sitting height in the present study ($r=0.47$) is similar to those reported for Belgians ($r=0.40$; Susanne, 1975), U.S. Whites (0.34 to 0.61; Mueller and Malina, 1980), and U.S. Blacks (0.39 to 0.61; Mueller and Malina, 1980). Similarly, sibling correlations for skeletal breadths fall within the range of those reported in Table 2.6. Parent-offspring correlations for skeletal dimensions and circumferences also fall within the range of values reported in other studies. The magnitude of sibling and parent-offspring correlations are similar, which makes it difficult to speculate about genetic and environmental influences on these traits.

Fatness and Relative Fat Distribution

Phenotypic Comparisons

EA and FN subjects differed significantly in fatness and relative fat distribution phenotypes. Generally, FN subjects were fatter and had a more central fat distribution than EA subjects. The differences between ethnic groups were greatest among adult females; however, there were differences apparent in each age and sex group. Some differences were not statistically significant in all groups, but the direction of the difference was consistent.

FN females 20-75 years had a greater mean body mass than EA females of the same age, while body mass did not differ between ethnic groups in the other age and sex groups. A comparison of adult body mass relative to reference data indicated that FN females were heavy throughout adulthood, tracking at the 90th percentile. These results suggest that FN females are at increased risk of overweight and/or obesity during adulthood.

Males generally had less subcutaneous adiposity, but had a greater tendency to store proportionally more fat on the trunk than females. These differences are particularly evident in the adults of both ethnic groups; the trends are also apparent in the younger age groups, especially for relative fat distribution.

The finding of greater central fat deposition in males is consistent with observations among the Canadian Inuit and the Siberian nGanasan (Rode and Shephard, 1995). Similarly, Hall et al. (1991) indicated that mean WHRs among the Navajo were 0.90 for females and 0.96 for males ≥ 20 years of age. Corresponding WHRs in the present study of FN are 0.85 for females and 0.93 for males, indicating a similar relative fat distribution.

According to anthropometric z-scores in each age and sex group, EA and FN subjects carried more subcutaneous fat on the trunk versus the extremity relative to reference data (NHANES II; Najjar and Rowland, 1987). In all groups except FN

males 5-19 years, anthropometric z-scores for the triceps skinfold were consistently lower than those for the subscapular skinfold in each group. The results are somewhat consistent with the data presented by Johnston et al. (1978) for urban Native American school children, which indicated that Native American females tend to carry proportionally more subcutaneous fat on the trunk relative to reference data, while boys do not. In the present sample, both EA and FN groups had higher z-scores for the subscapular skinfold than for the triceps skinfold.

The TER was compared to values from the Québec Family Study (QFS) in Figures 5.1 through 5.4. In EA males and females 5-19 years, mean TERs approximate the medians from the QFS, whereas FN TERs are higher. Among adults, the TERs of EA subjects are higher than the QFS values, and FN TERs are higher still. These comparisons suggest that adults in the present sample have a more central or truncal subcutaneous fat distribution than the Québec sample.

There are little North American reference data available for the WHR. The WHRs of the present sample of adults were compared to a study from France (Tichet et al., 1993). In general, the WHRs of EA adults approximated the medians of the reference data (Figures 5.5 and 5.6), whereas the WHRs of FN adults were between the 50th and 95th percentiles. In both males and females, FN adults demonstrated greater WHRs than EA adults, and the difference was more apparent in the females.

The comparisons of relative fat distribution indices to other studies indicate that the present sample have a proportionally greater amount of subcutaneous fatness on the trunk than on the extremities. Although males have greater TERs and WHRs than women, FN adult females appear to deviate the most from reference values.

Familial Resemblance

There is significant familial resemblance for all indicators of fatness and relative fat distribution, however, spousal correlations for all variables are low and not significant, ranging from 0.01 to 0.11 (Table 4.21), which suggests that assortative

mating for fatness has not occurred, and that the role of the living environment has had only minimal effects on spousal similarities in fatness and relative fat distribution in this population. These results are somewhat consistent with the spousal correlations presented in Table 2.8, which indicate that some populations have significant spousal correlations and some do not. Possible explanations for this finding include a sexual division of labor and changing activity patterns in this population. There appears to be a significant sexual division of labor such that men are occupied in activities which may be more energy expensive (construction work, guiding etc.), whereas females may be involved more in less energy expensive activities (housework, clerical professions). The FN people of Temagami and Bear Island are acculturated and they do not have to rely on traditional lifeways to survive. The acculturation process has probably resulted in changing activity patterns in both men and women, such as has been demonstrated in other populations (Godin and Shephard, 1973). Thus, a sexual division of labor, as well as perhaps differential effects of acculturation on FN men and women may explain the lack of significant spousal correlations for fatness.

Intraclass correlations among siblings indicate significant sibship effects. The magnitude of the correlations are similar across the BMI, SUM and TRUNK; 0.28, 0.23, and 0.29, respectively. The sibling correlation is lower for EXTREMITY, 0.13, and higher for TER and WHR, 0.38 and 0.37, respectively.

Parent-offspring correlations are generally of similar magnitude as the sibling correlations. Mother-offspring correlations are the strongest and most significant, but this may reflect larger sample sizes for mother-offspring than for father-offspring correlations. Alternatively, the maternal influence on fatness and relative fat distribution may be greater than the paternal influence. A greater maternal influence could operate through genetic or environmental pathways, or both. However, there is no clear evidence from the literature for a specific maternal or paternal effect on fatness (Bouchard et al., 1997).

Correlations for all indicators of fatness are of similar magnitude, but TER and WHR demonstrate lower correlations. Similarly, heritability estimates based on offspring mid-parent regressions are higher for fatness indicators than for TER and WHR. The results suggest that both genetic and environmental effects are important for the familial aggregation of body fatness. Relative fat distribution may have a greater influence from the living environment, based on high sibling correlations. The results for relative fat distribution are not consistent with studies in the literature (Bouchard et al., 1997). Using the twin model, Selby et al. (1989) indicated that the level of heritability for central deposition of subcutaneous fat was quite high (0.77). Similarly, the transmissibility of the TER and the WHR across generations was 37% and 28%, respectively, in the CFS (Pérusse et al., 1988). Perhaps greater environmental effects on fatness were operating in the present sample which increased the familial resemblance. Such an effect might overshadow a possible greater influence from genetic factors on fat distribution.

Relative fat distribution is dependent on overall fatness (Garn et al., 1982; Malina, 1996). In the present study, there was a positive association between SUM and the TER and WHR which indicated that relative central subcutaneous fat distribution increased as fatness increased (Table 5.1). With the exception of FN females ($r = -0.32$, $p < .05$), correlations between SUM and indices of relative fat distribution were generally positive and significant (0.18 to 0.80). The results in the FN females should be viewed with caution, as this sample is significantly fatter than any other group studied, and interrelationships among fatness indicators may differ in the markedly obese.

Given that there is a relationship between subcutaneous fatness and relative fat distribution (Table 5.1), family correlations for fat distribution (TER, WHR) were recalculated after controlling for subcutaneous fatness (SUM) (Table 5.2). With few exceptions, the recalculated correlations are similar to the original ones. Differences do

not follow a pattern. Thus, the use of regression to adjust indicators of relative fat distribution for the effects of fatness does not appear to affect estimates of familial aggregation.

The estimate of heritability for body mass is 0.26 based on mid-parent regression, which is lower than that for stature; however, parent-offspring correlations for body mass are higher than for stature, ranging from 0.10 to 0.45. The intraclass sibling correlation for body mass is 0.29, which is lower than the correlation for stature, and generally lower than the parent-offspring correlations for body mass. Thus, it appears as though genetic factors are more important than the living environment in explaining the familial resemblance in body mass.

Prevalence of Obesity

The prevalence of obesity in FN is generally higher than in EA. Among children and youth 5-19 years, estimated prevalences of obesity (≥ 85 th percentile age-specific NHANES II BMI; Najjar and Rowland, 1987) are 2.3% in EA males, 38.1% in FN males, 16.9% in EA females, and 29.4% in FN females. These prevalences were greater than those reported by Broussard et al. (1991) among Native American adolescents: 24.5% in males and 25.0% in females (≥ 85 th percentile age-specific NHANES II BMI; Najjar and Rowland, 1987). Based on comparisons to 95th percentiles of the BMI in the NCHS data set, 11.2% and 12.5% of Navajo girls and boys, respectively, exceeded the cut-off (Sugarman et al., 1990).

Prevalences of obesity in FN subjects 5-19 years based on the triceps skinfold (≥ 85 th percentile age-specific NHANES II triceps skinfold; Najjar and Rowland, 1987) were 28.6% in males and 11.8% in females. Corresponding estimates in Cherokee youth (≥ 85 th percentile triceps skinfold, Ten State Nutrition Study) were 49.7% in boys and 31.6% in girls 13-17 years (Story et al., 1986). These statistics are not directly comparable though as the present sample encompasses a wider age range.

Significant differences in the prevalence of obesity were evident only in the 20-75 year old females. In adult females the estimated prevalence of obesity based on the BMI (BMI ≥ 27.8 in males and BMI ≥ 27.3 in females) was 58.8% in the FN and 35.0% in the EA ($p=0.002$). Corresponding prevalences in adult males were 51.4% FN and 39.0% EA for the BMI (Table 4.23).

Broussard et al. (1991) estimated that prevalences of overweight (BMI ≥ 27.8 in males and BMI ≥ 27.3 in females) in Native American adults ≥ 18 years at 33.7% in males and 40.3% in females, which are lower than those estimated in the present study. The prevalence of overweight among the Navajo (BMI ≥ 27.8 in males and BMI ≥ 27.3 in females) was estimated at 30.3% in males and 50.0% in females (Hall et al., 1991), which is similar for females but lower than that for males in the present study. Age specific prevalence rates for overweight (BMI ≥ 27.8 in males and BMI ≥ 27.3 in females) among the Pima ranged from 31% to 78% for males ≥ 20 years, and from 48% to 87% for females ≥ 20 years (Knowler et al., 1991).

The estimated prevalence of obesity based on the triceps skinfold (triceps skinfold ≥ 17.5 mm in males and triceps skinfold ≥ 29.5 mm in females) was 47.1% in FN and 29.9% in EA females 20-75 years ($p=0.03$). Corresponding prevalences in males were 17.1% FN and 14.1% EA.

There is considerable variability in the cut-off point used to define overweight/obesity among studies. Estimated prevalences will vary by the percentile cut-off used (ex. 85th, 95th percentile) as well as the reference data used to define the cut-off. Although different criteria were used among studies, the evidence indicates that Native Americans have a greater prevalence of obesity than the general North American population.

Studies of the prevalence of overweight among Native groups generally indicate higher prevalences in females than males (Broussard et al., 1991; Hall et al., 1991; Knowler et al., 1991; McIntyre and Shah, 1986; Young and Sevenhuysen, 1989).

Results of the present study indicate that adult FN males have a similar rate of obesity as females, 51.4% and 58.8%, respectively. This trend is also evident in EA adults. Males have a rate of 39.0% and the females have a rate of 35.0%. Females 5-19 years demonstrate lower prevalences of obesity than males of the same ethnic group.

The results suggest that adult males in the present sample are heavy for their stature, but they are not overly fat, as BMI Obese rates are more than double triceps obese rates, and TSF+BMI Obese rates are 11.4% FN and 13.0% EA (Table 4.23). In contrast, adult females are both heavy and fat, as indicated by high prevalences of BMI Obesity and TSF Obesity, with TSF+BMI Obesity rates of 43.1% FN and 26.0% EA.

Using the classification scheme of Van Italie and Abraham (1985), prevalence rates of obesity differ by the criteria used, i.e., BMI, triceps skinfold, or both (Table 4.23). There are also morphological differences between adult subjects classified as obese by the different criteria (Table 4.24). In all sex and ethnic groups except FN males 20-75 years, BMI Obese subjects have greater TERs than TSF+BMI Obese ($p \leq 0.05$). In general, endomorphy was also greater in the TSF+BMI Obese group, and in the EA sample, mesomorphy was greater and ectomorphy was lower in the TSF+BMI Obese sample. In EA males and females, the TSF+BMI Obese group also demonstrated greater bicondylar breadths.

Comparisons between TSF Obese and BMI Obese may not be equivalent for FN and EA groups. Given that FN has a significantly greater truncal subcutaneous fat distribution, the use of the triceps skinfold to assess obesity may not be valid, and may underestimate the prevalence. Likewise, the use of the subscapular skinfold may overestimate the prevalence of obesity in FN groups. A combination of triceps+subscapular may be the best alternative. A similar question can be raised when comparing obesity rates between men and women because men have a greater truncal subcutaneous fat distribution than women.

A study among U.S. school children from Philadelphia also demonstrated differences among subjects classified as obese by similar criteria as used in the present study (Malina et al., 1989). The TSF+BMI Obese children were heavier and taller, had greater arm muscle circumferences, and had greater bicondylar and biepicondylar breadths than the TSF obese group. The characteristics of the TSF+BMI Obese EA samples in the present study had greater bicondylar and biepicondylar breadths than the BMI obese group, but comparisons to a TSF obese group could not be made due to small numbers.

Physique

Phenotypic Comparisons

The results indicated that FN subjects were significantly more endomorphic than EA subjects in all groups except 5-19 year old females, in whom differences in somatotype were small but in the same direction as the other groups (greater endomorphy). Females were consistently more endomorphic than males within age groups; however, the somatotype difference was not significant in the FN 5-19 years. Also, males were significantly more mesomorphic in all age and ethnic groups, except FN adults, where the difference was small and did not reach significance. Thus, FN females were the most endomorphic in the present study.

The results are consistent with a study of Alaskan Eskimos which demonstrated that Eskimo men and women had a physique characterized by high endomorphy and mesomorphy (Carter and Heath, 1990). Mean adult somatotypes in Eskimos were 3.4-5.9-1.3 in males and 6.4-4.8-0.8 in females. These data suggest that females are more endomorphic than males, and that males are more mesomorphic than females. Mean adult somatotype in this study was 5.2-6.2-1.0 in FN males and 7.4-5.9-0.7 in FN females. Corresponding values for EA subjects were 4.6-6.0-1.4 for males and 6.1-5.1-1.3 for females.

There are three major sources of comparative somatotype data for Canadians: the YMCA-LIFE program (Bailey, 1982), the Canada Fitness Survey (CFS, Pérusse et al., 1988), and the Québec Family Study (Katzmarzyk et al., 1997; Malina et al., 1997). The YMCA-LIFE program was a nation-wide testing program conducted in 1976-78 to characterize the lifestyle and fitness of Canadians (Bailey et al., 1982). A large sample (13,599 subjects) of Canadians were somatotyped by the Heath-Carter anthropometric protocol as part of the YMCA-LIFE program. The CFS was conducted in 1981 and involved collecting anthropometric and fitness data on 13,804 subjects 7 to 69 years of age from across Canada (Pérusse et al., 1988). The anthropometric

battery of the CFS included the dimensions necessary for the calculation of Heath-Carter anthropometric somatotypes. Phase I of the Québec Family Study (QFS) was conducted from 1978-82, which involved collecting anthropometric, activity, dietary, fitness, and metabolic data on a sample of French Canadian subjects from the Greater Québec City area (Bouchard, 1989). Heath-Carter anthropometric somatotype was assessed as part of the anthropometric battery of the QFS, and the data used in the analyses of Katzmarzyk et al. (1997) and Malina et al (1997) were reanalyzed according to the age groups used in the present study for the purpose of providing comparative data.

Little data have been presented on the somatotypes calculated in the CFS. Pérusse et al. (1988) present mean somatotypes for the entire CFS sample, from 7 to 69 years of age. The mean somatotypes were 3.6-4.9-2.2 for males and 4.4-4.2-2.1 for females (Pérusse et al., 1988). These results compare to mean somatotypes of 4.2-5.6-1.8 and 5.0-5.7-1.5 for EA and FN males, respectively, and 5.7-4.7-1.7 and 6.7-5.3-1.3 for EA and FN females, respectively, from 7 to 69 years in the present sample. The EA sample in the present study is more endomorphic and mesomorphic, and slightly less ectomorphic than the CFS sample. The FN sample is considerably more endomorphic and mesomorphic, and less ectomorphic than the CFS sample.

Table 5.3 presents mean Heath-Carter anthropometric somatotypes for this study, the YMCA-LIFE program (Bailey et al., 1982), and the QFS (Katzmarzyk et al., 1997; Malina et al., 1997) by age and sex. The QFS group is less endomorphic and more ectomorphic than the other studies in the 15-19 and 20-29 year age groups; thereafter the QFS means are similar to those for the YMCA-LIFE program. The FN sample is consistently more endomorphic and mesomorphic, and less ectomorphic than the other samples, especially in the older age groups. Similarly, the EA group tends to approximate the means of the YMCA-LIFE program in the 15-19 and 20-29 year age

groups; thereafter, the EA sample consistently demonstrates higher endomorphy and mesomorphy than the other samples, with the exception of the FN.

Familial Resemblance

Spousal correlations for somatotype are uniformly low and not significant, demonstrating correlations of 0.14 for endomorphy, 0.08 for mesomorphy, and 0.02 for ectomorphy. These are comparable to the spousal correlations of 0.14, 0.10, and 0.12 for endomorphy, mesomorphy, and ectomorphy, respectively, in the CFS (Pérusse et al., 1988). Low spousal correlations have also been demonstrated in the QFS: 0.05, 0.10, and 0.06 for endomorphy, mesomorphy and ectomorphy, respectively (Song et al., 1993). Corresponding spousal correlations based on maximum likelihood estimations in a sample from Spain were 0.19, -0.08, and 0.14 for endomorphy, mesomorphy, and ectomorphy, respectively (Sánchez-Andrés, 1995). Thus, the available evidence suggests that assortative mating for physique, as assessed by the Heath-Carter anthropometric somatotype, is quite small; however, there may be differences among other cultures.

Parent-offspring and sibling correlations are generally higher than spousal correlations indicating significant familial resemblance in somatotype. Intraclass correlations within sibships are 0.29 for mesomorphy and 0.27 for ectomorphy, whereas the correlation for endomorphy was low and not significant. Resemblance between fathers and sons, based on interclass correlations, was quite low, whereas mother-daughter correlations for all three somatotype components were significant. Correlations among fathers and offspring are low and not significant for endomorphy, while those among mothers and offspring are significant, indicating that there may be a maternal effect in the transmission of endomorphy between generations. Since endomorphy generally indicates a preponderance of fatness, the maternal effect could be explained by cohabitation and the mother's role in providing nutrition for her children, rather than a maternal genetic effect.

Parent-offspring correlations in the present study are similar in magnitude to those reported in the literature (Table 2.9). Parent-offspring correlations in the present study ranged from 0.00 to 0.45, which compares to ranges of -0.04 to 0.30 in a Spanish population (Sánchez-Andrés, 1995), 0.15 to 0.41 in the QFS (Song et al., 1993), and 0.21 to 0.24 in the CFS (Pérusse et al., 1988). Heritability estimates, based on mid-parent regression, indicate that 18% to 26% of the phenotypic variance in somatotype is explained by familial factors. Using a path analysis, Pérusse et al. (1988) indicated that the transmissibility from parents to offspring (cultural and genetic factors) accounted for between 36% to 45% of the variance in somatotype in the CFS.

The pattern of familial correlations and regressions of offspring on the mid-parent values indicate that mesomorphy demonstrates the most consistent pattern of familial resemblance. Parent-offspring correlations for mesomorphy ranged from 0.15 to 0.22, and the intraclass sibling correlation is 0.29, while the regression coefficient for the offspring-midparent regression was 0.24. The other somatotype components did not show a consistent pattern of association among relatives. These results are consistent with those of Song et al. (1993), which also demonstrated that the familial aggregation for mesomorphy was the most consistent and strongest of the three components. Similarly, Sánchez-Andrés (1995) demonstrated that parent-offspring correlations for mesomorphy tended to be greater than for endomorphy or ectomorphy. Thus, available evidence suggests that familial aggregation for mesomorphy may be greater than for the other somatotype components; however, the results from the studies surveyed cannot separate genetic from environmental effects.

Grip Strength, Trunk Flexibility and Motor Fitness

Phenotypic Comparisons

The distributions of trunk flexibility and combined grip strength were generally between the 10th and 90th percentiles of the reference data in all age and sex groups (Fitness Canada, 1985, 1986). Ten-year age-specific means for combined grip strength (right + left) in EA males 20-75 years were greater than the 50th percentile of the reference data. Similarly, EA males 20-75 years are significantly stronger than FN males. All other ethnic comparisons in performance were not significant, with the exception of males 20-75 years, in which EA males demonstrated greater trunk flexibility than FN males.

EA and FN children 5-15 years did not differ significantly in sit-ups, flexed arm hang, 35-meter dash, and standing long jump. The distributions of performance scores generally were between the 10th and 50th percentiles of the reference data for both ethnic groups (Fitness Canada, 1985; Haubenstricker et al., 1991), indicating that the EA and FN children were not performing as well in these events as children in the Canada Fitness Survey (sit-ups) and the Michigan State University Motor Performance Study (flexed arm hang, dash, and standing long jump). Motor skills are not taught as part of physical education of the Temagami children which may explain some of the observed differences between this sample and the reference data.

Given the associations between body size and motor fitness (Malina, 1975, 1994), body morphology in the present sample may help explain the apparent differences between the EA and FN children and the reference data. There is a positive association between body size and grip strength (Table 4.37). Since the body size (stature, mass, BMI) of children in this sample is similar to the children in the Canadian Fitness Survey (see descriptive results), it seems appropriate that the combined grip strength is also similar, although there may be dynamometer differences between the present study and the CFS (Figures 4.69 through 4.72). There is generally a negative

association between fatness and performance in events which require the subject to move the body through space, such as in the dash or standing long jump, or to support their body mass, as in the flexed arm hang (Malina, 1994). Triceps and subscapular skinfolds were consistently greater than reference data for U.S. children (Najjar and Rowland, 1987), demonstrating anthropometric z-scores ranging from 0.08 to 0.80 for triceps and 0.39 to 1.47 for subscapular (Table 4.10). Perhaps the greater adiposity of the sample may lead to poorer performance in sit-ups, flexed arm hang, standing long jump, and the 35-meter dash. These associations are explored in the subsequent section on body size, fatness, physique and motor fitness.

Familial Resemblance

There was significant aggregation of grip strength and flexibility within families. Spousal correlations approximated zero, indicating no assortative mating for these variables. Spousal correlations for grip strength and flexibility in selected studies are also low (Table 2.10), with the exception of studies from Czechoslovakia (Kovar, 1981) and Poland (Szopa, 1982), which demonstrate spousal correlations of 0.26, and 0.15 to 0.26, respectively, for measures of grip strength. Malina et al. (1983) also reported significant spousal correlations for right grip ($r=0.29$) and left grip ($r=0.27$) in a rural Zapotec community; however, second order partial correlations controlling for the ages of husband and wife were not significant (right grip $r=-0.12$, left grip $r=-0.04$).

Sibling correlations for grip strength were within the range of correlations reported in other studies (Table 2.10), and the sibling correlation for flexibility (0.15) was lower than those reported in a Mennonite community (0.44, Devor and Crawford, 1984) and in the CFS (0.36, Pérusse et al., 1988). Parent-offspring correlations for grip strength and flexibility were generally significant, and were of similar magnitude to those reported in selected studies across all variables.

Heritability estimates based on the regression of offspring on mid-parent values were 0.34, 0.36, and 0.49 for right grip, left grip, and flexibility, respectively. These values compare well with transmissibility estimates of 0.37 for grip strength/body mass and 0.48 for flexibility in the CFS (Pérusse et al., 1988).

Secular Trends

Stature

There were significant decreases in stature with age in EA males and females, but not in the FN group. Statural loss due to aging (shrinkage) was estimated at 0.12 cm/year and 0.06 cm/year in EA males and females, respectively. These estimates are greater than those obtained in Colombian women, which were 0.024 cm/decade in a lower socioeconomic status (SES) group and 0.013 cm/decade in an upper SES group (Dufour et al., 1994). The estimated statural loss due to shrinkage in rural Colombian women was 0.027 cm/year, whereas that for men was 0.121 cm/year (Himes and Mueller, 1977a, 1977b). There was also an association between SES and age-related statural loss in the rural Colombian sample, such that individuals from higher SES lost stature at a slower rate than those from lower SES (Himes and Mueller, 1977b).

Trotter and Gleser (1951) estimated an average rate of decline in stature with age of 0.06 cm/decade and suggested that it may be applicable to the general population. The shrinkage effect in EA females was the same as reported by Trotter and Gleser; however, the EA males lost stature at twice this rate.

The analysis of secular change in stature indicated that within this sample of Canadians, there was an estimated secular increase of 1.0 cm/decade ($p < 0.05$) and 0.4 cm/decade (ns) in EA males and females, respectively. Shephard (1986) reviewed several studies conducted in Canada from 1953 to 1981, and suggested that a secular trend of approximately 1.0 cm/decade in both males and females has occurred in Canada over the past 25 years; however, there may have been some regional variation (Shephard, 1986). The data also suggested that urban centers in Canada may have

experienced a lesser secular gain than rural areas. It must be noted that statistical analyses of the data were not performed, and conclusions were based on examining trends in means among studies.

The results of the present study were compared of data collected in 1953 (Pett and Ogilvie, 1956), 1970-72 (Health and Welfare Canada, 1980), and 1981 (Fitness Canada, 1983). Figure 5.7 presents the mean statures of Canadian males 5-19 years from four studies conducted since 1953. It is apparent that stature has increased from 1953 to the present; however, stature in the present study is similar to the 1981 Canada Fitness Survey, with the exception of late adolescence, where the present sample is taller. Figure 5.8 presents the results of four studies of adult males conducted since 1953. There is thus a secular increase in stature over time.

Stature among Canadian females follows a similar trend as in males. Stature increases with time among the various studies (Figures 5.9 and 5.10). Among females 5-19 years, the present sample is similar in stature to the 1981 Canada Fitness Survey (Fitness Canada, 1983), allowing for sampling variation. Adult female stature is greater in this study than in any previous Canadian study.

Body Mass

Since body mass has a tendency to increase with age, an internal statistical analysis of secular changes in body mass was not possible. Age specific means for body mass in males 5-19 years are presented in Figure 5.11 with corresponding values from Canadian surveys conducted in 1953 (Pett and Ogilvie, 1956), 1970-72 (Health and Welfare Canada, 1980), and 1981 (Fitness Canada, 1983). In general, body mass has increased from 1953 to the present; however, the age-specific means of the present study are similar to the 1981 CFS, with the exception of the older age groups, which are heavier (Fitness Canada, 1983). This trend is similar to that observed for stature in the same samples. Among adult males, the current sample is heavier than observed in

any study in Canada since 1953 (Figure 5.12). Body mass has generally increased with time in Canada.

Body mass of females follows the same trend as in males (Figures 5.13 and 5.14). There has been an increase in the mean body mass of Canadian women since 1953. There is considerable overlap among studies, and the increase does not appear to be as great as in Canadian males. However, the mean body masses of adult females in the present study are consistently higher than those presented in any previous study.

In a review of body mass among selected studies from 1953 to 1981, Shephard (1986) indicated that there had been an increase in body mass among Canadian males and females. Sampling problems and changes in lifestyle (smoking) over the past 35 years made it hard to interpret changes in body mass relative to stature; however, it was noted that the increase in body mass was not greater than what would be expected due to the increase in stature which had been observed.

Although increases in body mass are apparent with time, this does not mean that there is increasing obesity in the population, as stature has also increased over time. The question which must be addressed is whether stature and body mass have increased in a complimentary manner, or whether body mass has increased proportionally more. To answer this question, secular trends in the BMI were examined.

BMI

Given recent concern over increasing obesity in the North American population (NIH, 1985), the BMI was estimated from mean statures and body masses in studies from 1953 and 1970-72, and the derived BMI from 1981, and were compared to the BMI in the present study. Figures 5.15 and 5.16 illustrate the BMI in males 5-19 years and 20-75 years, respectively. The trend over time is difficult to interpret from these figures as the distributions overlap considerably. In adult males (Figure 5.16), the

present sample has considerably higher BMIs than previous studies, but the previous studies overlap considerably.

The BMI of females from the studies is presented in Figures 5.17 and 5.18. As in males, there is considerable overlap in the distributions of the various studies, and there is no apparent trend over time. Among adult females, the present sample demonstrates higher BMIs than in any of the previous studies, especially in young adults.

The temporal comparisons of the BMI demonstrate that, although body mass has increased in Canada since 1953, it has apparently increased proportionally with the increase in stature. Overall, body size of Canadians has increased from 1953 to 1981; however this increase has not resulted in an increase in the BMI. The exception to this trend is the significant increase in the BMI in the present sample of adults over any previous study. There are two possible explanations for this finding: (1) the population of Temagami demonstrates significantly higher values for the BMI than the general population of Canada, or (2) there has been a significant increase in the BMI of Canadians over the past 15 years (1981 to 1996), and the population of Temagami is representative of the rest of Canada. It is difficult to extrapolate these findings to the national level, due to regional differences in body size among Canadians (Shephard, 1986). It is likely that a combination of both explanations could explain the higher BMIs in Temagami, such that there may have been an overall increase in the BMI in Canada over the past 15 years, and the population of Northern Ontario demonstrates greater BMI values relative to Canadians in general.

Body Size, Fatness, Physique and Health-Related Fitness

Body Size and Health-Related Fitness

The results of this study are consistent with established relationships among stature, body mass and health-related fitness (Malina 1975, 1994). In all age and sex groups, stature and body mass were positively associated with right and left grip strength, which has been demonstrated in numerous studies spanning the ages of early childhood through adulthood (Malina, 1975).

Greater stature is generally associated with greater strength. Partial correlations between stature and right and left grip strength were 0.52 and 0.47 in males 5-19 years, respectively, and 0.59 and 0.69 in females 5-19 years, respectively, controlling for age. Among Philadelphia children 6-11 years, age-specific correlations between stature and right grip strength range from 0.26 to 0.76 in boys and 0.01 to 0.75 in girls (Malina, 1994). Corresponding correlations for left grip strength range from 0.22 to 0.82 and from -0.23 to 0.54 in boys and girls 6-11 years, respectively (Malina, 1994). Correlations between stature and right and left grip strength were somewhat lower in a sample of 4-5 year old children (sexes combined), ranging from 0.12 to 0.46 (Merrett, 1992).

Correlations between body mass and grip strength are similar to those reported for stature. Among males and females 5-19 years, partial correlations between body mass and right grip strength, controlling for age were 0.53 in males and 0.58 in females. Corresponding partial correlations for left grip strength are 0.51 and 0.67 in males and females, respectively. Among Philadelphia schoolchildren, age-specific correlations between body mass and right grip strength ranged from 0.34 to 0.79 in boys and from 0.16 to 0.77 in girls (Malina, 1994). Similarly, correlations between body mass and left grip strength ranged from 0.24 to 0.91 in boys and from 0.06 to 0.76 in girls (Malina, 1994). Corresponding correlations among 4-5 year old children

(sexes combined) ranged from 0.05 to 0.29 for right and left grip strength (Merrett, 1992).

Partial correlations between stature and body mass, and flexibility, controlling for age followed no consistent pattern, ranging from -0.22 to 0.00 in the present study. There are few comparative data available relating body size to trunk flexibility (Malina, 1994). In boys 5- 19 years, correlations between trunk flexibility and stature and mass were -0.22 ($P < 0.05$) and -0.16 (ns) respectively. The results are consistent with those of Montoye et al. (1972), who reported age-specific correlations ranging from -0.17 to 0.18 for stature, body mass and trunk flexibility in boys 9-18 years. In girls, correlations were -0.05 (ns) and -0.09 (ns) between flexibility and stature and mass, respectively. Corresponding age-specific correlations for girls 9-18 years ranged from -0.19 to 0.05 (Montoye et al., 1972).

Relationships between body size and sit-ups were low. In boys, correlations between sit-ups and stature and mass were -0.12 and -0.14, respectively. Corresponding age-specific values for sit-ups were -0.04 to 0.06 for stature and -0.13 to -0.05 for mass in boys 10-17 years (Espenschade, 1963). Similarly, Montoye et al (1972) reported age-specific correlations ranging from -0.09 to 0.23 for stature and -0.30 to 0.02 for mass in boys 9-18 years. Correlations between body size and sit-ups were low and positive in girls: 0.18 for stature and 0.16 for mass. Espenschade (1963) reported age-specific correlations of -0.09 to 0.07 for stature and -0.18 to 0.10 for mass in girls 10-17 years, while Montoye et al. (1972) indicated age-specific correlations ranging from -0.18 to 0.04 for stature and -0.33 to -0.08 for mass in girls 9-18 years.

There is considerable variability in reported correlations between body size and the dash (Espenschade, 1963; Rarick and Oyster, 1964; Montoye et al., 1972; Malina, 1975, 1994). In the present study, correlations between stature and the dash were 0.20 (ns) in boys and 0.16 (ns) in girls. Corresponding correlations for mass were 0.21

(ns) in boys and -0.33 ($p < 0.05$) in girls. In 8 year old boys, Rarick and Oyster (1964) reported correlations of 0.19 and 0.07 between the 30-yard dash and stature and mass, respectively. Age specific correlations between the 50-yard dash and stature ranged from -0.35 to 0.18 in 10-17 year old boys (Espenschade, 1963) and -0.41 to 0.01 in 9-18 year old boys (Montoye et al., 1972). Corresponding correlations in boys for mass were -0.14 to 0.30 and -0.11 to 0.26 , respectively. Among girls, a similar pattern is evident. Age-specific correlations ranged from -0.13 to 0.02 for stature and 0.04 to 0.24 for mass in 10-17 year olds (Espenschade, 1964), and from -0.26 to 0.08 for stature and 0.09 to 0.45 for mass in 9-18 year olds (Montoye et al., 1972). It must be noted that neither Montoye et al. (1972) nor Espenschade (1963) indicated whether the correlation for the dash had been inverted as in the present study.

Age-specific correlations between body size and performance in the 35-yard dash ranged from moderately negative to moderately positive in a sample of Philadelphia school children (Malina, 1994). Correlations in boys from -0.33 to 0.34 for stature and -0.56 to 0.21 for mass. Similarly, correlations in girls ranged from -0.28 to 0.60 for stature and -0.32 to 0.68 for mass.

Correlations between body size and the flexed arm hang differ by sex in the present study. In boys, correlations between the flexed arm hang and stature and mass were -0.32 ($p < 0.05$) and -0.42 ($p < 0.05$) for stature and mass, respectively. The corresponding correlations for girls were 0.30 and -0.07 for stature and mass, respectively. Comparative data for the flexed arm hang are limited. Montoye et al. (1972) reported age-specific correlations ranging from -0.26 to 0.08 for stature and -0.47 to -0.35 for mass in girls 9-18 years. Although not directly comparable, Espenschade (1963) reported age-specific correlations ranging from -0.24 to 0.01 for stature and -0.35 to -0.10 for mass and number of pull-ups in boys. The available evidence suggests that there is generally a negative relationship between body size and performance in the flexed arm hang, particularly in boys.

The standing long jump demonstrates low correlations with body size. Stature was positively related to performance in boys ($r=0.25$, ns) and negatively related to performance in girls ($r=-0.12$, ns). Similarly, mass was positively related to performance in boys ($r=0.13$, ns) and negatively related to performance in girls ($r=-0.44$, $P<0.05$). Among Philadelphia school children (Malina, 1994), age-specific correlations between the standing long jump and stature ranged from -0.27 to 0.41 and -0.12 to 0.57 in boys and girls, respectively. Corresponding correlations for mass ranged from -0.39 to 0.39 and -0.34 to 0.41 in boys and girls, respectively. Espenschade (1963) showed positive correlations between stature and the standing long jump, ranging from 0.04 to 0.34 and 0.05 to 0.22 in boys and girls, respectively. Age specific correlations between mass and the standing long jump ranged from -0.13 to 0.14 in boys and -0.22 to -0.03 in girls. Similarly, age-specific correlations between stature and the standing long jump were generally positive in 9-18 year old children (Montoye et al., 1972). Correlations ranged from -0.02 to 0.42 in boys and -0.02 to 0.34 in girls. Correlations were more negative for mass, ranging from -0.30 to 0.22 in boys and -0.35 to 0.02 in girls.

The low-to-moderate correlations suggest that there is a relationship between body size and motor fitness; however, the relationships vary by sex and age. In general, body mass is negatively associated with performance in events in which the body is propelled through space, and positively associated with strength (Malina, 1994).

Fatness, Relative Fat Distribution and Health-Related Fitness

In all age and sex groups, there are significant associations between fatness, relative fat distribution and performance. Partial correlations between the BMI, SUM, and grip strength, controlling for age, are consistently positive, although they are of lower magnitude than the correlations between stature, mass and grip strength. Correlations ranged from 0.26 to 0.43 for the BMI and grip strength and from 0.11 to

0.28 for SUM. The results are consistent with those among Philadelphia schoolchildren 6-11 years, which indicated that the sum of three skinfolds were generally positively related to right and left grip strength (range -0.21 to 0.72; Malina, 1994). The results suggest that fatness per se does not negatively influence strength; the positive correlations reflect the larger size of fatter children (Malina et al., 1989).

Fatness was weakly and negatively associated with trunk flexibility. Correlations ranged from -0.16 to -0.05 for the BMI, and from -0.26 to -0.12 for SUM. The results are consistent with those reported for Belgian males 12-20 years, which demonstrated correlations between 0.00 and -0.13 for the sum of four skinfolds and trunk flexibility (Beunen et al., 1983).

The associations among fatness and motor performances in males and females 5-15 years were variable in magnitude, and followed few apparent patterns. SUM was negatively related to the standing long jump in both males and females, with partial correlations, controlling for age of -0.32 and -0.66, respectively. The BMI was also negatively related to the standing long jump in females ($r=-0.47$), but not in males ($r=0.02$). Since the BMI does not distinguish between lean and fat tissue, it may not be representing the same thing in male and female children. The adolescent growth spurt in mass is characterized by increases in muscle mass in boys more so than in girls (Malina and Bouchard, 1991); thus, the negative association between the BMI and the long jump in girls may be due to increased fatness with a higher BMI in girls but not boys. This explanation is also suggested by the negative association between SUM and the standing long jump in both boys and girls. Similar associations between the sum of three skinfolds and the standing long jump have been reported in Philadelphia children 6-11 years (Malina, 1994). Age-specific correlations ranged from -0.61 to -0.05 in boys and girls (Malina, 1994). SUM was also negatively related to sit-ups in males and females, although the correlations were not significant. Similarly, SUM was negatively related to the flexed arm hang in males ($r=-0.43$) and females ($r=-0.21$),

which is consistent with results in Belgian males 12-20 years, in whom the sum of four skinfolds had correlations of -0.44 to -0.28 with the flexed arm hang (Beunen et al., 1983).

Results relating indicators of fatness to the 35-meter dash are puzzling. In males, there was a positive association between fatness, central fat distribution, and performance in the dash. In females, there was a negative association between fatness and central fat distribution and the dash (Table 4.37). Results of other studies generally indicate a negative association between fatness and the dash or shuttle run (Malina, 1975, 1994).

In events which require the subject to propel the body through space (standing long jump, dash) or support the body (flexed arm hang), there is a negative association with fatness (Malina, 1994). Additionally, some evidence suggests that a more central distribution of subcutaneous fat may have a negative effect on the motor performances of children (Malina and Pena Reyes, 1994). The results of the present study generally fit this suggestion, taking into account a few spurious correlations.

Physique and Health-Related Fitness

The results of this study generally indicate that endomorphy is negatively associated with fitness and mesomorphy is positively related with fitness, while ectomorphy is not related to fitness. The results are consistent with those from other studies, although not completely comparable, as many studies report zero order correlations within narrow age ranges, and do not control for the other two somatotype components (Malina, 1975).

Partial correlations between endomorphy and grip strength ranged from -0.17 to -0.08, and from -0.37 to -0.17 for flexibility, controlling for age and the other two somatotype components. In a longitudinal study of boys 12-17 years, Clarke (1971) reported correlations ranging from 0.07 to 0.21 between endomorphy and a composite strength score. Generally, correlations between endomorphy and strength are low and

positive (Malina, 1975). There was also a negative association between endomorphy and sit-ups in males and females 5-19 years, controlling for age and the other two somatotype components (-0.31 and -0.35, respectively). Partial correlations between endomorphy and other performance measures showed no consistent pattern.

Mesomorphy was positively related to grip strength ($r=0.20$ to 0.35) and showed no relationship with flexibility. Similarly, Clarke (1971) demonstrated positive correlations ranging from 0.27 to 0.40 between mesomorphy and a composite strength measure in boys 12-17 years. Mesomorphy was not consistently related to other performance measures in the Medford Boys Study (Clarke, 1971).

Ectomorphy was not related to strength, flexibility or motor fitness in this study. Generally, correlations between ectomorphy and motor performance variables are low and variable in direction (Malina, 1975). Ectomorphy did, however, demonstrate negative associations with strength, indicating that high ectomorphy was related to a deficit in strength (Malina, 1975). Ectomorphy was generally quite low in the present sample, which could explain the absence of associations with strength and performance.

Body size and Familial Resemblance in Strength and Flexibility

The results of this study indicate that including measures of body size in correlation and regression analyses does not appreciably alter estimates of familial resemblance (Table 4.39). Sibling correlations were virtually unchanged while heritability estimates from regressions on mid-parent values varied somewhat for grip strength. Table 3.11 presents the amount of variation explained by $\text{age} + \text{age}^2 + \text{age}^3$ as well as that explained by adding mass, stature, and the BMI into the regressions independently. In each instance, the incorporation of body size into the regression increased the amount of variance explained; however, the increase was not very great, since age explained a considerable amount of the variability, particularly in the 5-19 year groups as would be expected. Given that the proportion of the total phenotypic

variance in performance measures explained using multiple regression did not increase appreciably by incorporating body size into the regression it does not seem surprising that the familial correlations did not change (Table 3.12).

The results are not consistent with those of a study in which stature and body mass were partialled out of correlations for performance measures between siblings (Malina and Mueller, 1981). Sibling correlations for strength and motor performance were reduced slightly when body size was controlled by partial correlation, suggesting that removing body size removes some of the covariation due to environmental factors (Malina and Mueller, 1981). However, the results are not directly comparable since different analytical strategies were used in adjusting the variables for the effects of age and sex, and interclass correlations were used to estimate sibling effects rather than intraclass correlation, which was used in the present study.

Grip strength is sometimes expressed as a ratio with body mass, i.e., kg/kg body mass. Pérusse et al. (1988) indicated a parent-offspring correlation of 0.20 and a sibling correlation of 0.29 for grip strength/kg body mass in the CFS. Similarly, Pérusse et al. (1987) reported a parent-child correlation of 0.32 and a sibling correlation of 0.28 for the same measure in the QFS. These values fall within the range of reported values for unadjusted grip strength (Table 2.10).

Grip strength was expressed as right grip, left grip, and relative grip in a study of Polish families (Szopa, 1982). Relative grip strength was calculated as $(\text{right} + \text{left}) / \text{body mass}$. Familial correlations for left grip and right grip were of similar magnitude as relative grip strength. The variability among correlations for right and left was as great as between relative grip strength and either right or left. Thus, as in the present study, adjusting grip strength for body mass did little to alter the family correlations.

Adjusting performance measures for body size may impact inferences regarding sources of variation in a given trait; however, familial correlations may not be sensitive

enough to demonstrate significant differences. Additionally, measurement variability will increase the error in the familial correlations. A study which incorporates low measurement error and large numbers of subjects may be needed to estimate the effects of incorporating body size into the estimation of familial effects on performance.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

The purpose of the study was to compare Canadians of First Nation (FN) and European (EA) ancestry in terms of body size, physique, and indicators of health-related fitness, and to determine the familial resemblance in these variables. Data were collected during the Spring and Summer of 1996 (May-August) in the Northern Ontario communities of Temagami and Bear Island. All residents 5-75 years of age were eligible to participate.

A total of 624 subjects (130 FN, 494 EA) participated in the study. Nineteen anthropometric dimensions were taken on each subject: stature; sitting height; body mass; skinfolds at the biceps, triceps, subscapular, abdominal, suprailiac, supraspinale and medial calf sites; biacromial, bicristal, biepicondylar, and bicondylar breadths; and flexed and relaxed mid-arm, maximal calf, waist and hip circumferences. Eight indices were derived: subischial length; the body mass index (BMI); Heath-Carter anthropometric somatotype; the sitting height/stature ratio; hip-to-shoulder breadth ratio; sum of skinfolds; a trunk to extremity skinfold ratio; and the waist-to-hip circumference ratio. Grip strength and trunk flexibility (sit-and-reach) were also measured as components of health-related fitness. Additionally, children attending the public schools (5-15 years) completed a battery of motor fitness tests which included the standing long jump, flexed arm hang, sit-ups, and the 35-meter dash. Technical errors of measurement for the anthropometry were similar to those reported for national surveys in the United States (Johnston et al., 1972; Malina et al., 1973; Chumlea et al.,

1990; Malina, 1995). Reliability coefficients for the fitness tests exceeded 0.99 for all tests.

The results indicated significant differences between EA and FN Canadians and significant familial resemblance in body size and health-related fitness. Generally, FN subjects were fatter and had a more central or truncal subcutaneous fat distribution than EA subjects. The differences between ethnic groups were greatest in the 20-75 year sample of females; however, there were differences apparent in each age and sex group. Some differences were not statistically significant in all groups, but the direction of the differences was consistent. Males generally had less subcutaneous adiposity, but had a greater tendency to store proportionally more subcutaneous fat on the trunk than females. There were few differences for stature and skeletal dimensions.

FN subjects were generally more endomorphic than EA subjects. Results were significant for all groups except the 5-19 year old females, in whom differences in somatotype were small but in the same direction as the other groups (greater endomorphy).

The estimated prevalence of obesity in FN was generally higher than in EA. However, significant differences in prevalences of obesity were evident only in the 20-75 year old females. Among males and females 5-19 years, the prevalence of obesity (≥ 85 th percentile age-specific NHANES II BMI) was 38.1% and 29.4% in FN males and females, respectively, and 21.3% and 16.9% in EA males and females, respectively. In FN adults 20-75 years, the prevalence of obesity (≥ 85 th percentile NHANES II BMI for 20-29 year old people) was 51.4% in FN males, 58.8% in FN females, 39.0% in EA males, and 35.0% in EA females.

There were differences between adult subjects classified as obese by the BMI only and the BMI+triceps skinfold in combination; however, the numbers were inadequate in the 5-19 year old groups to make comparisons. Also, there were too few subjects classified as obese by the triceps only to compare to the other groups. In

males, BMI obese subjects had greater TERs than the BMI+triceps obese ($p \leq 0.05$). In general, endomorphy was also greater in the BMI+triceps obese group, and in the EA sample, mesomorphy was greater and ectomorphy was lower in the BMI+triceps obese sample. In EA males, the BMI+triceps obese group also had greater bicondylar and biépicondylar breadths.

Analyses of secular changes indicated significant decreases in stature with age in EA males and females but not in FN. The estimated decreases in stature with age in FN were similar in magnitude to EA, but due to small numbers, the estimates were not significant. The statural loss due to aging (shrinkage) was estimated at 0.12 cm/year and 0.06 cm/year in EA males and females, respectively. Taking into account the estimated statural loss due to aging, positive secular trends of 1.0 cm/decade ($p \leq 0.05$) and 0.4 cm/decade (ns) in EA males and females, respectively, were estimated. A comparison of studies from 1953 to 1981 indicated that a secular trend in stature had occurred in Canada, and that the temporal trend in body mass appeared to mirror that of stature; however, there was no secular trend in the BMI.

Mean BMIs of adults in the present study were greater than any reported study in Canada since 1953. There are two possible explanations for this finding: (1) the population of Temagami demonstrates significantly higher values for the BMI than the general population of Canada, and/or (2) there has been a significant increase in the BMI of Canadians over the past 15 years (1981 to 1996), and the population of Temagami is representative of the rest of Canada. It is possible that both scenarios may help explain the high BMIs in the present sample.

The results indicated significant familial resemblance in body size, physique, adiposity, relative fat distribution, grip strength and flexibility. Spousal correlations showed a lack of assortative mating (positive or negative) in this population. Further, the role of a shared living environment has apparently had minimal effects on spousal similarities in this population.

Interclass correlations between parents and offspring were significant and demonstrated familial resemblance for all variables, suggesting that genetic factors were operating on the familial associations. Additionally, intraclass correlations indicated significant sibship effects. Sibling correlations were typically higher or of the same magnitude as parent-offspring correlations, which suggested that the shared living environment may be important in explaining some of the variation within families.

Results of partial correlation analyses indicated that mesomorphy was positively associated with right and left grip strength, whereas endomorphy was negatively associated with flexibility. There were few consistent correlations between body size and motor performance in children. The sum of skinfolds was negatively associated with the standing long jump in both sexes, and all measures of body size were negatively related to the flexed arm hang in boys. There was significant familial resemblance in grip strength and flexibility, and the inclusion of body size as a covariate in the correlation and regression analyses did not appreciably affect the results.

Conclusions

The conclusions are best framed within the explicit hypotheses presented in Chapter 1.

Hypothesis 1

There are significant differences between Canadians of First Nation (FN) and European ancestry (EA) in body size, physique, and indicators of health-related fitness.

1a) FN Canadians are heavier and demonstrate greater subcutaneous fatness than EA Canadians throughout childhood into adulthood.

This hypothesis was partially supported. FN subjects were not significantly heavier in terms of body mass and the BMI, except in females 20-75 years. FN males 5-19 years were significantly fatter than EA males, and FN females 20-75 years were significantly fatter than EA females, in terms of subcutaneous fatness. There were few statistically significant differences among males 20-75 years and females 5-19 years; however, FN subjects were consistently fatter in all indicators of subcutaneous fatness.

1b) There are significant differences in relative fat distribution and physique between FN and EA Canadians.

This hypothesis was supported. In all age and sex groups, FN subjects had significantly greater TERs, and in all groups except females 5-19 years, FN subjects had greater WHRs. These results indicated that FN subjects had a more central subcutaneous fat distribution than EA subjects. Additionally, FN subjects were significantly more endomorphic than EA subjects in all groups except females 5-19 years. Among females 5-19 years, FN females were also more endomorphic, but the difference was not statistically significant.

1c) There are no differences in stature and other skeletal dimensions between FN and EA Canadians.

This hypothesis was partially supported. Significant differences in stature and skeletal dimensions appeared only sporadically among the comparisons, with the

exception of females 20-75 years. Among adult females, all skeletal breadths were significantly greater in the FN group. FN adult females had a larger overall frame size than EA females.

Hypothesis 2

Secular trends in body size are evident in FN and EA Canadians.

2a) There are significant secular increases in stature, mass and the BMI in FN and EA Canadians.

This hypothesis was partially supported. There was a significant secular trend towards increasing stature in EA males; however, the secular trend in EA females and FN males and females was not significant. Comparisons among selected studies from 1953 to 1981 indicated that body mass had increased over time in a similar manner as stature. However, the BMI had not increased significantly over time in the Canadian population, with the exception of the present study, indicating that body mass has not increased more than would be expected given the secular trend in stature. The BMIs in the present study were greater than earlier surveys in Canada, which could mean that a recent secular trend in the BMI has occurred in Canada since the last national survey (1981), or that this sample is not representative of the general Canadian population.

Hypothesis 3

There is significant familial resemblance in body size, physique and indicators of health-related fitness in FN and EA Canadians.

3a) There is significant familial resemblance in body size, physique and indicators of health-related fitness in FN and EA Canadians.

This hypothesis was supported. Spousal correlations indicated an absence of assortative mating (positive and negative) in this population. Correlations among nuclear family members and regression of the offspring on mid-parent values indicated significant familial resemblance in body size, physique, adiposity, relative fat distribution, grip strength, and trunk flexibility. Ethnic differences in familial

resemblance could not be determined due to insufficient sample sizes in the First Nation group.

3b) Estimated heritabilities for strength and flexibility are greater after body morphology is factored into the analyses as a covariate.

This hypothesis was not supported. The incorporation of stature, body mass, and the BMI into familial aggregation analyses for grip strength and trunk flexibility did not increase the correlation or regression coefficients. The incorporation of body size had little to no effect on the magnitude of the associations.

Recommendations for Future Research

This study has demonstrated significant differences between Canadians of First Nation and European ancestry in components of health-related fitness; in particular, physique, fatness and relative fat distribution. Considerable evidence has been accumulated to suggest that excess fatness and a centripetal fat distribution are both independent risk factors for coronary heart disease and metabolic disorders. Similarly, there is also research which suggests that physique itself is related to risk factors for disease, or may be in and of itself, a risk factor. More research is required to better characterize the relationships between physique, fat distribution, metabolic fitness, and disease among First Nation Canadians, who are at increased risk for metabolic disorders.

This study has demonstrated that differences between Canadians of European and First Nation ancestry are apparent in childhood and adolescence. Since many metabolic disorders such as obesity and diabetes may have their roots in childhood, emphasis should be placed on studying the growth characteristics of Native North Americans. The present study presents cross-sectional data on the growth of children; however, a longitudinal study may be more appropriate such that growth rates and other growth parameters may be estimated.

More study is needed to better characterize activity patterns and daily energy intakes and expenditures in Native North Americans. These data are difficult to obtain, but their value becomes increasingly great. Clinical interventions are necessary to determine the effects of diet and activity programs among Native groups.

Particular attention should be given to the genetic aspects of fatness and relative fat distribution, especially among Native North Americans. As the human genome becomes better characterized, ethnic variation at specific loci may help explain the greater susceptibility of Native North Americans to several metabolic diseases.

The best way to further the understanding of the etiologies of metabolic disorders among Native North Americans is through the use of family data. The ideal design would be a large scale longitudinal family study similar to the Québec Family Study, which would include measures of dietary intake, physical activity, indicators of metabolic fitness, and anthropometry among members of extended families of Native North Americans.

TABLES

TABLE 2.1 Comparison of stature, mass and estimated BMI among selected samples of adult Native North Americans. BMIs are estimated from means for stature and mass in each sample.

Population	Location	n	Ages	Stature (cm)		Mass (kg)		BMI (kg/m ²)		Reference
				Mean	SD	Mean	SD	Mean	SD	
Males										
Athapaskan	Yukon	27	>18	169.7	6.5	69.6	11.9	24.2		Lee & Birkbeck, 1977
	Yukon	11	>18	171.3	6.3	69.2	10.1	23.6		Lee & Birkbeck, 1977
	British Columbia	47	>18	172.4	5.0	67.9	11.4	22.8		Lee & Birkbeck, 1977
Nootka	British Columbia	36	≥20	170.4	6.0	79.6	10.6	27.4		Birkbeck et al., 1971
Chilcotin	British Columbia	36	≥20	170.3	5.4	70.7	15.7	24.4		Birkbeck et al., 1971
Apache	Arizona	31	≥20	168.5	2.1	68.9		24.3		Kraus, 1961
Apache	Arizona	31	22-27	170.2		73.9		25.5		Miller, 1970
Blackfeet	Montana	38	20-39	177.4		74.7		23.7		ICNND, 1964
Eskimos	Alaska	43	≥25	166.3	6.2	67.3	9.8	24.3		Jamison & Zegura, 1970
Females										
Athapaskan	Yukon	34	>18	158.3	5.1	61.4	12.2	24.5		Lee & Birkbeck, 1977
	Yukon	27	>18	157.3	6.1	57.7	13.4	23.3		Lee & Birkbeck, 1977
	British Columbia	43	>18	158.1	8.0	65.1	16.4	26.0		Lee & Birkbeck, 1977
Nootka	British Columbia	45	≥20	158.3	6.3	65.6	13.4	26.2		Birkbeck et al., 1971
Chilcotin	British Columbia	55	≥20	156.5	4.4	65.8	11.3	26.9		Birkbeck et al., 1971
Apache	Arizona	46	≥20	153.3	0.8					Kraus, 1961
Blackfeet	Montana	46	20-39	164.8		64.2		23.6		ICNND, 1964
Eskimos	Alaska	37	≥25	155.8	6.0	66.4	15.2	27.4		Jamison & Zegura, 1970

TABLE 2.2 Components of health-related fitness.

Morphological

BMI

Body Composition

Subcutaneous Fat Distribution

Flexibility

Muscular

Power

Strength

Endurance

Motor

Agility

Balance

Coordination

Cardiorespiratory

Exercise Capacity

Heart and Lung Functions

Blood Pressure

Metabolic

Glucose Tolerance

Lipid Metabolism

Substrate Oxidation

Adapted from Bouchard & Shephard (1994)

TABLE 2.3 Evidence for familial resemblance in stature.

Sample	Type of Correlation	n	Correlations			Reference
			Spousal	Sibling	Parent-Offspring	
African American	Intraclass	533	0.12	0.26 to 0.54	0.01 to 0.27	Rotimi & Cooper, 1995
Utah	Intraclass	529	0.37	0.14 to 0.43	0.37 to 0.48	Ramirez, 1993
CFS	Interclass	18073	0.43	0.34	0.20	Pérusse et al., 1988
FOS	Interclass	7948	0.39	0.44 to 0.51	0.47 to 0.54	Heller et al., 1984
Montreal	Interclass	997	0.25		0.34 to 0.43	Annest et al., 1983
	Intraclass			0.37		
London	Interclass	1083			0.46 to 0.67	Hawk & Brook, 1979
Rural Colombia	Interclass	1447			0.24 to 0.29	Mueller & Titcomb, 1977
Belgium	Interclass	532		0.59	0.51	Susanne, 1975
Montreal	Interclass	415			0.34	Bouchard et al., 1980b
U.S. White	Interclass	583	0.34	0.31 to 0.48	0.28 to 0.44	Malina et al., 1976 Mueller & Malina, 1976 Mueller & Malina, 1980
U.S. Black	Interclass	646	0.06	0.50 to 0.67	0.15 to 0.34	Malina et al., 1976 Mueller & Malina, 1976 Mueller & Malina, 1980

FOS: Framingham Offspring Study; CFS: Canada Fitness Survey

TABLE 2.4 Evidence for familial resemblance in body mass.

Sample	Type of Correlation	n	Correlations			Reference
			Spousal	Sibling	Parent-Offspring	
African American	Intraclass	533	0.15	0.30 to 0.35	0.36 to 0.52	Rotimi & Cooper, 1995
CFS	Interclass	18073	0.16	0.34	0.16	Pérusse et al., 1988
Montreal	Interclass	997	0.18		0.22 to 0.35	Annest et al., 1983
	Intraclass			0.16		
London	Interclass	1083			0.30 to 0.47	Hawk & Brook, 1979
Rural Colombia	Interclass	1447			0.28 to 0.37	Mueller & Titcomb, 1977
Montreal	Interclass	998	0.39		0.31	Biron et al., 1977
Belgium	Interclass	532		0.54	0.34	Susanne, 1975
U.S. White	Interclass	583	0.17	0.21 to 0.54		Mueller & Malina, 1976 Mueller & Malina, 1980
U.S. Black	Interclass	446	0.23	0.43 to 0.61		Mueller & Malina, 1976 Mueller & Malina, 1980

CFS: Canada Fitness Survey

TABLE 2.5 Evidence for familial resemblance in circumferences.

Sample	Type of Correlation	n	Circumference	Correlations			Reference
				Spousal	Sibling	Parent-Offspring	
African American	Intraclass	533	Waist	0.11	0.29 to 0.35	0.30 to 0.38	Rotimi & Cooper, 1985
			Hip	0.07	0.09 to 0.40	0.14 to 0.31	
			Arm	0.04	0.22 to 0.42	0.29 to 0.32	
Rural Colombia	Interclass	1447	Arm			0.30 to 0.44	Mueller & Titcomb, 1977
			Calf			0.29 to 0.41	
			Arm Muscle			0.18 to 0.39	
Belgium	Interclass	532	Arm		0.46	0.30	Susanne, 1975
			Flexed Arm		0.45	0.28	
			Calf		0.26	0.21	
France	Interclass	903	Waist			0.38 to 0.47	Tiret et al., 1991
			Arm	0.31 0.10	0.50 0.33	0.26 to 0.27	
U.S. White	Interclass	583	Arm			0.29 to 0.38	Mueller & Malina, 1980
			Calf			0.26 to 0.45	
U.S. Black	Interclass	446	Arm			0.42 to 0.53	Mueller & Malina, 1980
			Calf			0.45 to 0.54	

TABLE 2.6 Evidence for familial resemblance in skeletal dimensions.

Sample	Type of Correlation	n	Measure	Correlations			Reference
				Spousal	Sibling	Parent-Offspring	
Rural Colombia	Interclass	1447	Sitting Height			0.20 to 0.28	Mueller & Titcomb, 1977
			Subischial Length			0.22 to 0.29	
			SSR			0.07 to 0.34	
			Biacromial Breadth			0.19 to 0.43	
			Bicristal Breadth			0.18 to 0.43	
			Bicondylar Breadth			0.23 to 0.37	
Belgium	Interclass	532	Bleptcondylar Breadth			0.24 to 0.32	Susanne, 1975
			Sitting Height		0.40	0.37	
			Biacromial Breadth		0.40	0.33	
			Bicristal Breadth		0.53	0.49	
Montreal	Interclass	415	Sitting Height		0.24		Bouchard et al., 1980b
			Biacromial Breadth		0.31		
			Bicristal Breadth		0.11		
			Bicondylar Breadth		0.25		
			Bleptcondylar		0.27		
U.S. White	Interclass	583	Sitting Height		0.34 to 0.61		Mueller & Malina, 1980
			Biacromial Breadth		0.20 to 0.54		
			Bicristal Breadth		-0.02 to 0.44		
			Bicondylar Breadth		0.15 to 0.39		
			Bleptcondylar Breadth		0.16 to 0.52		
U.S. Black	Interclass	446	Sitting Height		0.39 to 0.61		Mueller & Malina, 1980
			Biacromial Breadth		0.37 to 0.68		
			Bicristal Breadth		0.36 to 0.49		
			Bicondylar Breadth		0.25 to 0.54		
			Bleptcondylar Breadth		0.28 to 0.44		

TABLE 2.7 Evidence for familial resemblance in the BMI.

Sample	Type of Correlation	n	Correlations			Reference
			Spousal	Sibling	Parent-Offspring	
African American	Intraclass	533	0.12	0.26 to 0.23	0.28 to 0.30	Rotimi & Cooper, 1995
Italy	Interclass	250			0.27 to 0.38	Antonella et al., 1994
Utah	Intraclass	529	-0.05	0.21 to 0.46	0.03 to 0.29	Ramirez, 1993
India	Maximum Likelihood	1691	0.37	0.28 to 0.55	0.24	Nirmala et al., 1993
MPFS	Interclass Intraclass	1302	0.17	0.35	0.22	Moll et al., 1991
Norway	Interclass	74994	0.12	0.21 to 0.26	0.18 to 0.21	Tambs et al., 1991
LRC	Interclass	3925	0.09	0.22	0.18	Price et al., 1990
CFS	Interclass	18073	0.12	0.31	0.20	Pérusse et al., 1988
QFS	Interclass	1698	0.10	0.26	0.23	Bouchard et al., 1988
Jerusalem	Interclass	5740	0.08	0.33	0.22	Friedlander et al., 1987
Michigan	Interclass Intraclass	9226	0.12	0.23 to 0.38	0.27	Longini et al., 1984
FOS	Interclass	7948	0.19	0.09 to 0.27	0.21 to 0.27	Heller et al., 1983
Montreal	Interclass Intraclass	997	0.11	0.40	0.02 to 0.18	Annest et al., 1983

CFS: Canada Fitness Survey; FOS: Framingham Offspring Study; QFS: Québec Family Study; MPFS: Muscatine Ponderosity Family Study; LRC: Lipid Research Clinics program

TABLE 2.8 Evidence for familial resemblance in fatness and relative fat distribution.

Sample	Type of Correlation	n	Measure	Correlations			Reference
				Spousal	Sibling	Parent-Offspring	
African American	Intraclass	533	WHR	0.08	0.00 to 0.09	0.00 to 0.24	Rotimi & Cooper, 1995
QFS	Maximum Likelihood	1628	SUM6		0.28	0.24	Borecki et al., 1995
			TRUNK ¹		0.27	0.23	
			TER ¹		0.24	0.26	
Utah	Intraclass	529	SUM4	0.02	0.28 to 0.47	0.13 to 0.29	Ramirez, 1993
			WHR	0.05	0.11 to 0.51	0.07 to 0.21	
India	Maximum Likelihood	1691	SUM6	0.46	0.50 to 0.68	0.38	Nirmala et al., 1993
			TRUNK ¹	0.44	0.36 to 0.65	0.36	
			TER ¹	0.01	0.22	0.22	
QFS	Interclass	1698	SUM6	0.06	0.26	0.22	Bouchard et al., 1988
			%BF	0.20	0.17	0.23	
			TER ¹	0.06	0.36	0.31	
CFS	Interclass	18073	SUM5	0.15	0.27	0.21	Pérusse et al., 1988
			TRUNK ²	0.13	0.29	0.20	
			EXTREMITY	0.13	0.27	0.22	
			TER ²	0.05	0.34	0.20	
			WHR	0.11	0.23	0.16	

CFS: Canada Fitness Survey; QFS: Québec Family Study; WHR: waist to hip circumference ratio;
 SUM4: (triceps+subscapular+suprailiac+caif) skinfolds; SUM5: (suprailiac+subscapular+biceps+triceps+caif) skinfolds;
 SUM6: (subscapular+suprailiac+abdominal+triceps+biceps+medial caif) skinfolds; %BF: % body fat derived from underwater weighing;
 TRUNK¹: (suprailiac+subscapular+abdominal) skinfolds; TRUNK²: (suprailiac+subscapular) skinfolds;
 EXTREMITY: (biceps+triceps+caif) skinfolds; TER¹: (subscapular+suprailiac+abdominal)/(triceps+biceps+medial caif) skinfolds;
 TER²: (subscapular+suprailiac)/(triceps+biceps+caif) skinfolds

TABLE 2.9 Evidence for familial resemblance in somatotype.

Type of Study	Sample	Type of Correlation	n	Component	Correlations			Reference
					Spousal	Sibling	Parent-Offspring	
Family	Madrid	Maximum Likelihood	835	Endomorphy	0.19	0.22 to 0.44	0.15 to 0.24	Sánchez-Andrés, 1995
				Mesomorphy	-0.08	0.28 to 0.38	-0.04 to 0.30	
				Ectomorphy	0.14	0.28 to 0.40	0.13 to 0.25	
Family	QFS	Interclass	938	Endomorphy	0.05	0.23 to 0.35	0.18 to 0.35	Song et al., 1993
				Mesomorphy	0.10	0.53 to 0.59	0.24 to 0.41	
				Ectomorphy	0.06	0.32 to 0.40	0.15 to 0.28	
Family	CFS	Interclass	18073	Endomorphy	0.14	0.25	0.21	Pérusse et al., 1988
				Mesomorphy	0.10	0.29	0.24	
				Ectomorphy	0.12	0.29	0.24	
Family	Montreal	Interclass	817	Endomorphy		0.40		Bouchard et al., 1980a
				Mesomorphy		0.30		
				Ectomorphy	0.23	0.38	0.22	
Twin	QFS	Intraclass	56 ¹ , 36 ²	Endomorphy, male		0.75 ¹ , 0.64 ²		Song et al., 1994
			68 ¹ , 42 ²	Endomorphy, female		0.83 ¹ , 0.38 ²		
			56 ¹ , 36 ²	Mesomorphy, male		0.51 ¹ , 0.22 ²		
			68 ¹ , 42 ²	Mesomorphy, female		0.74 ¹ , 0.27 ²		
			56 ¹ , 36 ²	Ectomorphy, male		0.74 ¹ , 0.60 ²		
			68 ¹ , 42 ²	Ectomorphy, female		0.75 ¹ , 0.51 ²		
Twin	Prague	Intraclass	28 ¹ , 20 ²	Endomorphy		0.83 ¹ , 0.44 ²		Kovar, 1977
			28 ¹ , 20 ²	Mesomorphy		0.90 ¹ , 0.15 ²		
			28 ¹ , 20 ²	Ectomorphy		0.90 ¹ , 0.22 ²		

QFS: Québec Family Study; CFS: Canada Fitness Survey

¹MZ twins

²DZ twins

TABLE 2.10 Evidence for familial resemblance in grip strength and trunk flexibility.

Type of Study	Sample	Type of Correlation	n	Measure	Correlations			Reference
					Spousal	Sibling	Parent-Offspring	
Family	U.S. Black	Interclass	228	Right Grip		0.32		Malina & Mueller, 1981
	U.S. White		202	Right Grip		0.17		
	U.S. Black		228	Left Grip		0.25		
	U.S. White		202	Left Grip		0.10		
Family	Prague	Interclass	120	Grip	0.26		0.07 to 0.31	Kovar, 1981
Family	Poland	Intraclass	1420	Right Grip	0.15	0.17 to 0.29	0.08 to 0.20	Szopa, 1982
				Left Grip	0.26	0.13 to 0.25	0.09 to 0.14	
Family	Mennonite	Interclass	244	Dominant Grip	0.01	0.55	-0.05	Devor & Crawford, 1984
				Flexibility	-0.09	0.44	0.29	
Family	CFS	Interclass	18073	Grip/mass	0.08	0.29	0.20	Pérusse et al., 1988
				Flexibility	0.10	0.36	0.26	
Twin	LLTS	Intraclass	82 ¹ , 74 ²	Flexibility		0.82 ¹ , 0.53 ²		Maes et al., 1993
Twin/ Family	LLTS	Maximum Likelihood	391	Flexibility	0.09		0.32 to 0.42	Maes et al., 1996

LLTS: Leuven Longitudinal Twin Study; CFS: Canada Fitness Survey

¹MZ twins²DZ twins

TABLE 3.1 Age and sex distribution of subjects compared to reported populations of Temagami and Bear Island.

Temagami					
Age Group	Number of Residents*	Subjects			% Participation
		Males	Females	Total	
<15	200	65	55	120	60.0
15-29	170	55	43	98	57.6
30-44	230	68	81	149	64.8
45-64	300	65	68	133	44.3
≥65	130	16	22	38	29.2
Total	1030	269	269	538	47.6
Bear Island					
Age Group	Number of Residents**	Subjects			% Participation
		Males	Females	Total	
<15	28	12	6	18	64.2
15-29	52	12	15	27	51.9
30-44	37	6	10	16	43.2
45-64	38	10	10	20	52.6
≥65	19	2	3	5	26.3
Total	174	42	44	86	49.4

*Data from Statistics Canada (1995)

**Data from Temagami First Nation band records

TABLE 3.2 Age and sex distribution of the subsample participating in the analysis of measurement variability.

	n	FN	EA	Mean Age (years)	Age Range (years)
Males	34	5	29	22.2	4.7 - 75.3
Females	30	5	25	29.0	4.4 - 67.6
Total	64	10	54	25.4	4.4 - 75.3

TABLE 3.3 Mean differences ($\bar{X}_d$), intraobserver technical errors of measurement (TEM) and intraclass correlation coefficients (r_{intra}) between replicate measurements (n=64).

Measure	n	$\bar{X}_d$	TEM	r_{intra}
Mass	64	0.21 kg	0.72 kg	1.000
Stature	64	0.28 cm	0.54 cm	1.000
Sitting Height	63	0.83	0.95	0.997
<u>Skinfolds</u>				
Triceps	63	0.19 mm	0.94 mm	0.994
Biceps	64	0.08	0.96	0.981
Subscapular	63	0.26	1.03	0.994
Suprailiac	63	0.07	1.13	0.988
Supraspinale	63	0.20	1.34	0.986
Medial Calf	60	0.09	1.11	0.984
Abdominal	63	0.14	1.64	0.990
<u>Breadths</u>				
Bicondylar	63	0.02 cm	0.18 cm	0.989
Biepicondylar	64	0.03	0.10	0.995
Biacromial	64	0.12	0.57	0.995
Bicristal	64	0.09	0.58	0.993
<u>Circumferences</u>				
Flexed Arm	64	0.11 cm	0.40 cm	0.998
Relaxed Arm	64	0.13	0.51	0.996
Maximal Calf	60	0.01	0.34	0.998
Waist	64	0.29	1.15	0.997
Hip	64	0.22	1.43	0.996
<u>Somatotype</u>				
Endomorphy	63	0.06	0.20	0.995
Mesomorphy	60	0.03	0.17	0.993
Ectomorphy	64	0.04	0.13	0.995

TABLE 3.4 Comparison of intraobserver technical errors of measurement (TEM) with those reported in selected studies.

Measure	This Study	HHANES ¹	NHANES ^{2,3}	Mexican Americans ⁴	Philadelphia Children ⁵	Soccer Players ⁶	Alpine Skiers ⁷	Taiwanese Children ⁸
Mass	0.72 kg		1.17	0.2	0.27	0.21	0.23	0.21
Stature	0.54 cm	1.28	0.49	0.8	0.48	0.18	0.21	0.22
Sitting Height	0.95 cm	0.57	0.54		0.55	0.11	0.22	
Skinfolds								
Triceps	0.94 mm	1.60	0.80	2.2	0.82	0.35	0.23	0.32
Biceps	0.96					0.19	0.34	
Subscapular	1.03	2.22	1.83	2.6	0.68	0.32	0.34	0.48
Suprailiac	1.13	3.25	1.87	2.5		0.41	0.60	0.30
Supraspinale	1.34					0.33	0.48	
Medial Calf	1.11	2.72	1.44	2.2		0.21	0.34	0.41
Abdominal	1.64					0.30	0.41	
Breadths								
Bicondylar	0.18 cm		0.11	0.3	0.12	0.02	0.16	
Biepicondylar	0.10	0.28	0.12	0.2	0.09	0.04	0.12	
Biacromial	0.57	0.40	0.54		0.46	0.31	0.18	
Bicristal	0.58	1.10	0.71		0.31	0.15	0.26	
Circumferences								
Flexed Arm	0.40 cm			0.7		1.3	2.0	
Relaxed Arm	0.51	0.65	0.35	0.8	0.37	0.12	0.24	
Maximal Calf	0.34	0.85	0.87	0.8	0.23	0.10	0.25	
Waist	1.15		1.31	0.8				
Hip	1.43		1.23	0.9				

¹Chumlea et al. (1980); ²Johnston et al. (1972); ³Malina et al. (1973); ⁴Eschwey M.J. (1994);

⁵Malina and Moriyama (1991); ⁶Siegel (1995); ⁷Kilka (1995); ⁸Huang (1994)

TABLE 3.5 Sample sizes, age ranges, and intraclass correlations (r_{intra}) for replicate motor performance tests.

Test	n	Age Range (years)	r_{intra}
Right grip	617	4.3 - 76.5	0.997
Left grip	618	4.3 - 76.5	0.998
Trunk flexibility	592	4.3 - 76.5	0.995
Standing long jump	102	5.9 - 14.8	0.991
35-meter dash	99	5.9 - 14.8	0.990

TABLE 3.6 Comparison of reliability coefficients for replicate performance tests.

Test	This Study	Philadelphia Children ¹		Zapotec Children ²	
		Males	Females	Males	Females
Right grip	0.997	0.79 - 0.98	0.85 - 0.97	0.63 - 0.97	0.51 - 0.94
Left grip	0.998	0.80 - 0.97	0.79 - 0.93		
Trunk flexibility	0.995				
Standing long jump	0.991	0.72 - 0.95	0.50 - 0.93	0.88 - 0.94	0.82 - 0.94
35-meter dash	0.990	0.39 - 0.98	0.79 - 0.96	0.52 - 0.86	0.71 - 0.89

¹Malina and Mueller (1981)²Malina and Buschang (1985)**TABLE 3.7 Least squares regression equations for the prediction of individual skinfolds in a sample of Canadians.**

Variable	Males			Females	
	Subscapular	Abdominal	Medial Calf	Abdominal	Medial Calf
Constant	-2.311	5.937	2.291	7.744	4.929
Age	0.059	0.073	-0.042	0.098	-0.020
Subscapular		0.383	0.034	0.216	-0.070
Abdominal	0.178		0.007		-0.020
Suprailiac	0.265	-0.021	0.246	0.494	0.127
Supraspinale	0.241	0.612	0.124	0.108	0.029
Medial Calf	0.082	0.036		-0.022	
Triceps	-0.120	0.399	0.406	0.092	0.548
Biceps	1.128	-0.264	0.354	0.043	0.169
R²	0.77	0.66	0.63	0.76	0.61
S.E.	4.26	6.25	2.76	4.99	4.75

TABLE 3.8 Skewness statistics for variables with skewed distributions and skewness statistics after log₁₀ transformation of the variables.

Variable					Transformed			
	γ	S.E.	Z	p	γ	S.E.	Z	p
5-19 yrs								
<u>Males</u>								
Mass	0.79	0.25	3.20	<.005 *	0.19	0.25	0.76	ns
BMI	0.82	0.25	3.33	<.005 *	0.54	0.25	2.18	<.05 *
EXTREMITY	1.16	0.25	4.66	<.001 *	0.38	0.25	1.52	ns
TRUNK	1.32	0.25	5.31	<.001 *	0.42	0.25	1.70	ns
SUM	1.24	0.25	4.99	<.001 *	0.47	0.25	1.87	ns
TER	0.84	0.25	3.39	<.005 *	0.32	0.25	1.27	ns
Endomorphy	1.27	0.25	5.06	<.001 *	0.40	0.25	1.58	ns
Mesomorphy	0.60	0.25	2.40	<.025 *	-0.12	0.25	-0.46	ns
Right Grip	1.01	0.25	4.11	<.001 *	0.18	0.25	0.72	ns
Left Grip	1.06	0.25	4.34	<.001 *	0.12	0.25	0.49	ns
Hang	1.46	0.37	4.42	<.001 *	-0.05	0.33	1.36	ns
<u>Females</u>								
Mass	1.47	0.27	5.43	<.001 *	-0.02	0.27	-0.08	ns
BMI	1.52	0.27	5.50	<.001 *	0.98	0.27	3.62	<.001 *
EXTREMITY	1.39	0.28	5.02	<.001 *	0.61	0.28	2.19	<.05 *
TRUNK	1.43	0.28	5.11	<.001 *	0.34	0.28	1.21	ns
SUM	1.36	0.28	4.88	<.001 *	0.53	0.28	1.91	ns
TER	0.55	0.28	1.98	<.05 *	-0.19	0.28	-0.69	ns
Endomorphy	1.09	0.28	3.92	<.001 *	0.40	0.28	1.45	ns
Mesomorphy	1.08	0.28	3.91	<.001 *	-0.25	0.28	-0.88	ns
Right Grip	0.58	0.27	2.11	<.05 *	-0.41	0.27	-1.49	ns
Left Grip	0.82	0.27	3.00	<.005 *	-0.35	0.27	-1.27	ns
Hang	1.29	0.37	3.49	<.001 *	0.12	0.37	0.32	ns
20-75 yrs								
<u>Males</u>								
Mass	0.70	0.17	4.18	<.001 *	0.17	0.17	1.02	ns
BMI	0.65	0.17	3.89	<.001 *	0.14	0.17	0.81	ns
EXTREMITY	0.99	0.17	5.90	<.001 *	0.00	0.17	-0.02	ns
TER	0.60	0.17	3.64	<.001 *	-0.01	0.17	-0.04	ns
Ectomorphy	1.11	0.17	6.63	<.001 *	-0.46	0.17	2.75	<.01 *
Bicondylar	0.44	0.17	2.63	<.01 *	0.23	0.17	1.40	ns
Biepicondylar	0.46	0.17	2.78	<.01 *	0.22	0.17	1.33	ns
<u>Females</u>								
Mass	0.85	0.16	5.33	<.001 *	0.35	0.16	2.16	<.05 *
BMI	0.81	0.16	5.00	<.001 *	0.39	0.16	2.43	<.025 *
EXTREMITY	0.44	0.16	2.72	<.01 *	-0.30	0.16	-1.83	ns
TER	2.23	0.17	13.40	<.001 *	0.14	0.17	0.82	ns
Ectomorphy	0.89	0.17	5.24	<.001 *	-0.22	0.17	-1.32	ns
Bicondylar	1.07	0.16	6.69	<.001 *	0.77	0.16	4.78	<.001 *
Biepicondylar	0.74	0.16	4.68	<.001 *	0.51	0.16	3.21	<.005 *

γ : skewness statistic

Z: standardized skewness statistic (skewness statistic / S.E.)

TABLE 3.9 Effects of age, by gender, on skeletal dimensions, circumferences, and AMA.

	Males R² x 100^a	Females R² x 100^a
5-19 yrs		
Stature	93.4 *	90.5 *
Sitting Height	90.9 *	88.4 *
SSR	22.2 *	14.4 *
SIL	90.1 *	86.5 *
Biacromial Breadth	87.9 *	83.5 *
Bicristal Breadth	90.1 *	74.7 *
Bicondylar Breadth	81.2 *	48.9 *
Biepicondylar Breadth	81.1 *	66.6 *
Flexed Arm Circumference	70.8 *	52.5 *
Relaxed Arm Circumference	67.0 *	48.3 *
Maximal Calf Circumference	78.3 *	61.7 *
Waist Circumference	64.7 *	38.5 *
Hip Circumference	79.7 *	65.1 *
AMA	82.7 *	53.5 *
20-75 yrs		
Stature	15.3 *	6.4 *
Sitting Height	20.9 *	11.0 *
SSR	3.0	7.2 *
SIL	4.6 *	1.4
Biacromial Breadth	8.8 *	0.3
Bicristal Breadth	8.2 *	9.5 *
Bicondylar Breadth	0.9	2.6
Biepicondylar Breadth	3.9 *	11.7 *
Flexed Arm Circumference	5.5 *	3.0
Relaxed Arm Circumference	6.0 *	2.5
Maximal Calf Circumference	4.0 *	2.4
Waist Circumference	16.1 *	4.6 *
Hip Circumference	2.8	2.7
AMA	5.8 *	1.0

*Regressions significant at $p \leq 0.05$ ^a $Y = \text{age} + \text{age}^2 + \text{age}^3$

TABLE 3.10 Effects of age, by gender, on fatness, relative fat distribution, physique, grip strength, and trunk flexibility.

	<u>Males</u>	<u>Females</u>
	$R^2 \times 100^a$	$R^2 \times 100^a$
5-19 yrs		
Body Mass	85.2 *	60.1 *
BMI	42.9 *	32.6 *
SUM	11.0 *	18.3 *
TRUNK	15.2 *	20.4 *
EXTREMITY	5.3	12.6 *
TER	35.1 *	25.3 *
WHR	28.8 *	40.6 *
Endomorphy ^b	71.9 *	76.4 *
Mesomorphy ^b	82.1 *	72.5 *
Ectomorphy ^b	90.1 *	83.2 *
Right Grip	86.7 *	74.8 *
Left Grip	87.3 *	70.8 *
Flexibility	2.4	6.3
20-75 yrs		
Body Mass	3.7 *	2.5
BMI	10.5 *	2.6
SUM	6.4 *	3.4
TRUNK	9.6 *	2.9
EXTREMITY	1.9	2.7
TER	6.9 *	2.8
WHR	33.7 *	6.4 *
Endomorphy ^b	54.2 *	71.4 *
Mesomorphy ^b	68.8 *	65.7 *
Ectomorphy ^b	76.6 *	75.9 *
Right Grip	25.6 *	19.7 *
Left Grip	22.6 *	19.2 *
Flexibility	24.4 *	9.5 *

*Regressions significant at $p \leq 0.05$

^a $Y = \text{age} + \text{age}^2 + \text{age}^3$

^bAdjusted for the effects of age(as in note above), and the other somatotype components

TABLE 3.11 Distribution of sibship size among 266 families.

Group	1	2	3	4	5	6	Total	N
EA	114	50	23	2	–	1	190	297
FN	46	21	6	3	–	–	76	118
Total	160	71	29	5	–	1	266	415

TABLE 3.12 Effects of age, mass, stature and the BMI, by gender, on grip strength and flexibility.

	<u>Males</u>	<u>Females</u>
	<u>R² x 100</u>	<u>R² x 100</u>
5-19 yrs		
Flexibility ^a	2.4	6.3
Flexibility ^b	4.5	6.7
Flexibility ^c	6.2	6.6
Flexibility ^d	2.8	7.3
Right Grip ^a	86.7 *	74.8 *
Right Grip ^b	90.9 *	85.8 *
Right Grip ^c	89.0 *	83.0 *
Right Grip ^d	88.8 *	81.9 *
Left Grip ^a	87.3 *	70.8 *
Left Grip ^b	92.0 *	83.5 *
Left Grip ^c	89.2 *	80.8 *
Left Grip ^d	90.1 *	79.0 *
20-75 yrs		
Flexibility ^a	24.4 *	9.5 *
Flexibility ^b	25.9 *	13.1 *
Flexibility ^c	25.0 *	9.6 *
Flexibility ^d	25.3 *	13.3 *
Right Grip ^a	25.6 *	19.7 *
Right Grip ^b	43.6 *	33.8 *
Right Grip ^c	33.9 *	32.8 *
Right Grip ^d	37.6 *	27.1 *
Left Grip ^a	22.6 *	19.2 *
Left Grip ^b	42.1 *	32.5 *
Left Grip ^c	32.3 *	30.7 *
Left Grip ^d	35.4 *	26.6 *

*Regressions significant at $p \leq 0.05$ ^a $Y = \text{age} + \text{age}^2 + \text{age}^3$ ^b $Y = \text{age} + \text{age}^2 + \text{age}^3 + \text{mass}$ ^c $Y = \text{age} + \text{age}^2 + \text{age}^3 + \text{stature}$ ^d $Y = \text{age} + \text{age}^2 + \text{age}^3 + \text{BMI}$

TABLE 4.1 Sample sizes, means and standard deviations for age and indicators of body size.

Age Group (yrs)	n	Age (yrs)		Body Mass (kg)		Stature (cm)		Sitting Height (cm)		SSR (%)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males											
EA											
5-9	37	7.0	1.6	25.3	7.5	121.5	11.6	64.8	5.1	53.4	2.1
10-14	22	11.8	1.4	42.2	12.2	150.6	13.0	78.4	6.7	52.1	1.3
15-19	16	16.8	1.3	73.7	9.3	179.2	5.6	92.8	3.5	51.8	1.5
20-29	34	24.6	2.9	80.3	12.1	180.9	6.6	94.8	3.8	52.4	1.2
30-39	39	34.7	3.0	85.4	15.9	176.5	5.7	92.6	3.0	52.5	1.4
40-49	45	44.5	2.8	83.0	16.3	174.4	7.2	91.8	3.9	52.7	1.6
50-59	34	54.3	2.7	89.3	17.4	173.8	7.5	90.6	3.7	52.2	1.7
60-69	15	63.7	2.4	81.5	12.5	172.6	6.5	89.1	3.0	51.7	1.6
70-75	12	72.0	2.0	79.2	15.3	169.2	4.8	87.5	2.3	51.7	1.3
FN											
5-9	8	6.8	1.3	29.8	10.0	125.5	9.4	66.0	6.2	52.5	1.9
10-14	6	11.2	1.4	45.3	10.9	150.0	12.9	78.0	5.5	52.1	2.6
15-19	8	16.9	2.2	67.9	18.4	175.5	9.0	91.1	5.8	51.9	1.3
20-29	11	24.8	3.1	87.8	17.0	178.0	5.5	93.6	3.1	52.6	2.2
30-39	10	34.0	2.4	80.6	4.9	174.2	6.3	92.4	3.8	53.1	2.3
40-49	6	45.8	2.9	97.1	17.3	178.0	5.0	92.4	5.5	51.9	2.4
50-59	4	51.5	1.3	84.4	7.2	173.1	4.9	91.9	2.6	53.1	0.9
60-69	4	64.5	3.5	90.2	12.3	173.2	2.9	90.8	2.2	52.4	0.7
70-75	-										
Females											
EA											
5-9	24	6.9	1.5	23.5	5.9	120.1	13.3	63.8	6.4	53.2	1.7
10-14	20	11.7	1.2	43.8	14.0	150.1	9.3	78.8	5.3	52.5	1.2
15-19	16	16.7	1.5	61.7	18.9	165.1	8.3	86.7	4.9	52.5	1.0
20-29	19	24.4	3.1	66.2	14.1	162.1	5.9	85.8	4.1	52.9	1.9
30-39	54	34.1	2.9	66.1	12.7	163.0	5.8	86.4	3.2	53.0	1.1
40-49	40	44.4	2.5	73.1	19.5	163.6	5.9	87.2	3.8	53.5	1.7
50-59	33	53.5	2.9	70.5	14.6	161.4	5.4	85.6	3.1	53.0	1.1
60-69	24	64.4	3.2	66.3	12.5	158.4	5.3	83.3	3.1	52.5	1.1
70-75	10	71.4	1.3	65.2	16.2	158.4	5.0	83.0	3.2	52.4	1.0
FN											
5-9	4	7.2	1.9	28.0	5.2	123.5	10.7	69.1	3.7	54.2	2.0
10-14	9	11.6	1.4	45.2	13.5	152.4	11.1	79.6	5.6	52.3	1.1
15-19	6	16.5	1.6	62.9	28.0	162.1	7.9	87.3	5.4	53.9	0.9
20-29	17	23.1	2.5	74.8	17.3	165.5	4.4	87.6	3.0	52.9	1.0
30-39	12	32.9	3.0	77.8	14.0	162.7	5.4	86.3	2.9	53.0	1.4
40-49	12	44.4	3.5	73.6	15.0	158.7	6.3	85.0	2.7	53.6	1.2
50-59	5	52.8	2.5	78.9	11.3	161.6	4.0	85.8	2.5	53.1	1.7
60-69	7	62.6	2.9	76.5	13.2	165.4	3.8	85.0	2.1	51.4	0.9
70-75	1	71.1		70.3		153.4		78.9		51.4	

SSR: sitting height / stature ratio (sitting height/stature X 100)

TABLE 4.2 Sample sizes, means and standard deviations for indicators of fatness and relative fat distribution.

Age Group		BMI		SUM		TER		WHR	
(yrs)	n	(kg/m ²)		(mm)		(mm/mm)		(cm/cm)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males									
EA									
5-9	37	16.8	2.5	49.9	31.5	0.91	0.18	0.89	0.06
10-14	22	18.3	3.4	58.7	36.8	1.01	0.36	0.84	0.05
15-19	16	22.9	2.2	71.5	22.8	1.56	0.37	0.85	0.05
20-29	34	24.6	3.8	75.0	31.4	2.01	0.50	0.87	0.04
30-39	39	27.3	4.3	96.6	43.1	2.28	0.60	0.90	0.05
40-49	45	27.2	4.9	90.7	38.2	2.26	0.54	0.91	0.05
50-59	34	29.5	4.8	106.4	39.2	2.53	0.63	0.96	0.05
60-69	15	27.7	4.1	90.5	31.1	2.37	0.62	0.96	0.03
70-75	12	27.6	5.0	87.1	29.0	2.10	0.33	0.95	0.05
FN									
5-9	8	18.5	4.1	73.8	40.4	1.29	0.37	0.94	0.04
10-14	6	19.9	2.6	95.5	25.4	1.59	0.33	0.88	0.03
15-19	7	22.1	4.6	73.3	51.1	1.43	0.38	0.86	0.02
20-29	11	27.6	4.7	103.9	35.4	2.09	0.43	0.88	0.04
30-39	10	26.6	2.1	87.7	22.5	2.61	0.84	0.91	0.03
40-49	6	30.5	4.1	111.1	45.7	2.50	0.56	0.96	0.05
50-59	4	28.2	3.3	98.0	24.4	2.72	0.28	0.96	0.09
60-69	4	30.0	3.4	124.0	27.2	2.51	0.33	1.00	0.06
70-75	-								
Females									
EA									
5-9	24	16.1	1.8	53.4	21.5	0.81	0.19	0.87	0.05
10-14	20	19.1	4.2	77.4	42.7	1.02	0.30	0.79	0.07
15-19	16	22.3	4.5	97.4	43.2	1.18	0.29	0.76	0.06
20-29	19	25.2	5.2	117.5	51.5	1.12	0.27	0.75	0.04
30-39	53	24.9	4.9	108.7	43.0	1.19	0.29	0.77	0.04
40-49	40	27.3	6.9	136.6	48.9	1.24	0.24	0.80	0.06
50-59	33	27.0	5.1	135.4	43.9	1.26	0.30	0.80	0.07
60-69	24	26.4	4.6	137.4	44.2	1.29	0.45	0.82	0.06
70-75	10	25.8	5.3	126.6	53.2	1.44	0.88	0.82	0.05
FN									
5-9	4	18.2	0.3	73.5	19.2	1.22	0.10	0.82	0.12
10-14	9	19.2	4.4	82.8	41.1	1.22	0.29	0.81	0.07
15-19	5	20.4	2.4	79.4	16.3	1.20	0.28	0.76	0.04
20-29	17	27.2	5.9	139.4	57.3	1.57	0.46	0.83	0.06
30-39	12	29.4	4.9	167.5	40.7	1.34	0.23	0.85	0.06
40-49	12	29.3	6.1	142.0	32.8	1.57	0.38	0.84	0.05
50-59	5	30.2	3.9	170.0	32.0	1.27	0.06	0.87	0.04
60-69	7	28.1	5.5	156.7	57.0	1.43	0.23	0.88	0.03
70-75	1	29.9		148.0		2.10		0.91	

SUM: sum of six skinfolds, (triceps+biceps+medial calf+subscapular+suprailliac+abdominal);

TER: trunk / extremity ratio (subscapular+suprailliac+abdominal / triceps+biceps+medial calf);

WHR: waist / hip circumference ratio

TABLE 4.3 Sample sizes, means, medians, and standard deviations for extremity skinfolds.

Age Group (yrs)	n	Triceps (mm)			Biceps (mm)			Medial Calf (mm)			EXTREMITY (mm)		
		Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Males													
EA													
5-9	37	10.7	9.0	5.4	4.6	4.3	2.3	9.3	8.0	5.0	23.9	21.2	11.6
10-14	22	11.7	9.0	5.4	5.3	4.0	3.3	11.1	9.3	5.2	28.1	22.2	13.5
15-19	16	12.5	10.7	5.3	5.3	5.0	2.1	10.4	8.9	3.8	28.3	25.5	9.9
20-29	34	11.3	11.7	4.4	4.4	3.7	2.5	9.3	8.1	4.6	25.0	23.8	10.3
30-39	38	12.9	12.4	5.5	6.1	5.2	3.7	10.4	10.0	5.2	28.7	28.0	12.2
40-49	45	12.8	12.2	5.5	5.2	4.5	2.3	9.9	8.6	5.2	27.0	25.6	10.6
50-59	34	13.4	11.0	6.3	7.3	5.6	4.1	10.6	9.0	5.8	30.4	25.0	14.0
60-69	14	12.2	10.6	5.2	6.0	5.3	2.6	8.9	8.2	4.2	27.0	22.6	11.4
70-75	12	13.1	12.8	5.2	6.5	6.0	2.7	9.0	9.1	3.5	28.6	30.8	10.5
FN													
5-9	8	13.3	10.1	6.5	6.5	5.9	2.2	11.0	10.8	3.3	30.8	26.5	11.4
10-14	6	15.7	17.6	3.6	7.5	7.6	1.1	13.5	14.5	3.7	36.6	38.5	7.4
15-19	7	12.0	9.0	7.5	5.2	4.6	2.6	11.6	10.0	5.8	28.8	24.2	15.4
20-29	11	14.8	14.0	4.8	6.8	6.0	2.9	11.9	11.0	4.4	33.5	30.8	10.6
30-39	10	11.4	11.5	4.0	4.7	4.1	1.6	9.0	8.3	4.0	25.1	24.7	8.5
40-49	6	14.9	12.5	5.9	7.1	7.1	2.9	9.5	8.0	4.5	31.5	28.0	12.1
50-59	4	12.5	7.2	3.6	6.5	4.6	2.1	7.7	6.0	2.9	26.6	18.0	7.6
60-69	4	15.4	15.8	5.2	8.7	7.6	2.6	12.2	10.2	5.4	36.2	33.8	11.6
70-75	-												
Females													
EA													
5-9	23	12.6	11.2	4.0	5.4	5.0	1.9	11.0	9.6	4.2	29.2	26.3	9.6
10-14	20	14.7	11.7	6.2	7.1	5.2	4.5	15.7	12.7	7.7	37.5	28.2	17.7
15-19	16	19.1	15.8	8.0	7.9	6.5	3.7	17.4	17.2	8.3	44.4	39.6	18.7
20-29	19	24.1	21.4	9.2	9.2	6.0	6.6	21.7	19.0	8.3	55.1	43.4	22.7
30-39	53	23.1	22.0	7.5	9.9	7.8	5.9	18.8	17.6	7.3	51.7	46.2	19.0
40-49	40	27.0	24.4	8.6	13.3	10.0	7.5	21.7	19.2	7.7	61.4	55.0	22.4
50-59	33	26.2	25.8	7.6	12.5	12.0	6.0	22.3	21.2	7.3	60.9	62.0	18.8
60-69	23	26.2	23.0	8.3	13.0	11.2	6.7	21.5	21.4	7.5	60.7	55.4	20.7
70-75	10	23.3	20.0	11.6	12.3	10.3	7.6	19.2	17.8	8.0	54.7	49.4	25.5
FN													
5-9	3	15.6	17.0	4.7	6.3	6.2	1.6	11.0	11.4	1.4	32.9	34.6	7.6
10-14	9	14.6	15.2	4.5	7.8	6.0	4.0	13.6	14.4	5.2	36.0	35.2	13.3
15-19	5	14.5	14.8	3.6	5.0	5.2	1.4	17.2	16.4	6.1	36.7	36.6	10.6
20-29	16	25.7	24.9	10.3	12.8	11.5	7.8	19.7	16.8	11.3	58.4	56.6	28.9
30-39	11	31.4	30.4	7.4	16.6	17.4	4.7	23.8	22.0	6.8	71.8	77.4	16.5
40-49	12	25.2	25.0	7.2	13.9	10.6	9.3	18.6	16.1	6.8	56.5	56.2	16.1
50-59	5	30.1	32.0	6.5	19.1	16.4	8.4	26.0	26.4	1.9	75.2	76.2	15.2
60-69	7	30.1	32.0	11.8	14.4	14.6	8.0	21.5	21.6	9.4	66.0	70.2	26.8
70-75	1	20.4		7.2			20.2			47.8			

EXTREMITY: sum of extremity skinfolds (biceps+triceps+medial calf)

TABLE 4.4 Sample sizes, means, medians, and standard deviations for trunk skinfolds.

Age Group		Subscapular (mm)			Suprailiac (mm)			Abdominal (mm)			TRUNK (mm)		
(yrs)	n	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Males													
EA													
5-9	37	7.4	5.8	4.8	6.0	4.0	5.2	10.9	8.8	8.5	24.4	19.2	18.3
10-14	22	8.5	6.1	6.2	9.3	5.9	7.9	12.8	7.9	10.8	30.6	19.7	24.1
15-19	16	10.7	11.3	2.7	10.8	11.4	3.4	21.8	22.4	9.0	43.2	47.2	14.2
20-29	34	14.1	12.0	6.8	12.2	11.1	6.7	23.6	24.5	10.6	50.0	49.8	22.3
30-39	39	19.8	18.0	10.0	13.7	12.4	6.7	32.1	33.4	12.8	64.1	61.6	25.9
40-49	45	18.7	17.4	10.2	13.7	12.4	6.9	29.9	32.0	11.0	62.3	63.2	25.4
50-59	34	25.2	24.5	9.9	15.7	15.1	6.9	33.7	34.0	10.3	74.6	73.4	25.0
60-69	15	21.0	18.8	11.0	14.1	10.0	9.6	34.7	33.0	12.7	69.7	58.2	31.4
70-75	12	17.8	17.2	6.3	11.2	10.7	4.6	29.4	30.6	9.2	58.5	57.9	18.8
FN													
5-9	8	12.8	8.2	9.5	10.4	7.0	7.6	19.9	16.6	12.3	43.1	31.6	29.2
10-14	6	18.7	20.3	6.9	14.3	13.8	6.7	25.9	25.8	8.0	58.8	62.4	19.3
15-19	7	12.6	11.5	6.8	11.9	7.2	10.1	20.0	12.6	14.6	44.5	29.6	36.0
20-29	11	20.2	21.4	10.1	17.0	19.6	7.9	33.2	36.4	9.8	70.5	78.4	26.1
30-39	10	19.4	19.7	5.8	11.7	11.9	3.5	31.5	31.9	9.5	62.6	67.9	17.1
40-49	6	28.4	27.4	14.1	15.0	13.8	7.1	36.1	37.6	13.9	79.5	78.8	34.6
50-59	4	19.6	18.2	5.8	15.3	14.1	3.2	36.5	34.3	8.8	71.4	66.6	17.0
60-69	4	28.5	24.7	9.9	22.1	22.2	5.4	37.3	36.5	2.9	87.8	86.4	15.6
70-75	-												
Females													
EA													
5-9	22	7.5	6.4	3.3	6.6	5.4	3.8	10.2	7.9	5.7	24.2	19.9	12.6
10-14	20	11.9	8.8	7.2	11.7	8.2	8.8	16.4	13.3	10.7	39.9	31.5	26.0
15-19	16	14.9	11.8	8.3	14.1	10.8	8.5	23.3	19.4	10.1	52.5	46.2	26.2
20-29	19	20.8	17.8	10.4	15.7	13.2	9.8	26.0	22.6	11.1	62.4	54.6	30.3
30-39	46	19.6	16.0	10.2	14.2	10.3	8.6	25.7	23.7	10.0	59.5	51.2	28.0
40-49	39	24.9	26.0	10.0	19.2	18.0	10.0	31.5	30.2	10.2	75.2	74.0	28.0
50-59	31	23.9	23.2	9.8	20.0	19.8	9.1	31.5	33.0	9.5	75.5	75.6	26.6
60-69	23	22.3	20.2	9.6	19.5	18.4	9.6	33.4	33.2	9.4	75.1	73.8	27.0
70-75	10	18.5	15.8	9.7	18.9	18.9	10.4	31.9	31.7	10.2	69.3	63.9	28.6
FN													
5-9	3	10.8	11.8	3.8	12.3	13.0	5.1	17.5	18.2	3.3	40.6	45.2	11.6
10-14	9	13.3	11.2	7.7	14.2	10.0	10.2	19.3	15.8	10.6	46.8	37.8	28.1
15-19	6	12.6	11.2	3.7	16.2	11.8	12.7	23.7	19.5	12.2	42.7	42.0	9.0
20-29	16	27.7	31.6	11.4	22.8	26.2	10.9	32.9	32.1	8.0	82.2	86.8	30.0
30-39	10	32.4	34.1	9.4	27.1	27.3	11.2	36.2	37.5	7.4	95.7	98.8	25.7
40-49	12	29.0	28.3	10.3	22.9	22.1	8.8	35.6	36.0	6.7	89.7	85.8	23.5
50-59	5	29.5	29.4	5.5	27.2	26.6	6.6	38.0	39.6	6.2	94.8	95.6	16.9
60-69	7	27.7	25.6	12.7	24.9	27.8	9.3	38.2	40.0	10.6	90.7	87.6	31.3
70-75	1	22.0			31.0			47.2			100.2		

TRUNK: sum of trunk skinfolds (subscapular+suprailiac+abdominal)

TABLE 4.5 Sample sizes, means and standard deviations for skeletal breadths.

Age Group (yrs)	n	Bicondylar (cm)		Biepicondylar (cm)		Biacromial (cm)		Bicristal (cm)		HSR (%)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males											
EA											
5-9	37	7.5	0.8	5.1	0.5	27.9	3.0	20.2	2.3	72.6	3.7
10-14	22	8.9	0.7	6.1	0.6	33.8	3.4	24.6	3.1	72.8	4.2
15-19	16	9.7	6.9	7.1	0.5	41.5	1.9	30.0	1.8	72.3	3.5
20-29	34	9.7	0.7	7.2	3.5	44.0	2.1	30.6	1.8	69.6	3.3
30-39	39	9.9	0.7	7.3	0.4	44.0	2.5	31.8	2.7	72.2	4.1
40-49	45	9.7	0.7	7.2	0.5	43.1	2.4	31.8	2.6	73.5	3.6
50-59	34	9.9	0.7	7.5	0.6	42.7	2.6	33.1	2.9	77.4	5.3
60-69	15	9.9	0.8	7.4	0.6	42.4	2.4	31.9	2.9	75.8	5.4
70-75	12	9.8	0.7	7.4	0.3	41.3	1.9	32.6	2.1	79.0	3.7
FN											
5-9	8	7.6	0.7	5.3	0.3	29.4	2.6	20.6	2.5	69.9	3.5
10-14	6	9.0	0.7	6.3	0.5	33.9	1.7	24.0	2.3	70.6	4.2
15-19	8	9.5	0.8	7.1	0.6	42.0	4.0	29.0	3.7	70.4	4.2
20-29	11	10.1	1.0	7.5	0.4	44.6	3.3	32.1	2.3	72.0	2.9
30-39	10	9.9	0.3	7.2	0.3	43.2	1.7	30.9	2.2	71.4	4.5
40-49	6	10.1	0.8	7.6	0.4	45.1	1.3	34.2	2.2	76.0	5.5
50-59	4	10.0	0.5	7.5	0.4	43.3	2.3	33.0	1.5	76.1	1.6
60-69	4	9.9	0.7	7.4	0.4	42.1	2.4	34.3	1.4	81.4	2.2
70-75	-										
Females											
EA											
5-9	23	7.1	0.7	4.8	0.5	27.6	2.5	20.0	1.9	72.6	3.2
10-14	20	8.4	0.8	5.8	0.3	33.9	3.0	25.2	3.1	74.3	4.0
15-19	16	8.7	1.0	6.1	0.6	37.4	2.0	28.9	3.1	77.2	5.5
20-29	19	9.0	0.7	6.1	0.4	37.7	1.6	29.1	2.1	77.0	4.6
30-39	54	9.1	0.9	6.2	0.4	38.2	2.0	30.4	2.6	79.6	4.8
40-49	40	9.5	1.3	6.5	0.5	38.6	2.4	31.4	3.5	81.0	6.4
50-59	33	9.5	0.9	6.4	0.4	38.0	2.1	32.1	2.8	84.5	5.9
60-69	24	9.4	0.7	6.6	0.5	37.9	1.9	31.9	2.6	83.8	5.7
70-75	10	9.3	0.8	6.5	0.5	38.3	1.6	32.5	2.0	84.9	3.3
FN											
5-9	4	7.3	0.3	5.0	0.2	28.3	1.6	20.9	1.9	73.5	3.5
10-14	9	8.3	0.5	5.7	0.3	34.2	3.5	26.0	2.9	76.1	2.3
15-19	16	8.7	1.0	6.1	0.6	37.4	2.0	28.9	3.1	74.2	6.2
20-29	17	9.5	1.3	6.4	0.4	39.6	2.1	31.4	3.2	79.4	6.3
30-39	12	9.7	0.8	6.5	0.3	39.8	1.7	32.4	2.0	81.4	4.5
40-49	12	9.6	1.0	6.6	0.5	38.6	1.8	32.0	3.0	82.9	5.3
50-59	5	9.8	0.4	6.9	0.1	39.6	1.5	34.5	1.5	87.3	4.4
60-69	7	9.9	1.1	6.9	0.7	40.2	1.4	34.4	2.2	85.5	5.0
70-75	1	9.2		6.3		38.2		34.0		89.0	

HSR: hip / shoulder ratio (bicristal/biacromial x 100)

TABLE 4.6 Sample sizes, means and standard deviations for circumferences and AMA.

Age Group (yrs)	n	Flexed Arm (cm)		Relaxed Arm (cm)		Maximal Calf (cm)		Waist (cm)		Hip (cm)		AMA (cm ²)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males													
EA													
5-9	37	20.2	2.9	19.0	2.8	24.5	3.1	58.4	6.9	65.9	8.0	19.6	3.8
10-14	22	24.3	3.7	22.7	3.6	30.0	3.4	67.5	9.5	80.0	9.1	29.1	7.1
15-19	16	32.3	2.7	29.4	2.8	35.7	2.3	82.9	6.8	97.1	5.4	52.0	9.4
20-29	34	34.6	3.3	31.8	3.5	36.7	3.1	86.2	7.7	99.3	5.6	64.1	14.2
30-39	39	36.6	3.5	33.0	3.5	38.4	3.4	92.5	10.9	102.0	7.4	66.4	12.8
40-49	45	35.5	3.2	32.3	3.2	37.0	3.7	92.9	11.7	100.9	7.2	64.4	11.8
50-59	34	36.2	3.5	33.1	3.3	37.8	2.8	100.1	12.5	104.3	9.0	67.0	12.0
60-69	15	35.3	5.3	31.3	3.2	37.1	4.1	97.2	9.5	101.6	7.3	60.4	10.3
70-75	12	33.6	3.8	30.3	3.5	34.8	3.1	96.3	10.4	101.2	7.3	55.0	10.9
FN													
5-9	8	22.1	4.2	20.3	3.5	25.5	3.2	64.7	10.6	68.7	9.2	20.9	4.6
10-14	6	26.2	2.7	24.3	2.6	30.0	3.3	73.0	7.7	83.0	8.1	29.9	5.4
15-19	8	32.7	7.2	29.4	6.6	34.7	3.6	80.7	11.4	93.2	11.5	44.7	7.5
20-29	11	36.7	4.2	32.7	3.6	37.8	3.1	92.3	11.5	104.0	8.4	63.4	13.0
30-39	10	35.5	2.4	32.3	2.5	36.3	1.5	91.0	2.7	99.8	3.2	66.1	11.6
40-49	6	37.8	3.3	34.7	3.0	37.7	4.3	102.1	11.8	106.1	8.9	72.4	16.8
50-59	4	35.1	3.2	33.0	3.6	36.4	1.0	95.7	3.9	100.1	3.4	68.2	17.6
60-69	19	35.4	5.0	31.5	3.1	36.9	3.9	98.5	9.0	102.0	6.7	61.3	14.2
70-75	-												
Females													
EA													
5-9	23	19.9	2.2	18.8	2.2	24.5	2.5	56.0	4.8	64.8	7.1	17.8	3.3
10-14	20	24.4	3.5	23.1	3.3	30.7	4.1	65.1	10.5	83.0	10.9	27.4	6.0
15-19	16	28.9	4.9	27.3	5.2	34.4	3.9	72.4	10.7	94.8	11.0	37.0	12.3
20-29	19	30.2	4.0	28.7	3.8	35.7	3.4	77.1	9.6	101.9	10.1	35.6	6.0
30-39	53	30.8	3.7	29.2	3.8	35.8	3.1	77.5	10.9	100.6	10.9	38.7	8.1
40-49	40	32.2	4.4	30.9	4.8	35.9	3.9	84.4	14.7	105.5	13.9	40.7	10.4
50-59	33	32.3	4.1	30.0	3.7	35.6	3.3	85.2	13.5	106.1	11.8	38.1	7.1
60-69	24	32.1	4.6	30.2	4.6	35.0	2.6	84.9	11.6	103.6	9.7	40.1	8.7
70-75	10	31.8	6.3	29.5	4.9	34.3	3.1	83.5	11.0	101.3	10.6	39.4	7.1
FN													
5-9	3	22.0	2.3	20.5	1.5	26.2	9.0	63.3	2.4	78.6	14.6	19.5	0.8
10-14	9	24.1	3.0	22.9	3.4	29.8	3.1	67.7	12.4	83.4	11.2	27.1	7.2
15-19	6	28.7	5.6	26.9	5.7	34.1	6.7	72.3	14.1	94.9	16.2	32.1	3.9
20-29	17	32.1	4.3	30.3	4.2	36.7	4.9	87.6	11.8	105.9	12.8	40.8	6.9
30-39	11	34.8	4.0	32.1	3.0	37.5	3.2	92.4	10.7	108.8	8.8	39.4	5.8
40-49	12	34.4	5.4	32.0	5.1	35.5	3.3	89.6	12.2	106.9	13.3	42.2	10.0
50-59	5	33.1	2.2	30.5	2.1	36.2	1.9	95.5	10.3	109.2	9.8	35.2	2.5
60-69	7	34.5	5.6	32.3	5.3	34.9	2.6	97.4	11.0	110.3	10.2	41.8	6.3
70-75	1	28.7		27.8		33.0		105.5		115.5		36.4	

AMA: estimated arm muscle area

TABLE 4.7 Sample sizes, means and standard deviations for Heath-Carter anthropometric somatotype components.

Age Group		<u>Endomorphy</u>		<u>Mesomorphy</u>		<u>Ectomorphy</u>	
(yrs)	n	Mean	SD	Mean	SD	Mean	SD
Males							
EA							
5-9	34	3.2	1.6	4.9	1.0	2.1	1.2
10-14	22	3.0	1.7	4.3	1.3	3.5	1.6
15-19	16	3.3	1.1	4.3	1.2	2.8	1.0
20-29	34	3.7	1.5	4.9	1.6	2.4	1.4
30-39	39	4.7	1.9	6.2	1.4	1.3	1.0
40-49	44	4.5	1.8	5.9	1.6	1.3	1.2
50-59	34	5.3	1.8	6.6	1.4	0.8	0.8
60-69	15	4.9	2.1	6.6	2.3	1.0	1.3
70-75	12	4.5	1.5	6.0	1.6	1.1	1.1
FN							
5-9	8	4.6	2.3	5.0	1.0	1.8	1.2
10-14	6	5.4	1.6	4.9	1.3	2.4	1.5
15-19	7	3.5	2.3	4.3	1.4	3.1	1.5
20-29	11	5.1	1.7	6.2	1.8	1.3	1.2
30-39	10	4.6	1.3	6.0	1.1	1.2	0.9
40-49	6	5.6	1.8	6.6	1.3	0.5	0.4
50-59	4	4.9	1.2	6.3	1.5	0.8	1.1
60-69	4	6.3	1.4	6.2	1.7	0.4	0.6
70-75	-						
Females							
EA							
5-9	22	3.6	1.2	4.3	1.1	2.5	1.2
10-14	9	4.5	1.9	3.3	0.9	3.3	1.8
15-19	15	4.9	1.8	3.8	1.4	2.4	1.5
20-29	19	5.9	2.0	4.6	1.7	1.5	1.3
30-39	44	5.6	1.8	4.5	1.6	1.7	1.2
40-49	34	6.4	1.7	5.0	1.9	1.5	1.2
50-59	31	6.6	1.8	5.4	1.6	1.0	1.1
60-69	23	6.5	1.7	6.0	1.5	0.8	0.8
70-75	10	5.9	1.9	5.7	1.8	1.0	0.6
FN							
5-9	3	4.6	1.0	4.5	0.6	1.6	0.5
10-14	9	4.5	1.9	3.3	0.9	3.3	1.8
15-19	6	5.3	2.2	4.1	2.6	2.3	1.6
20-29	12	6.7	2.3	5.3	2.1	1.2	1.1
30-39	9	8.1	1.7	6.3	1.7	0.5	0.8
40-49	10	7.5	1.4	6.2	1.3	0.4	0.4
50-59	4	7.8	1.2	6.1	0.9	0.3	0.3
60-69	7	7.3	2.3	5.9	2.5	1.0	1.5
70-75	1	7.1		5.3		0.1	

TABLE 4.8 Sample sizes, means and standard deviations for grip strength and trunk flexibility.

Age Group (yrs)	Right Grip (kg)			Left Grip (kg)			Flexibility (cm)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Males									
EA									
5-9	37	13.2	4.2	37	12.3	4.1	35	28.1	4.5
10-14	22	24.9	9.0	22	24.0	7.8	22	23.8	8.6
15-19	16	52.1	8.6	16	50.2	8.5	16	29.5	6.0
20-29	34	60.4	8.2	34	57.4	8.1	34	32.4	6.6
30-39	39	58.9	8.4	39	58.0	8.3	38	31.7	7.6
40-49	45	57.8	9.4	45	55.1	9.5	42	26.7	9.0
50-59	34	53.5	9.6	34	51.3	9.8	34	22.0	7.5
60-69	15	50.2	9.7	15	47.8	9.1	12	23.0	7.0
70-75	12	39.8	6.9	12	39.2	5.2	11	16.8	10.1
FN									
5-9	8	11.9	4.0	8	11.3	4.1	8	26.8	5.5
10-14	6	21.7	5.2	6	20.8	4.3	6	24.3	7.2
15-19	8	49.0	11.7	8	45.3	14.0	8	28.3	6.6
20-29	11	59.0	10.7	11	56.4	10.6	11	29.4	11.2
30-39	9	52.1	5.9	10	49.5	10.6	10	27.9	9.5
40-49	6	49.6	8.9	6	47.9	10.5	6	23.1	12.6
50-59	4	50.6	7.3	4	47.5	9.9	4	19.3	8.8
60-69	4	41.8	7.8	3	31.3	11.9	4	15.1	10.6
70-75	-								
Females									
EA									
5-9	23	11.4	3.4	23	10.8	3.3	21	28.8	5.0
10-14	20	23.0	5.2	20	21.0	4.9	20	28.8	6.7
15-19	15	33.4	7.8	15	30.2	8.4	14	30.6	5.8
20-29	19	32.9	6.6	19	31.1	6.1	19	30.9	7.8
30-39	54	34.8	5.9	54	32.9	6.0	52	32.3	8.4
40-49	39	34.0	5.8	40	31.7	5.6	38	27.1	8.6
50-59	32	30.4	6.6	33	28.5	6.6	32	25.1	9.1
60-69	23	29.2	5.0	22	27.0	6.2	20	27.6	8.7
70-75	10	24.8	4.5	10	24.2	4.8	8	23.3	4.7
FN									
5-9	4	10.8	2.3	4	10.8	2.2	3	30.3	4.5
10-14	9	20.7	6.9	9	19.0	4.7	9	27.9	6.4
15-19	6	33.1	10.0	6	29.1	8.4	6	31.0	6.3
20-29	17	36.1	6.2	17	33.2	5.4	17	30.3	8.7
30-39	12	36.0	7.0	12	34.3	6.7	12	34.5	9.5
40-49	12	33.4	7.9	12	31.0	7.6	12	29.6	6.6
50-59	5	29.4	4.8	5	28.6	3.2	5	29.0	4.2
60-69	7	27.6	3.7	7	23.5	3.9	7	24.2	4.5
70-75	1	16.0		1	14.0		1	9.5	

TABLE 4.9 Sample sizes, means and standard deviations for age and motor fitness in children 5-15 years of age.

Group	Age (yrs)			Sit-ups(n/min)			Standing Long Jump (m)			Flexed Arm Hang (s)			35-meter Dash (s)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Males															
EA	49	9.3	2.6	49	25	11	40	1.42	0.29	39	17.4	14.6	40	7.44	1.07
FN	13	9.5	2.9	13	23	12	13	1.34	0.38	10	8.1	6.3	12	7.37	1.18
Total	62	9.3	2.6	62	25	11	53	1.40	0.31	49	15.5	13.8	52	7.43	1.08
Females															
EA	34	9.8	2.5	34	25	9	31	1.35	0.19	29	12.7	10.3	29	7.43	0.77
FN	13	11.0	2.3	13	24	9	13	1.30	0.23	9	9.9	9.9	13	7.07	0.79
Total	47	10.1	2.5	47	25	9	44	1.34	0.20	38	12.1	10.1	42	7.32	0.79

TABLE 4.10 Anthropometric z-scores^{1,2} and results of t-tests for differences between males and females, and between EA and FN samples.

Group	EA			FN		
	n	Mean	SD	n	Mean	SD
Males						
5-19 yrs						
z-stature	75	0.49	1.05	22	0.98	0.72 *
z-SSR	74	-0.66	1.23	22	-0.73	1.48
z-mass	75	0.68	1.20	21	1.44	1.62 *
z-BMI	75	0.40	1.02	21	0.82	1.33
z-triceps	75	0.45	1.06	21	0.80	1.10
z-subscapular	73	0.44	0.87	21	1.47	1.72 *
z-AMA	75	0.02	0.82	21	0.15	0.87
20-75 yrs						
z-stature	167	0.47	0.92	35	0.42	0.71
z-SSR	167	-0.41	1.03	35	-0.21	1.19
z-mass	166	0.89	1.31	35	1.14	1.13
z-BMI	176	0.52	1.15	35	0.80	0.87
z-triceps	175	0.13	0.81	35	0.31	0.70
z-subscapular	177	0.37	1.10	35	0.75	1.04
z-AMA	175	0.12	1.06	35	0.26	0.70
Females						
5-19 yrs						
z-stature	60	0.65	1.32	19	0.75	1.03
z-SSR	60	-0.54	0.84	18	-0.10	0.96
z-mass	60	0.74	1.76	19	1.11	2.11
z-BMI	60	0.26	1.06	18	0.39	1.05
z-triceps	59	0.21	0.96	17	0.08	0.70 #
z-subscapular	58	0.39	0.94	17	0.54	0.85 #
z-AMA	59	0.11	1.14	17	0.03	0.90
20-75 yrs						
z-stature	170	0.41	0.81	53	0.55	0.86
z-SSR	167	-0.41	1.01	53	-0.38	0.87
z-mass	168	-0.43	1.30 #	53	0.21	1.20 # *
z-BMI	178	0.37	0.98	54	0.99	1.05 *
z-triceps	178	0.05	0.87	51	0.47	1.00 *
z-subscapular	168	0.24	0.84	51	0.98	0.98 *
z-AMA	178	0.08	0.78	51	0.35	0.79 *

*FN and EA samples significantly different at $p \leq 0.05$ #Male and female samples significantly different at different at $p \leq 0.05$ ¹Stature, mass, and SSR were z-standardized using Canadian reference data (Health and Welfare Canada, 1980)²BMI, triceps and subscapular were z-standardized using NHANES II reference data (Najjar and Rowland, 1987)³AMA z-standardized using NHANES I and II reference data for Whites (Frisancho, 1990)

TABLE 4.11 Anthropometric z-scores¹ for FN adults 20-75 yrs standardized using FN reference data from Canada and results of t-tests for differences between males and females.

	Male			Female		
	n	Mean	SD	n	Mean	SD
z-stature	35	0.70	0.93	53	0.98	1.00
z-mass	35	1.38	1.19	53	0.69	1.09 #
z-SSR	35	0.01	1.36	53	-0.37	0.80

#Male and female samples significantly different at different at $p \leq 0.05$

¹Stature, mass, and SSR were z-standardized using FN reference data (Health and Welfare Canada, 1980)

TABLE 4.12 Results of the secular trend regression analysis for stature.

Group	Equation (cm)	S.E. (age)	S.E. (SIL)	r	p
<u>Stature on age</u>					
EA Males	$y = 184.6 - .209 \text{ age}$	.03		.41	<.001 *
EA Females	$y = 166.3 - .098 \text{ age}$	.03		.23	.002 *
FN Males	$y = 179.6 - .097 \text{ age}$	.07		.24	.17
FN Females	$y = 165.9 - .081 \text{ age}$	.05		.21	.13
<u>Stature on age and SIL</u>					
EA Males	$y = 80.3 - .121 \text{ age} + 1.20 \text{ SIL}$	.02	.05	.89	<.001 *
EA Females	$y = 76.3 - .062 \text{ age} + 1.16 \text{ SIL}$	.02	.07	.80	<.001 *
<u>Adjusted Stature on age</u>					
EA Males	$y = 181.7 - .10 \text{ age}$	.04		.21	<.005 *
EA Females	$y = 164.7 - .04 \text{ age}$	.19		.10	.19

*Regression equations significant at $p \leq 0.05$

SIL: subischial length

TABLE 4.13 Results of ANCOVAs for differences in stature, skeletal dimensions, and AMA between EA and FN subjects, with age as the covariate.

Group	EA			FN			F	p
	n	Mean	SD	n	Mean	SD		
Males								
5-19 yrs								
Stature (cm)	75	142.3	25.5	22	150.4	24.0	0.84	.363
SSR (%)	74	52.7	1.9	22	52.2	1.8	0.46	.501
Bicondylar (cm)	75	8.4	1.2	21	8.6	1.1	0.29	.590
Biepicondylar (cm)	75	5.8	0.9	22	6.2	0.9	2.77	.099
Biacromial (cm)	74	32.6	6.1	22	35.2	6.3	5.17	.025 *
Bicristal (cm)	74	23.7	4.6	21	24.4	4.6	0.01	.926
HSR (%)	74	72.6	3.8	21	70.3	3.7	6.34	.014 *
AMA (cm²)	75	29.3	14.0	21	31.4	11.8	0.04	.838
20-75 yrs								
Stature (cm)	179	175.5	7.3	35	175.8	5.6	0.29	.589
SSR (%)	179	52.3	1.5	35	52.6	2.0	0.71	.401
Bicondylar (cm)	177	9.8	0.7	35	10.0	0.7	2.37	.125
Biepicondylar (cm)	179	7.3	0.5	35	7.4	0.4	3.76	.054 *
Biacromial (cm)	178	43.2	2.5	35	43.9	2.5	0.79	.374
Bicristal (cm)	178	31.9	2.6	35	32.5	2.4	3.43	.065
HSR (%)	177	73.8	5.1	35	74.1	4.9	3.03	.083
AMA (cm²)	177	64.3	12.6	35	66.0	13.6	0.30	.582
Females								
5-19 yrs								
Stature (cm)	60	142.1	21.8	19	149.4	17.3	0.79	.378
SSR (%)	60	52.8	1.4	18	53.1	1.5	1.29	.259
Bicondylar (cm)	59	8.0	1.1	18	8.0	0.6	0.09	.767
Biepicondylar (cm)	59	5.5	0.7	19	5.7	0.6	0.91	.344
Biacromial (cm)	59	32.4	4.8	19	34.2	4.6	1.61	.209
Bicristal (cm)	59	24.2	4.5	19	25.7	4.0	0.76	.387
HSR (%)	59	74.4	4.5	19	75.0	4.1	0.04	.846
AMA (cm²)	59	26.2	10.8	17	27.2	7.0	0.25	.619
20-75 yrs								
Stature (cm)	180	161.9	5.9	54	162.8	5.6	0.12	.729
SSR (%)	177	53.0	1.4	54	52.9	1.3	1.16	.282
Bicondylar (cm)	178	9.3	1.0	54	9.6	1.0	7.04	.009 *
Biepicondylar (cm)	180	6.4	4.5	54	6.6	0.5	17.45	<.001 *
Biacromial (cm)	178	38.2	2.0	54	39.5	1.8	16.94	<.001 *
Bicristal (cm)	179	31.1	2.9	54	32.5	2.8	17.72	<.001 *
HSR (%)	177	81.4	5.9	54	82.3	5.9	5.95	.016 *
AMA (cm²)	178	38.9	8.4	51	40.3	7.1	1.71	.193

*EA and FN samples significantly different at $p \leq 0.05$

TABLE 4.14 Results of ANCOVAs for differences in stature, skeletal dimensions, and AMA between males and females, with age as the covariate.

Group	Male			Female			F	p
	n	Mean	SD	n	Mean	SD		
E A								
5-19 yrs								
Stature (cm)	75	142.3	25.5	60	142.1	21.8	5.18	.024 *
SSR (%)	74	52.7	1.9	60	52.8	1.4	0.59	.444
Bicondylar (cm)	75	8.4	1.2	59	8.0	1.1	15.73	<.001 *
Biepicondylar (cm)	75	5.8	0.9	59	5.5	0.7	33.14	<.001 *
Biacromial (cm)	74	32.6	6.1	59	32.4	4.8	5.81	.017 *
Bicristal (cm)	74	23.7	4.6	59	24.2	4.5	0.04	.844
HSR (%)	74	72.6	3.8	59	74.4	4.5	5.82	.017 *
AMA (cm²)	75	29.3	14.0	59	26.2	10.8	13.71	<.001 *
20-75 yrs								
Stature (cm)	179	175.5	7.3	180	161.9	5.9	414.02	<.001 *
SSR (%)	179	52.3	1.5	177	53.0	1.4	21.90	<.001 *
Bicondylar (cm)	177	9.8	0.7	178	9.3	1.0	41.19	<.001 *
Biepicondylar (cm)	179	7.3	0.5	180	6.4	4.5	414.89	<.001 *
Biacromial (cm)	178	43.2	2.5	178	38.2	2.0	451.87	<.001 *
Bicristal (cm)	178	31.9	2.6	179	31.1	2.9	8.82	.003 *
HSR (%)	177	73.8	5.1	177	81.4	5.9	204.45	<.001 *
AMA (cm²)	177	64.3	12.6	178	38.9	8.4	498.59	<.001 *
FN								
5-19 yrs								
Stature (cm)	22	150.4	24.0	19	149.4	17.3	2.31	.137
SSR (%)	22	52.2	1.8	18	53.1	1.5	3.23	.081
Bicondylar (cm)	21	8.6	1.1	18	8.0	0.6	12.08	.001 *
Biepicondylar (cm)	22	6.2	0.9	19	5.7	0.6	17.24	<.001 *
Biacromial (cm)	22	35.2	6.3	19	34.2	4.6	5.60	.023 *
Bicristal (cm)	21	24.4	4.6	19	25.7	4.0	0.54	.465
HSR (%)	21	70.3	3.7	19	75.0	4.1	13.65	.001 *
AMA (cm²)	21	31.4	11.8	17	27.2	7.0	13.15	.001 *
20-75 yrs								
Stature (cm)	35	175.8	5.6	54	162.8	5.6	119.94	<.001 *
SSR (%)	35	52.6	2.0	54	52.9	1.3	0.46	.498
Bicondylar (cm)	35	10.0	0.7	54	9.6	1.0	4.48	.037 *
Biepicondylar (cm)	35	7.4	0.4	54	6.6	0.5	84.51	<.001 *
Biacromial (cm)	35	43.9	2.5	54	39.5	1.8	93.02	<.001 *
Bicristal (cm)	35	32.5	2.4	54	32.5	2.8	0.00	.990
HSR (%)	35	74.1	4.9	54	82.3	5.9	4.48	.037 *
AMA (cm²)	35	66.0	13.6	51	40.3	7.1	130.0	<.001 *

*Male and female samples significantly different at $p \leq 0.05$

TABLE 4.15 Intraclass sibling correlations for stature, skeletal dimensions, circumferences, and AMA.

	EA			FN			TOTAL		
	r_{Intra}	F	p	r_{Intra}	F	p	r_{Intra}	F	p
Stature	.66	2.91	<.001 *	.79	9.88	<.001 *	.53	3.70	<.001 *
Sitting Height	.64	2.76	<.001 *	.51	4.52	<.001 *	.47	3.12	<.001 *
SSR	.48	1.90	.001 *	.35	2.84	.001 *	.33	2.17	<.001 *
SIL	.58	2.38	<.001 *	.60	6.09	<.001 *	.46	3.05	<.001 *
Biacromial	.58	2.39	<.001 *	.33	2.71	.002 *	.43	2.81	<.001 *
Bicristal	.44	1.77	.003 *	.13	1.51	.11	.26	1.86	<.001 *
Bicondylar	.52	2.06	<.001 *	-.08	0.76	.78	.19	1.57	.006 *
Biepicondylar	.60	2.48	<.001 *	.14	1.54	.10	.34	2.36	<.001 *
Flexed Arm C.	.53	2.10	<.001 *	.11	1.44	.14	.30	2.02	<.001 *
Relaxed Arm C.	.54	2.15	<.001 *	.14	1.55	.10	.31	2.09	<.001 *
Maximal Calf C.	.59	2.46	<.001 *	.04	1.14	.35	.29	1.97	<.001 *
Waist C.	.52	2.05	<.001 *	.25	1.59	.09	.36	2.33	<.001 *
Hip C.	.53	2.10	<.001 *	-.02	0.93	.58	.24	1.73	.001 *
AMA	.36	1.54	.02 *	.27	2.27	.008 *	.26	1.83	<.001 *

*Intraclass correlations significant at $p \leq 0.05$

TABLE 4.16 Interclass spousal and parent-offspring correlations for stature, skeletal dimensions, circumferences, and AMA.

	Father-Mother	Father-Son	Father-Daughter	Father-Offspring	Mother-Son	Mother-Daughter	Mother-Offspring
EA							
Number of Pairs	79	85	60	144	105	92	196
Stature	.07	.36 *	.43 *	.38 *	.29 *	.34 *	.31 *
Sitting Height	-.06	.03	.20	.08	.24 *	.39 *	.31 *
SSR	.08	.06	.14	.09	.23 *	.37 *	.29 *
SIL	.09	.38 *	.39 *	.38 *	.33 *	.35 *	.34 *
Biacromial	.04	.11	.15	.13	.30 *	.37 *	.33 *
Bicristal	.28 *	.13	.28 *	.21 *	.19 *	.37 *	.27 *
Bicondylar	.05	.11	.22	.19 *	.38 *	.27 *	.32 *
Biepicondylar	.05	.25 *	.28 *	.28 *	.25 *	.45 *	.34 *
Flexed Arm C.	.10	.21	.36 *	.27 *	.31 *	.36 *	.12
Relaxed Arm C.	.03	.19	.36 *	.26 *	.29 *	.38 *	.33 *
Maximal Calf C.	.05	.03	.38 *	.15	.24 *	.34 *	.29 *
Waist C.	.13	.16	.17	.18 *	.23 *	.30 *	.26 *
Hip C.	.14	.14	.37 *	.25 *	.35 *	.32 *	.32 *
AMA	-.11	.10	.11	.11	.02	.26 *	.14
FN							
Number of Pairs	12	10	18	27	18	29	46
Stature	-.09	.01	.00	.05	-.03	.51 *	.29 *
Sitting Height	.04	.22	.12	.15	-.15	.29	.11
SSR	-.06	.57	.45	.38	.81 *	.53 *	.61 *
SIL	.13	.76 *	.32	.37	.68 *	.65 *	.64 *
Biacromial	.61 *	.56	.62 *	.52 *	.46	.53 *	.49 *
Bicristal	.50	.38	.42	.40 *	.44	.34	.37 *
Bicondylar	.27	-.22	.23	.19	.39	-.02	.11
Biepicondylar	.75 *	.45	.41	.39 *	.23	.23	.23
Flexed Arm C.	-.18	-.17	.34	.07	.07	.28	.21
Relaxed Arm C.	-.20	-.17	.34	.11	.64 *	.26	.43 *
Maximal Calf C.	.26	-.34	.48	.33	.13	.46 *	.39 *
Waist C.	.10	-.12	.48	.24	.25	.33	.32 *
Hip C.	-.06	-.34	.50	.27	.20	.25	.22
AMA	.08	-.02	.26	.17	.42	.31	.35 *
TOTAL							
Number of Pairs	91	94	77	170	122	120	241
Stature	-.01	.16	.35 *	.18 *	.24 *	.37 *	.30 *
Sitting Height	-.05	.05	.18	.09	.20 *	.36 *	.28 *
SSR	.06	.09	.20	.13	.33 *	.40 *	.36 *
SIL	.09	.36 *	.38 *	.37 *	.37 *	.41 *	.38 *
Biacromial	.11	.15	.41 *	.24 *	.33 *	.42 *	.37 *
Bicristal	.30 *	.14	.33 *	.24 *	.22 *	.38 *	.30 *
Bicondylar	.07	.10	.24 *	.18 *	.39 *	.23 *	.29 *
Biepicondylar	.11	.25 *	.33 *	.29 *	.26 *	.42 *	.34 *
Flexed Arm C.	.07	.14	.37 *	.23 *	.29 *	.34 *	.31 *
Relaxed Arm C.	.00	.13	.38 *	.23 *	.35 *	.36 *	.35 *
Maximal Calf C.	.07	.01	.43 *	.17 *	.23 *	.37 *	.30 *
Waist C.	.13	.11	.28 *	.18 *	.23 *	.37 *	.31 *
Hip C.	.12	.08	.42 *	.25 *	.34 *	.30 *	.30 *
AMA	-.10	.09	.22	.14	.07	.27 *	.17 *

*Correlations significant at $p \leq 0.05$

TABLE 4.17 Heritability estimates for stature, skeletal dimensions, circumferences and AMA based on regression analyses of offspring on mid-parent values.

	n	h ²	S.E.	t	Significance
E A					
Stature	138	.68	.14	5.04	<.001 *
Sitting Height	133	.34	.12	2.83	.005 *
SSR	132	.38	.11	3.43	<.001 *
SIL	133	.62	.09	6.83	<.001 *
Biacromial	134	.29	.09	3.05	.003 *
Bicristal	134	.25	.08	2.99	.003 *
Bicondylar	134	.27	.08	3.20	.002 *
Blepicondylar	136	.38	.09	4.05	<.001 *
Flexed Arm C.	136	.99	.08	13.05	<.001 *
Relaxed Arm C.	135	.36	.08	4.38	<.001 *
Maximal Calf C.	126	.33	.11	3.16	.002 *
Waist C.	133	.25	.08	3.09	.003 *
Hip C.	132	.35	.08	4.45	<.001 *
AMA	132	.08	.08	0.88	.38
FN					
Stature	17	.04	.13	0.35	.73
Sitting Height	15	.25	.30	.82	.42
SSR	15	.47	.31	1.53	.15
SIL	15	.37	.29	1.27	.22
Biacromial	16	.64	.19	3.38	.004 *
Bicristal	15	.64	.32	2.03	.06
Bicondylar	15	.08	.58	.13	.90
Blepicondylar	16	.25	.29	.85	.41
Flexed Arm C.	13	.23	.44	0.52	.61
Relaxed Arm C.	14	1.13	.45	2.49	.03 *
Maximal Calf C.	13	.38	.42	0.90	.38
Waist C.	13	.56	.35	1.60	.14
Hip C.	13	.86	.47	1.83	.09
AMA	12	.10	.35	0.28	.79
TOTAL					
Stature	155	.40	.10	4.00	<.001 *
Sitting Height	150	.32	.11	2.92	.004 *
SSR	149	.39	.11	3.67	<.001 *
SIL	150	.59	.09	6.71	<.001 *
Biacromial	152	.37	.09	4.27	<.001 *
Bicristal	151	.29	.08	3.62	<.001 *
Bicondylar	151	.25	.09	2.92	.004 *
Blepicondylar	154	.36	.09	4.07	<.001 *
Flexed Arm C.	149	.35	.08	4.45	<.001 *
Relaxed Arm C.	151	.42	.08	4.94	<.001 *
Maximal Calf C.	142	.34	.10	3.37	.001 *
Waist C.	148	.27	.08	3.43	<.001 *
Hip C.	147	.38	.08	4.77	<.001 *
AMA	146	.08	.09	0.92	.36

*Regressions significant at $p \leq 0.05$

TABLE 4.18 Results of ANCOVAs for differences in body mass, fatness, and relative fat distribution between EA and FN subjects, with age as the covariate.

Group	EA			FN			F	p
	n	Mean	SD	n	Mean	SD		
Males								
5-19 yrs								
Body Mass (kg)	75	40.6	21.0	21	46.9	21.0	3.39	.069
BMI (kg/m ²)	75	18.5	3.6	21	20.1	4.0	2.62	.109
TRUNK (mm)	73	30.4	20.6	21	48.1	28.8	10.96	.001 *
EXTREMITY (mm)	73	26.1	11.9	21	31.8	11.9	4.43	.038 *
SUM (mm)	73	57.3	32.3	21	79.8	40.3	7.77	.006 *
TER (mm/mm)	73	1.08	0.38	21	1.42	0.36	17.05	<.001 *
WHR (cm/cm)	75	0.87	0.06	21	0.90	0.05	7.28	.008 *
20-75 yrs								
Body Mass (kg)	178	83.6	15.5	35	87.2	13.6	2.28	.132
BMI (kg/m ²)	178	27.2	4.7	35	28.2	3.8	3.65	.057
TRUNK (mm)	178	63.1	26.0	35	71.9	23.8	3.18	.076
EXTREMITY (mm)	175	27.7	11.6	35	30.3	10.4	5.54	.019 *
SUM (mm)	178	91.7	38.2	35	102.1	32.6	3.45	.065
TER (mm/mm)	179	2.26	0.58	35	2.43	0.60	3.79	.053 *
WHR (cm/cm)	177	0.92	0.06	35	0.93	0.05	7.25	.008 *
Females								
5-19 yrs								
Body Mass (kg)	60	40.5	20.3	19	47.2	21.7	1.41	.240
BMI (kg/m ²)	60	18.7	4.3	18	19.3	3.4	0.13	.725
TRUNK (mm)	57	37.2	24.3	17	44.5	21.0	1.95	.167
EXTREMITY (mm)	58	36.3	16.4	17	35.7	11.2	0.03	.871
SUM (mm)	57	73.4	39.7	17	80.2	31.1	0.53	.467
TER (mm/mm)	57	0.98	0.29	17	1.22	0.26	8.15	.006 *
WHR (cm/cm)	59	0.81	0.08	18	0.79	0.07	0.01	.917
20-75 yrs								
Body Mass (kg)	178	68.5	15.2	54	75.7	14.5	11.39	.001 *
BMI (kg/m ²)	178	26.1	5.5	54	28.6	5.4	11.98	.001 *
TRUNK (mm)	168	69.1	28.4	46	90.0	25.7	3.77	.053 *
EXTREMITY (mm)	177	57.3	21.0	49	63.6	22.6	23.80	<.001 *
SUM (mm)	166	126.0	47.3	45	152.5	45.6	13.84	<.001 *
TER (mm/mm)	168	1.23	0.36	45	1.47	0.35	21.55	<.001 *
WHR (cm/cm)	178	0.79	0.06	53	0.85	0.05	62.99	<.001 *

*EA and FN samples significantly different at $p \leq 0.05$

TABLE 4.19 Results of ANCOVAs for differences in body mass, fatness, and relative fat distribution between males and females, with age as the covariate.

Group	Male			Female			F	p
	n	Mean	SD	n	Mean	SD		
E A								
5-19 yrs								
Body Mass (kg)	75	40.6	21.0	60	40.5	20.3	2.06	.153
BMI (kg/m ²)	75	18.5	3.6	60	18.7	4.3	0.24	.628
TRUNK (mm)	73	30.4	20.6	57	37.2	24.3	3.75	.055
EXTREMITY (mm)	73	26.1	11.9	58	36.3	16.4	20.84	<.001 *
SUM (mm)	73	57.3	32.3	57	73.4	39.7	8.79	.004 *
TER (mm/mm)	73	1.08	0.38	57	0.98	0.29	6.63	.011 *
WHR (cm/cm)	75	0.87	0.06	59	0.81	0.08	24.96	<.001 *
20-75 yrs								
Body Mass (kg)	178	83.6	15.5	178	68.5	15.2	101.71	<.001 *
BMI (kg/m ²)	178	27.2	4.7	178	26.1	5.5	7.44	.007 *
TRUNK (mm)	178	63.1	26.0	168	69.1	28.4	3.75	.054 *
EXTREMITY (mm)	175	27.7	11.6	177	57.3	21.0	312.83	<.001 *
SUM (mm)	178	91.7	38.2	166	126.0	47.3	54.50	<.001 *
TER (mm/mm)	179	2.26	0.58	168	1.23	0.36	503.67	<.001 *
WHR (cm/cm)	177	0.92	0.06	178	0.79	0.06	558.13	<.001 *
FN								
5-19 yrs								
Body Mass (kg)	21	46.9	21.0	19	47.2	21.7	0.56	.459
BMI (kg/m ²)	21	20.1	4.0	18	19.3	3.4	0.87	.357
TRUNK (mm)	21	48.1	28.8	17	44.5	21.0	0.03	.868
EXTREMITY (mm)	21	31.8	11.9	17	35.7	11.2	1.26	.269
SUM (mm)	21	79.8	40.3	17	80.2	31.1	0.07	.790
TER (mm/mm)	21	1.42	0.36	17	1.22	0.26	4.66	.038 *
WHR (cm/cm)	21	0.90	0.05	18	0.79	0.07	28.17	<.001 *
20-75 yrs								
Body Mass (kg)	35	87.2	13.6	54	75.7	14.5	15.25	<.001 *
BMI (kg/m ²)	35	28.2	3.8	54	28.6	5.4	0.03	.855
TRUNK (mm)	35	71.9	23.8	46	90.0	25.7	76.00	<.001 *
EXTREMITY (mm)	35	30.3	10.4	49	63.6	22.6	10.02	.002 *
SUM (mm)	35	102.1	32.6	45	152.5	45.6	29.79	<.001 *
TER (mm/mm)	35	2.43	0.60	45	1.47	0.35	90.43	<.001 *
WHR (cm/cm)	35	0.93	0.05	53	0.85	0.05	61.18	<.001 *

*Male and female samples significantly different at $p \leq 0.05$

TABLE 4.20 Intraclass sibling correlations for fatness, and relative fat distribution.

	EA			FN			TOTAL		
	r_{res}	F	p	r_{res}	F	p	r_{res}	F	p
Body Mass	.57	2.29	<.001 *	.05	1.14	.346	.29	2.00	<.001 *
BMI	.52	2.11	<.001 *	.06	1.16	.324	.28	1.94	<.001 *
SUM	.46	1.82	.003 *	.05	1.11	.375	.23	1.73	.001 *
TRUNK	.46	1.82	.003 *	.16	1.52	.113	.29	2.01	<.001 *
EXTREMITY	.40	1.66	.008 *	-.11	0.76	.779	.13	1.34	.052 *
TER	.57	2.35	<.001 *	.25	1.81	.046 *	.38	2.51	<.001 *
WHR	.42	1.70	.006 *	.50	3.36	<.001 *	.37	2.42	<.001 *

*Intraclass correlations significant at $p \leq 0.05$ **TABLE 4.21 Interclass spousal and parent-offspring for fatness and relative fat distribution.**

	Father-Mother	Father-Son	Father-Daughter	Father-Offspring	Mother-Son	Mother-Daughter	Mother-Offspring
EA							
Number of Pairs	79	85	60	144	105	92	196
Body Mass	.08	.15	.38 *	.25 *	.36 *	.39 *	.37 *
BMI	.01	.23 *	.36 *	.29 *	.34 *	.34 *	.34 *
SUM	.07	.24 *	.25	.25 *	.41 *	.32 *	.36 *
TRUNK	.10	.21	.22	.22 *	.38 *	.29 *	.33 *
EXTREMITY	.09	.32 *	.22	.28 *	.43 *	.30 *	.35 *
TER	.14	.33 *	.04	.23 *	.21 *	.15	.20 *
WHR	.16	.08	-.14	.00	.10	.14	.12
FN							
Number of Pairs	12	10	18	27	18	29	46
Body Mass	.06	-.22	.53 *	.15	.19	.36	.28
BMI	-.04	-.20	.41	.06	.25	.09	.15
SUM	-.10	-.46	.08	-.19	-.01	.22	.16
TRUNK	-.08	-.36	-.23	-.28	-.01	.27	.20
EXTREMITY	-.09	-.55	.57 *	.17	.28	.18	.18
TER	-.04	.00	-.22	-.06	.26	.10	.18
WHR	-.18	-.10	.00	-.05	.52 *	.27	.35 *
TOTAL							
Number of Pairs	91	94	77	170	122	120	241
Body Mass	.09	.10	.45 *	.24 *	.34 *	.39 *	.36 *
BMI	.01	.15	.40 *	.24 *	.33 *	.31 *	.31 *
SUM	.05	.17	.22	.19 *	.37 *	.32 *	.34 *
TRUNK	.08	.13	.14	.14	.33 *	.33 *	.33 *
EXTREMITY	.06	.25 *	.27 *	.25 *	.42 *	.27 *	.32 *
TER	.12	.27 *	.00	.18 *	.21 *	.23 *	.21 *
WHR	.11	.06	-.06	.03	.16	.30 *	.24 *

*Correlations significant at $p \leq 0.05$

TABLE 4.22 Heritability estimates based on regression analyses of offspring on mid-parent values for fatness and relative fat distribution.

	n	h ²	S.E.	t	Significance
E A					
Body Mass	138	.32	.11	3.03	.003 *
BMI	137	.41	.08	4.91	<.001 *
SUM	120	.45	.10	4.44	<.001 *
TRUNK	121	.36	.09	3.94	<.001 *
EXTREMITY	131	.45	.09	4.95	<.001 *
TER	122	.30	.11	2.78	.007 *
WHR	134	.19	.14	1.32	.135
F N					
Body Mass	16	.11	.22	0.48	.639
BMI	16	.16	.26	0.61	.554
SUM	13	.01	.46	0.02	.983
TRUNK	13	.06	.38	-0.16	.879
EXTREMITY	13	.25	.53	0.47	.649
TER	13	.20	.19	1.03	.325
WHR	14	.04	.16	0.22	.829
TOTAL					
Body Mass	154	.26	.09	2.80	.006 *
BMI	153	.35	.08	4.50	<.001 *
SUM	133	.42	.10	4.28	<.001 *
TRUNK	134	.33	.09	3.76	<.001 *
EXTREMITY	144	.44	.09	4.82	<.001 *
TER	135	.25	.09	2.75	.007 *
WHR	148	.16	.11	1.50	.135

*Regressions significant at $p \leq 0.05$

TABLE 4.23 Prevalance of obesity.

		TSF and BMI Independently				TSF and BMI in combination					
		TSF ¹		BMI ²		TSF only		BMI only		TSF + BMI	
	N	n	%	n	%	n	%	n	%	n	%
5-19 yrs											
<u>Males</u>											
EA	75	17	22.7	16	21.3	3	4.0	2	2.7	14	18.7
FN	21	6	28.6	8	38.1	1	4.8	3	14.3	5	23.8
<u>Females</u>											
EA	59	11	18.6	10	16.9	5	8.5	4	6.8	6	10.2
FN	17	2	11.8	5	29.4	0	0.0	3	17.6	2	11.8
20-75 yrs											
<u>Males</u>											
EA	177	25	14.1	69	39.0	2	1.1	46	26.0	23	13.0
FN	35	6	17.1	18	51.4	2	5.7	14	40.0	4	11.4
<u>Females</u>											
EA	177	53	29.9	62	35.0	7	4.0	16	9.0	46	26.0
FN	51	24	47.1*	30	58.8*	2	3.9	8	15.7	22	43.1*

*EA and FN groups significantly different in estimated prevalence at $p \leq 0.05$ (chi square)

¹TSF Obese defined as ≥ 85 th percentile NHANES II age- and sex-specific reference data in 5-19 yr old groups, and ≥ 85 th percentile NHANES II for 18-24 yr old people: TSF ≥ 17.5 mm in males and TSF ≥ 29.5 mm in females in the 20-75 yr old groups

²BMI Obese defined as ≥ 85 th percentile NHANES II age- and sex-specific reference data in the 5-19 yr old groups and ≥ 85 th percentile NHANES II for 20-29 yr old people: BMI ≥ 27.8 in males and BMI ≥ 27.3 in females in the 20-75 yr old groups

TABLE 4.24 Differences between adult subjects classified as obese by different criteria.

	<u>BMI Only</u>		<u>BMI + TSF Obese</u>			
	Mean	SD	Mean	SD	F	p
EA MALES						
n	46		23			
Age, yrs	48.8	12.8	48.9	13.1	0.01	.970
Bicondylar Breadth, cm	10.2	0.6	10.6	0.6	6.69	.012 *
Biepicondylar Breadth, cm	7.5	0.4	7.7	0.5	4.02	.049 *
AMA, cm ²	73.7	12.1	67.0	13.4	5.06	.028 *
WHR, cm/cm	0.94	0.04	0.97	0.05	9.18	.004 *
TER, mm/mm	2.55	0.59	1.97	0.32	20.94	<.001 *
Endomorphy	5.4	1.0	7.2	1.1	50.12	<.001 *
Mesomorphy	7.1	0.9	7.7	1.0	5.52	.022 *
Ectomorphy	0.4	0.3	0.2	0.2	6.25	.015 *
Overall Somatotype	--	--	--	--	16.44	<.001 *
EA FEMALES						
n	16		46			
Age, yrs	49.0	11.7	46.0	13.2	0.62	.433
Bicondylar Breadth, cm	9.7	0.9	10.3	1.0	5.23	.026 *
Biepicondylar Breadth, cm	6.6	0.4	6.8	0.5	3.49	.067
AMA, cm ²	43.7	9.0	45.7	8.9	0.63	.430
WHR, cm/cm	0.82	0.05	0.81	0.05	0.10	.758
TER, mm/mm	1.34	0.26	1.24	0.19	2.30	.135
Endomorphy	7.2	1.2	8.5	0.8	22.36	<.001 *
Mesomorphy	6.4	1.4	7.2	1.4	4.80	.033 *
Ectomorphy	0.2	0.1	0.1	0.1	6.33	.015 *
Overall Somatotype	--	--	--	--	7.58	<.001 *
FN MALES						
n	14		4			
Age, yrs	44.1	13.9	41.2	15.9	0.13	.719
Bicondylar Breadth, cm	10.2	0.5	10.8	0.8	2.79	.116
Biepicondylar Breadth, cm	7.5	0.5	7.8	0.4	0.93	.349
AMA, cm ²	75.1	12.8	67.5	14.3	1.07	.318
WHR, cm/cm	0.95	0.04	0.96	0.07	0.42	.526
TER, mm/mm	2.80	0.40	2.05	0.27	14.92	.002 *
Endomorphy	5.5	1.1	7.3	1.1	0.43	.520
Mesomorphy	7.2	1.1	7.4	1.0	2.08	.170
Ectomorphy	0.3	0.3	0.3	0.3	0.14	.712
Overall Somatotype	--	--	--	--	2.28	.127
FN FEMALES						
n	8		22			
Age, yrs	37.0	15.9	44.1	14.4	1.38	.250
Bicondylar Breadth, cm	9.7	0.7	10.2	1.0	1.80	.191
Biepicondylar Breadth, cm	6.6	0.4	6.8	0.4	1.33	.259
AMA, cm ²	43.2	4.1	41.4	6.9	0.30	.589
WHR, cm/cm	0.85	0.03	0.86	0.05	0.00	.976
TER, mm/mm	1.63	0.43	1.31	0.18	7.15	.013 *
Endomorphy	7.8	0.6	8.8	0.7	12.18	.002 *
Mesomorphy	6.3	1.1	7.1	1.4	2.12	.159
Ectomorphy	0.1	0.1	0.1	0.1	0.02	.904
Overall Somatotype	--	--	--	--	3.93	.024 *

*p≤0.05

TABLE 4.25 Results of MANCOVAs and univariate F-tests for Heath-Carter anthropometric somatotype components between EA and FN subjects, with age as the covariate.

Group	n	Age (years)		Endomorphy		Mesomorphy		Ectomorphy		Wilks's		p
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	λ	F	
Males												
5-19 yrs												
EA	72	10.7	4.1	3.2	1.5	4.6	1.1	2.7	1.4			
FN	21	11.4	4.6	4.5	2.2	4.7	1.2	2.4	1.4	.85	5.30	.002 *
Univariate F				8.84		0.47		1.14				
p				.004 *		.493		.289				
20-75 yrs												
EA	57	11.2	4.1	4.6	1.8	6.0	1.7	1.4	1.2			
FN	35	38.6	13.5	5.2	1.5	6.2	1.4	1.0	0.9	.96	2.82	.040 *
Univariate F				5.13		1.83		6.15				
p				.025 *		.178		.014 *				
Females												
5-19 yrs												
EA	57	11.2	4.1	4.1	1.6	4.0	1.2	2.7	1.4			
FN	18	12.6	3.4	4.8	1.9	3.7	1.6	2.7	1.7	.91	2.18	.098
Univariate F				1.49		0.50		0.01				
p				.225		.481		.927				
20-75 yrs												
EA	161	45.4	14.3	6.1	1.8	5.1	1.7	1.3	1.2			
FN	43	40.3	15.3	7.4	1.9	5.9	1.8	0.7	1.0	.91	6.19	<.001 *
Univariate F				17.71		10.76		16.51				
p				<.001 *		.001 *		<.001 *				

*EA and FN groups significantly different at $p \leq 0.05$

TABLE 4.26 Summary of forward stepwise discriminant function analyses for the pairwise comparisons in the analysis of somatotype differences between EA and FN subjects: Entries show the component entered on each step and the F-value to enter.

Group	Step 1	Step 2	Step 3
Males			
5-19 yrs	Endomorphy (8.92)	Ectomorphy (6.53)	Mesomorphy (0.15)
20-75 yrs	Endomorphy (3.17)	Mesomorphy (1.67)	Ectomorphy (1.12)
Females			
5-19 yrs	Endomorphy (2.44)	Mesomorphy (5.58)	Ectomorphy (<0.00)
20-75 yrs	Endomorphy (15.48)	Ectomorphy (0.33)	Mesomorphy (0.54)

TABLE 4.27 Results of MANCOVAs and univariate F-tests for Heath-Carter anthropometric somatotype components between males and females, with age as the covariate.

Group	n	Age (years)		Endomorphy		Mesomorphy		Ectomorphy		Wilk's		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	λ	F	p
EA												
5-19 yrs												
Males	72	10.7	4.1	3.2	1.5	4.6	1.1	2.7	1.4			
Females	57	11.2	4.1	4.1	1.6	4.0	1.2	2.7	1.4	.62	25.79	<.001 *
Univariate F				14.96		8.91		0.03				
p				<.001 *		.003 *		.859				
20-75 yrs												
Males	57	11.2	4.1	4.6	1.8	6.0	1.7	1.4	1.2			
Females	161	45.4	14.3	6.1	1.8	5.1	1.7	1.3	1.2	.56	89.14	<.001 *
Univariate F				58.65		28.34		0.15				
p				<.001 *		<.001 *		.700				
FN												
5-19 yrs												
Males	21	11.4	4.6	4.5	2.2	4.7	1.2	2.4	1.4			
Females	18	12.6	3.4	4.8	1.9	3.7	1.6	2.7	1.7	.67	5.46	.004 *
Univariate F				0.74		5.81		0.13				
p				.396		.021 *		.724				
20-75 yrs												
Males	35	38.6	13.5	5.2	1.5	6.2	1.4	1.0	0.9			
Females	43	40.3	15.3	7.4	1.9	5.9	1.8	0.7	1.0	.54	20.40	<.001 *
Univariate F				30.57		0.95		3.14				
p				<.001 *		.332		.080				

*Male and female groups significantly different at $p \leq 0.05$

TABLE 4.28 Summary of forward stepwise discriminant function analyses for the pairwise comparisons in the analysis of somatotype differences between males and females: Entries show the component entered on each step and the F-value to enter.

Group	Step 1	Step 2	Step 3
EA			
5-19 yrs	Endomorphy (15.70)	Mesomorphy (45.44)	Ectomorphy (0.53)
20-75 yrs	Endomorphy (59.57)	Mesomorphy (173.85)	Ectomorphy (0.06)
FN			
5-19 yrs	Mesomorphy (6.89)	Endomorphy (9.05)	Ectomorphy (0.79)
20-75 yrs	Endomorphy (31.16)	Mesomorphy (23.00)	Ectomorphy (0.04)

TABLE 4.29 Intraclass sibling correlations for somatotype components.

	EA			FN			TOTAL		
	r_{Intra}	F	p	r_{Intra}	F	p	r_{Intra}	F	p
Endomorphy	.07	1.07	.374	.15	1.42	.158	.07	1.19	.171
Mesomorphy	.57	2.34	<.001 *	.13	1.36	.190	.29	2.01	<.001 *
Ectomorphy	.55	2.22	<.001 *	.18	1.52	.119	.27	1.88	<.001 *

*Intraclass correlations significant at $p \leq 0.05$ **TABLE 4.30 Interclass spousal and parent-offspring correlations for somatotype components.**

	Father-Mother	Father-Son	Father-Daughter	Father-Offspring	Mother-Son	Mother-Daughter	Mother-Offspring
EA							
Number of Pairs	70	83	58	140	87	77	163
Endomorphy	.12	.21	.07	.16	.25 *	.24 *	.25 *
Mesomorphy	.09	.20	.25	.24 *	.12	.26 *	.19
Ectomorphy	.04	.11	.49 *	.26 *	-.03	.29 *	.11
FN							
Number of Pairs	11	9	13	21	13	22	34
Endomorphy	.33	-.34	-.24	-.22	.38	.44 *	.39 *
Mesomorphy	.23	-.05	.25	.08	.57	.15	.24
Ectomorphy	-.25	-.29	.30	.24	.32	.25	.27
TOTAL							
Number of Pairs	80	91	70	160	99	98	196
Endomorphy	.14	.15	.02	.10	.27 *	.29 *	.27 *
Mesomorphy	.08	.15	.23	.19 *	.16	.22 *	.20 *
Ectomorphy	.02	.12	.45 *	.24 *	.00	.27 *	.13

*Correlations significant at $p \leq 0.05$ **TABLE 4.31 Heritability estimates based on regression analyses of offspring on mid-parent values for components of somatotype.**

	n	h^2	S.E.	t	Significance
EA					
Endomorphy	114	.27	.12	2.24	.027 *
Mesomorphy	114	.34	.10	3.42	.001 *
Ectomorphy	114	.20	.12	1.69	.095
FN					
Endomorphy	13	.13	.31	0.43	.673
Mesomorphy	13	-.06	.29	-0.21	.834
Ectomorphy	13	.19	.34	0.56	.586
TOTAL					
Endomorphy	127	.26	.11	2.32	.022 *
Mesomorphy	127	.24	.09	2.55	.012 *
Ectomorphy	127	.18	.11	1.60	.111

*Regressions significant at $p \leq 0.05$

TABLE 4.32 Results of ANCOVAs for differences in grip strength, trunk flexibility, and motor performance between EA and FN subjects, with age as the covariate.

Group	EA			FN			F	p
	n	Mean	SD	n	Mean	SD		
Males								
5-19 yrs								
Right Grip (kg)	75	24.9	16.6	22	28.1	18.3	1.06	.307
Left Grip (kg)	75	23.8	16.0	22	26.2	17.5	1.89	.172
Flexibility (cm)	73	27.1	6.6	22	26.7	6.3	0.09	.772
Situps (#/min)	49	25	11	13	23	12	0.66	.420
Arm Hang (sec)	39	17.4	14.6	10	8.1	6.3	2.84	.098
Long Jump (m)	40	1.42	0.29	13	1.34	0.38	0.80	.374
35-meter Dash (sec)	40	7.44	1.07	12	7.37	1.18	1.13	.294
20-75 yrs								
Right Grip (kg)	179	55.9	10.25	34	52.5	9.8	9.12	.003 *
Left Grip (kg)	179	53.8	10.0	34	49.6	12.1	12.70	<.001 *
Flexibility (cm)	171	27.1	9.2	35	25.1	11.2	5.51	.020 *
Females								
5-19 yrs								
Right Grip (kg)	58	21.1	10.3	19	22.5	10.9	0.76	.387
Left Grip (kg)	58	19.3	9.5	19	20.4	8.8	0.17	.681
Flexibility (cm)	55	29.2	5.8	18	29.3	6.0	0.02	.902
Situps (#/min)	34	9.8	2.5	13	11.0	2.3	2.91	.095
Arm Hang (sec)	29	12.7	10.3	9	9.9	9.9	1.22	.276
Long Jump (m)	31	1.35	0.19	13	1.30	0.23	2.32	.135
35-meter Dash (sec)	29	7.43	0.77	13	7.07	0.79	0.91	.345
20-75 yrs								
Right Grip (kg)	177	32.3	6.5	54	33.4	7.3	0.01	.945
Left Grip (kg)	178	30.4	6.5	54	30.9	7.1	0.36	.550
Flexibility (cm)	169	28.6	8.8	54	29.8	8.5	0.01	.913

*EA and FN samples significantly different at $p \leq 0.05$

TABLE 4.33 Results of ANCOVAs for differences in grip strength, trunk flexibility, and motor performance between males and females, with age as the covariate.

Group	Male			Female			F	p
	n	Mean	SD	n	Mean	SD		
E A								
5-19 yrs								
Right Grip (kg)	75	24.9	16.6	58	21.1	10.3	17.06	<.001 *
Left Grip (kg)	75	23.8	16.0	58	19.3	9.5	20.65	<.001 *
Flexibility (cm)	73	27.1	6.6	55	29.2	5.8	3.38	.069
Situps (#/min)	49	25	11	34	9.8	2.5	0.60	.439
Arm Hang (sec)	39	17.4	14.6	29	12.7	10.3	1.49	.227
Long Jump (m)	40	1.42	0.29	31	1.35	0.19	3.04	.085
35-meter Dash (sec)	40	7.44	1.07	29	7.43	0.77	0.52	.473
20-75 yrs								
Right Grip (kg)	179	55.9	10.25	177	32.3	6.5	795.13	<.001 *
Left Grip (kg)	179	53.8	10.0	178	30.4	6.5	800.61	<.001 *
Flexibility (cm)	171	27.1	9.2	169	28.6	8.8	3.76	.053 *
FN								
5-19 yrs								
Right Grip (kg)	22	28.1	18.3	19	22.5	10.9	5.43	.025 *
Left Grip (kg)	22	26.2	17.5	19	20.4	8.8	7.30	.010 *
Flexibility (cm)	22	26.7	6.3	18	29.3	6.0	1.69	.202
Situps (#/min)	13	23	12	13	11.0	2.3	0.95	.341
Arm Hang (sec)	10	8.1	6.3	9	9.9	9.9	0.00	.950
Long Jump (m)	13	1.34	0.38	13	1.30	0.23	3.83	.062
35-meter Dash (sec)	12	7.37	1.18	13	7.07	0.79	0.54	.471
20-75 yrs								
Right Grip (kg)	34	52.5	9.8	54	33.4	7.3	136.91	<.001 *
Left Grip (kg)	34	49.6	12.1	54	30.9	7.1	99.91	<.001 *
Flexibility (cm)	35	25.1	11.2	54	29.8	8.5	5.96	.017 *

*Male and female samples significantly different at $p \leq 0.05$

TABLE 4.34 Intraclass sibling correlations for grip strength and trunk flexibility.

	EA			FN			TOTAL		
	r_{Intra}	F	p	r_{Intra}	F	p	r_{Intra}	F	p
Right Grip	.36	1.55	.019 *	.30	1.99	.021 *	.28	1.95	<.001 *
Left Grip	.49	1.95	<.001 *	.26	1.82	.037 *	.25	1.81	<.001 *
Flexibility	.16	1.19	.207	.27	1.88	.030 *	.15	1.40	.031 *

*Intraclass correlations significant at $p \leq 0.05$

TABLE 4.35 Interclass spousal and parent-offspring correlations for grip strength and trunk flexibility.

	Father-Mother	Father-Son	Father-Daughter	Father-Offspring	Mother-Son	Mother-Daughter	Mother-Offspring
EA							
Number of Pairs	79	75	60	144	95	89	191
Right Grip	-.09	.26 *	.15	.23 *	-.06	.23 *	.07
Left Grip	-.05	.28 *	.45 *	.35 *	.09	.10	.09
Flexibility	.00	.39 *	.04	.23 *	.25 *	.41 *	.32 *
FN							
Number of Pairs	12	10	18	27	18	29	46
Right Grip	.30	.29	.44	.36	.20	.46 *	.35 *
Left Grip	.48	.23	.57 *	.36	.43	.47 *	.42 *
Flexibility	-.04	-.25	.40	.19	.06	-.04	-.01
TOTAL							
Number of Pairs	90	84	77	170	111	117	236
Right Grip	-.05	.27 *	.24 *	.26 *	.00	.28 *	.14 *
Left Grip	.03	.26 *	.48 *	.35 *	.18 *	.20 *	.19 *
Flexibility	.00	.31 *	.15	.23 *	.23 *	.32 *	.27 *

*Correlations significant at $p \leq 0.05$

TABLE 4.36 Heritability estimates for grip strength and trunk flexibility based on regression analyses of offspring on mid-parent values.

	n	h^2	S.E.	t	Significance
EA					
Right Grip	135	.28	.11	2.46	.001 *
Left Grip	135	.29	.10	2.96	<.001 *
Flexibility	117	.49	.10	4.95	<.001 *
FN					
Right Grip	17	.62	.26	2.38	.015 *
Left Grip	17	.57	.24	2.40	.004 *
Flexibility	14	.38	.38	1.00	<.001 *
TOTAL					
Right Grip	152	.34	.10	3.35	.031 *
Left Grip	152	.36	.09	4.00	.030 *
Flexibility	131	.49	.10	4.98	<.001 *

*Regressions significant at $p \leq 0.05$

TABLE 4.37 First-order partial correlations between body size and fitness, and grip strength, flexibility, and performance variables, controlling for age.

Group	n	Right Grip	Left Grip	Flexibility	n	Sit-ups	Standing Long Jump	Flexed Arm Arm Hang	35-meter Dash**
Males									
5-19 yrs									
Stature	91	.52*	.47*	-.22*	47	-.12	.25	-.32*	.20
Mass	91	.53*	.51*	-.16	47	-.14	.13	-.42*	.21
BMI	91	.32*	.33*	-.05	47	-.12	.02	-.34*	.14
SUM	91	.16	.19	-.12	47	-.28	-.32*	-.43*	.00
TER	91	.19	.14	.02	47	-.07	-.06	-.32*	.35*
WHR	91	-.15	-.16	-.04	47	-.07	-.06	-.32*	.35*
20-75 yrs									
Stature	203	.31*	.34*	-.09					
Mass	203	.51*	.51*	-.13					
BMI	203	.43*	.42*	-.10					
SUM	203	.28*	.25*	-.22*					
TER	203	.05	.04	-.01					
WHR	203	.20*	.18*	-.17*					
Females									
5-19 yrs									
Stature	69	.59*	.69*	-.05	35	.18	-.12	.30	.16
Mass	69	.58*	.67*	-.09	35	.16	-.44*	-.07	-.33*
BMI	69	.38*	.42*	-.05	35	.04	-.47*	-.29	-.54*
SUM	69	.22	.28*	-.22	35	-.16	-.66*	-.21	-.38*
TER	69	.01	.06	-.10	35	-.31	-.57*	-.01	-.44*
WHR	69	-.18	-.28*	-.08	35	-.01	-.17	.28	-.23
20-75 yrs									
Stature	201	.38*	.36*	.00					
Mass	201	.40*	.36*	-.15*					
BMI	201	.29*	.26*	-.16*					
SUM	201	.13	.11	-.26*					
TER	201	.12	.12	-.17*					
WHR	201	.02	.02	-.21*					

*Correlations significant at $p \leq 0.05$

**Direction of correlations for 35-meter dash have been reversed

TABLE 4.38 Third-order partial correlations between somatotype components and grip strength, flexibility, and performance variables, controlling for age and the other two somatotype components.

Group	n	Right Grip	Left Grip	Flexibility	n	Sit-ups	Standing Long Jump	Flexed Arm Am Hang	35-meter Dash**
Males									
5-19 yrs									
Endomorphy	90	-.07	-.02	-.17	47	-.31 *	.28	-.44 *	-.05
Mesomorphy	90	.25 *	.32 *	.04	47	.15	.14	.10	.17
Ectomorphy	90	.08	.16	-.08	47	-.02	.05	-.12	.08
20-75 yrs									
Endomorphy	203	-.02	-.05	-.20 *					
Mesomorphy	203	.22 *	.20 *	.08					
Ectomorphy	203	.00	-.02	-.01					
Females									
5-19 yrs									
Endomorphy	70	.01	.08	-.37 *	35	-.35 *	-.57 *	.06	.07
Mesomorphy	70	.31 *	.33 *	-.05	35	.28	.27	-.23	.30
Ectomorphy	70	.15	.21	-.25 *	35	-.01	.04	.08	.51 *
20-75 yrs									
Endomorphy	194	-.17 *	-.15 *	-.30 *					
Mesomorphy	194	.35 *	.32 *	.07					
Ectomorphy	194	.04	.05	-.11					

*Correlations significant at $p \leq 0.05$

**Direction of correlations for 35-meter dash have been reversed

TABLE 4.39 Results of familial aggregation analyses of flexibility and grip strength examining the effects of controlling for body size.

	Intraclass Correlations		Interclass Correlations								Mid-parent-Offspring Regressions					
	Siblings	Father-Mother		Father-Daughter		Father-Offspring		Mother-Son		Mother-Daughter		Mother-Offspring	h ²	S.E.	t	Significance
		Mother	Father-Son	Father-Daughter	Father-Offspring	Mother-Son	Mother-Daughter	Mother-Offspring								
Flexibility ^a	.15 *	.00	.31 *	.15	.23 *	.23 *	.32 *	.27 *	.49	.10	4.98	<.001 *				
Flexibility ^b	.13	-.04	.33 *	.16	.24 *	.23 *	.32 *	.28 *	.50	.10	5.05	<.001 *				
Flexibility ^c	.14	.01	.33 *	.14	.23 *	.24 *	.32 *	.28 *	.48	.10	4.98	<.001 *				
Flexibility ^d	.13	-.03	.33 *	.16	.24 *	.25 *	.32 *	.28 *	.50	.10	5.10	<.001 *				
Left Grip ^a	.28 *	.03	.26 *	.48 *	.35 *	.18 *	.20 *	.19 *	.36	.09	4.00	<.001 *				
Left Grip ^b	.25 *	.03	.18	.47 *	.30 *	.06	.25 *	.15 *	.20	.09	2.30	<.023 *				
Left Grip ^c	.28 *	.02	.21 *	.46 *	.30 *	.18 *	.17 *	.17 *	.33	.09	3.61	<.001 *				
Left Grip ^d	.27 *	-.01	.26 *	.49 *	.36 *	.07	.24	.15 *	.26	.09	2.83	.005 *				
Right Grip ^a	.20 *	-.05	.27 *	.24 *	.26 *	.00	.28 *	.14 *	.34	.10	3.35	.001 *				
Right Grip ^b	.15 *	-.04	.20	.30 *	.24 *	-.12	.36 *	.12 *	.20	.10	1.97	.051 *				
Right Grip ^c	.18 *	-.07	.25 *	.30 *	.27 *	.01	.27 *	.13 *	.36	.10	3.56	<.001 *				
Right Grip ^d	.18 *	-.06	.25 *	.30 *	.27 *	-.12	.35 *	.11 *	.22	.10	2.13	.035 *				

*Regressions significant at $p \leq 0.05$

^a $Y = \text{age} + \text{age}^2 + \text{age}^3$

^b $Y = \text{age} + \text{age}^2 + \text{age}^3 + \text{mass}$

^c $Y = \text{age} + \text{age}^2 + \text{age}^3 + \text{stature}$

^d $Y = \text{age} + \text{age}^2 + \text{age}^3 + \text{BMI}$

TABLE 5.1 Partial correlations between TER, WHR and SUM, controlling for age.

Group	n	TER	WHR
5-19 yrs			
EA Males	71	0.52 **	0.36 **
FN Males	19	0.80 **	0.51 *
EA Females	55	0.44 **	0.18
FN Females	15	0.54 *	0.40
20-75 yrs			
EA Males	175	0.12	0.70 **
FN Males	164	0.34 **	0.39 **
EA Females	33	0.15	0.62 **
FN Females	43	-0.32 *	0.38 **

*Correlations significant at $p \leq 0.05$

**Correlations significant at $p \leq 0.01$

TABLE 5.2 Results of familial aggregation analyses of TER and WHR, controlling for SUM.

EA	Intraclass Correlations		Interclass Correlations								Mid-parent-Offspring Regressions		
			Father-Offspring				Mother-Offspring						
	Siblings	Father-Mother	Father-Son	Father-Daughter	Father-Offspring	Mother-Son	Mother-Daughter	Mother-Offspring	h ²	S.E.	t	Significance	
TER ¹	0.57 *	0.14	0.33 *	0.04	0.23 *	0.21 *	0.15	0.20 *	0.30	0.11	2.78	.007 *	
		0.16	0.08	-0.14	0.00	0.10	0.14	0.12					0.19
TER ²	0.57 *	0.08	0.33 *	0.02	0.24 *	0.20	0.14	0.17 *	0.26	0.11	2.41	.017 *	
		0.30 *	0.05	-0.12	-0.05	0.05	0.10	0.07					0.13
FN													
TER ¹	0.25 *	-0.04	0.00	-0.22	-0.06	0.26	0.10	0.18	0.20	0.19	1.03	.325	
		-0.18	-0.10	0.00	-0.05	0.52 *	0.27	0.35					0.04
TER ²	0.18	-0.04	0.07	-0.04	0.04	0.22	0.06	0.14	0.18	0.19	0.95	.363	
		-0.36	0.10	0.15	0.07	0.75 *	0.22	0.37 *					0.16
Total													
TER ¹	0.38 *	0.12	0.27 *	0.00	0.18 *	0.21 *	0.23 *	0.21 *	0.25	0.09	2.75	.007 *	
		0.11	0.06	-0.06	0.03	0.16	0.30 *	0.24 *					0.16
TER ²	0.34 *	0.07	0.28 **	0.01	0.20 **	0.20 *	0.19	0.19 **	0.21	0.09	2.37	.019 *	
		0.11	0.10	-0.03	0.05	0.13	0.09	0.17 *					0.17

*Significant at p<0.05

¹Y = age + age² + age³

²Y = age + age² + age³ + SUM

TABLE 5.3 Means and standard deviations for Heath-Carter anthropometric somatotype components with comparative data from two Canadian samples.

Age Group (yrs)		Males				Females									
		n	Endomorphy	Mesomorphy	Ectomorphy	n	Endomorphy	Mesomorphy	Ectomorphy						
15-19	EA	16	3.3	1.1	4.3	1.2	2.8	1.0	15	4.9	1.8	3.8	1.4	2.4	1.5
	FN	7	3.5	2.3	4.3	1.4	3.1	1.5	6	5.3	2.2	4.1	2.6	2.3	1.6
	YMCA-LIFE ¹	161	3.0	1.4	4.7	1.5	2.8	1.4	235	4.3	1.2	3.7	1.1	2.4	1.1
	QFS ²	130	2.3	0.9	4.2	1.1	3.5	1.2	136	3.7	1.2	3.4	1.0	3.0	1.1
20-29	EA	34	3.7	1.5	4.9	1.6	2.4	1.4	19	5.9	2.0	4.6	1.7	1.5	1.3
	FN	11	5.1	1.7	6.2	1.8	1.3	1.2	12	6.7	2.3	5.3	2.1	1.2	1.1
	YMCA-LIFE	2259	3.6	1.4	5.0	1.3	2.2	1.1	1752	4.4	1.3	3.7	1.2	2.4	1.1
	QFS	45	2.6	1.2	4.6	1.3	2.9	1.3	35	3.4	1.1	3.2	1.3	3.0	1.3
30-39	EA	39	4.7	1.9	6.2	1.4	1.3	1.0	44	5.6	1.8	4.5	1.6	1.7	1.2
	FN	10	4.6	1.3	6.0	1.1	1.2	0.9	9	8.1	1.7	6.3	1.7	0.5	0.8
	YMCA-LIFE	2985	4.0	1.4	5.2	1.2	1.8	1.0	1201	4.6	1.4	3.9	1.2	2.3	1.1
	QFS	68	4.1	1.7	5.4	1.1	1.8	1.0	117	4.7	1.5	4.0	1.1	1.9	1.1
40-49	EA	44	4.5	1.8	5.9	1.6	1.3	1.2	34	6.4	1.7	5.0	1.9	1.5	1.2
	FN	6	5.6	1.8	6.6	1.3	0.5	0.4	10	7.5	1.4	6.2	1.3	0.4	0.4
	YMCA-LIFE	2031	4.1	1.3	5.3	1.2	1.7	1.0	787	5.1	1.4	4.4	1.3	1.8	1.0
	QFS	233	4.0	1.5	5.6	1.0	1.5	1.0	224	5.1	1.6	4.3	1.4	1.7	1.1
50-59	EA	34	5.3	1.8	6.6	1.4	0.8	0.8	31	6.6	1.8	5.4	1.6	1.0	1.1
	FN	4	4.9	1.2	6.3	1.5	0.8	1.1	4	7.8	1.2	6.1	0.9	0.3	0.3
	YMCA-LIFE	1159	4.1	1.2	5.4	1.2	1.6	0.9	498	5.4	1.4	4.5	1.3	1.8	1.0
	QFS	55	3.6	1.2	5.5	1.2	1.5	1.1	26	5.6	1.5	4.7	1.3	1.2	1.1

¹Data from Bailey et al. (1982)

²Data from Katzmarzyk et al. (1997) and Malina et al. (1997)

FIGURES

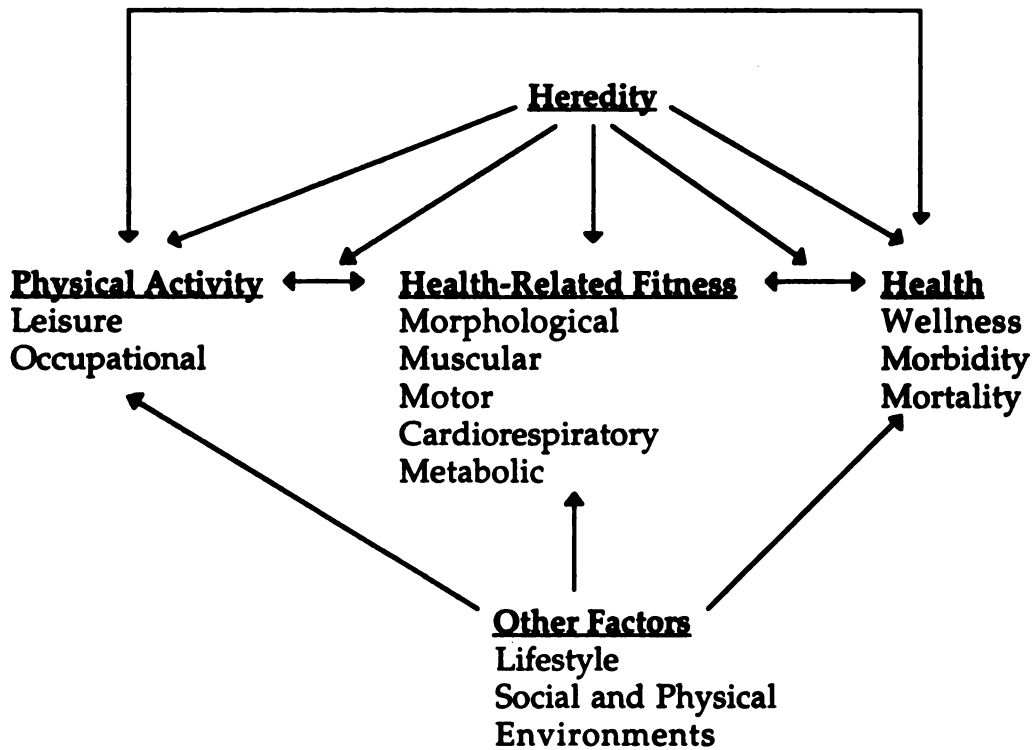


Figure 1.1 General model outlining the hypothesized relationships among activity, fitness and health (adapted from Bouchard and Shephard, 1994).

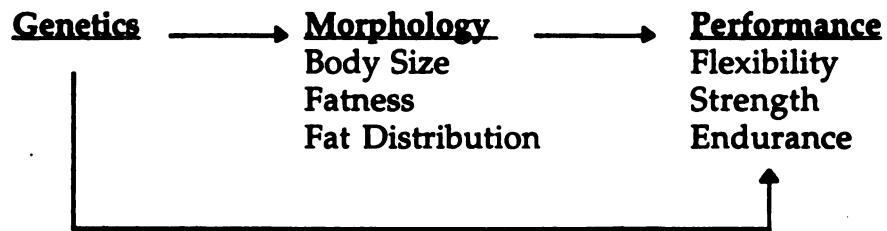


Figure 1.2 Proposed model for the study of the genetics of body size and performance.

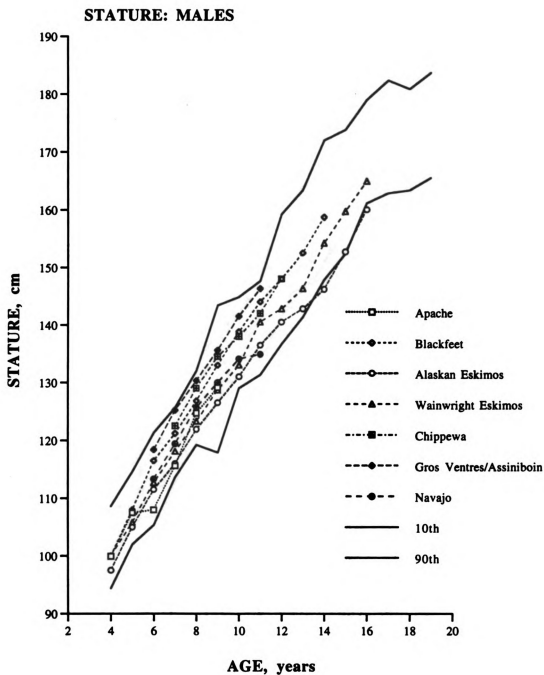


FIGURE 2.1 Stature of Native North American males 4-18 years plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Solid lines represent 10th and 90th percentiles.

STATURE: FEMALES

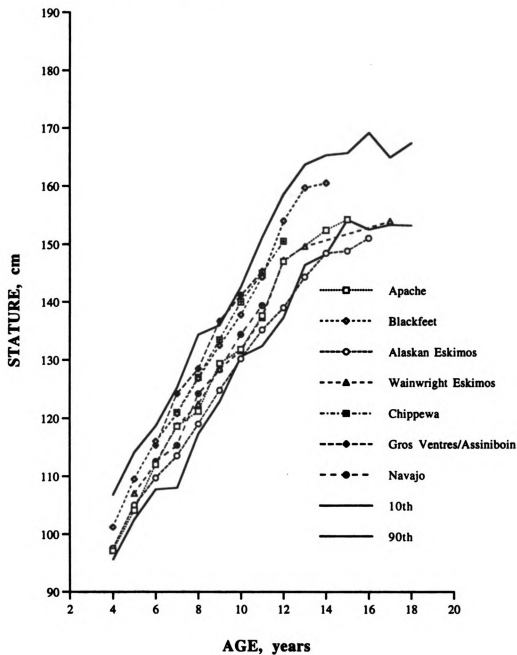


FIGURE 2.2 Stature of Native North American females 4–18 years plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Solid lines represent 10th and 90th percentiles.

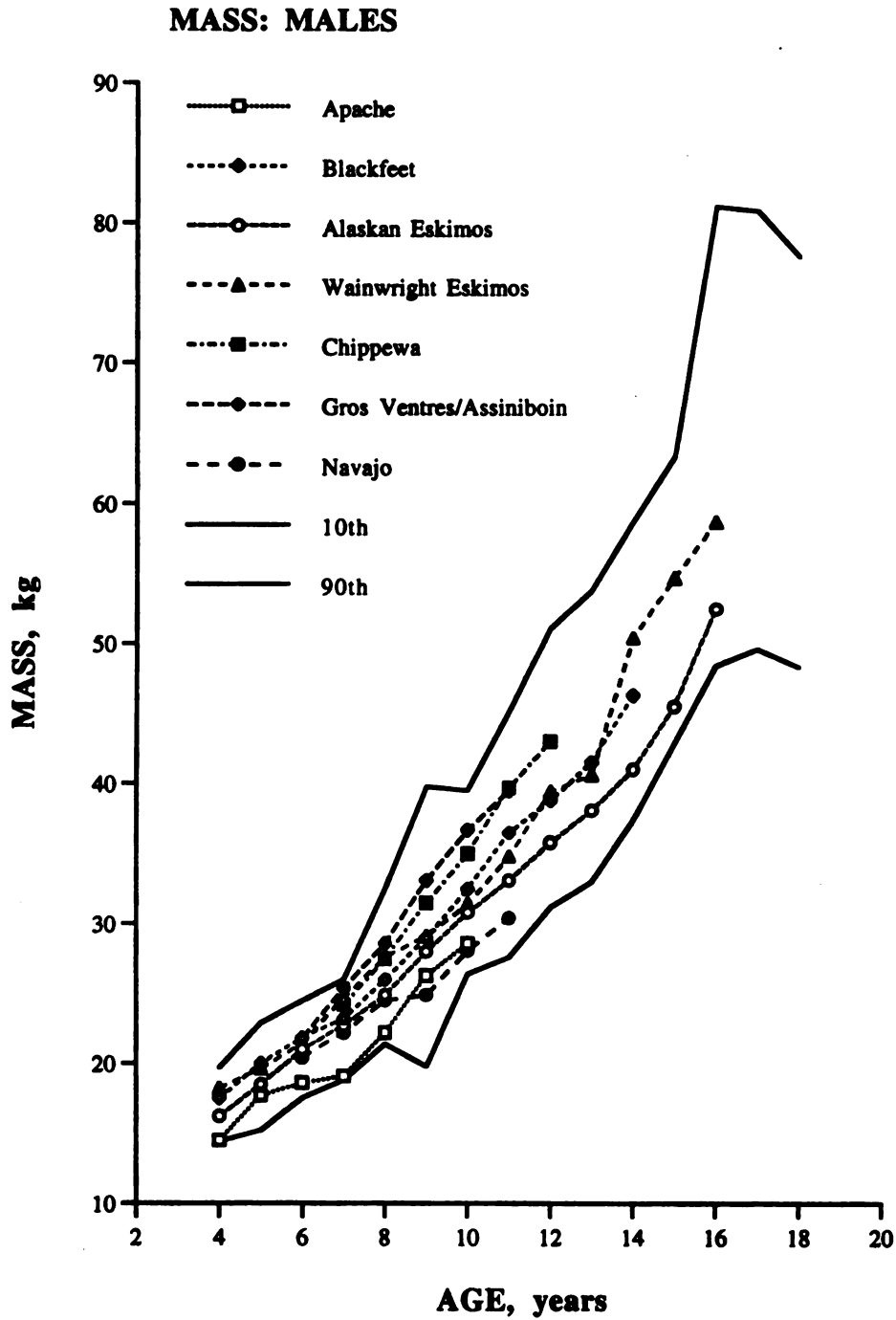


FIGURE 2.3 Body mass of Native North American males 4-18 years plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Solid lines represent 10th and 90th percentiles.

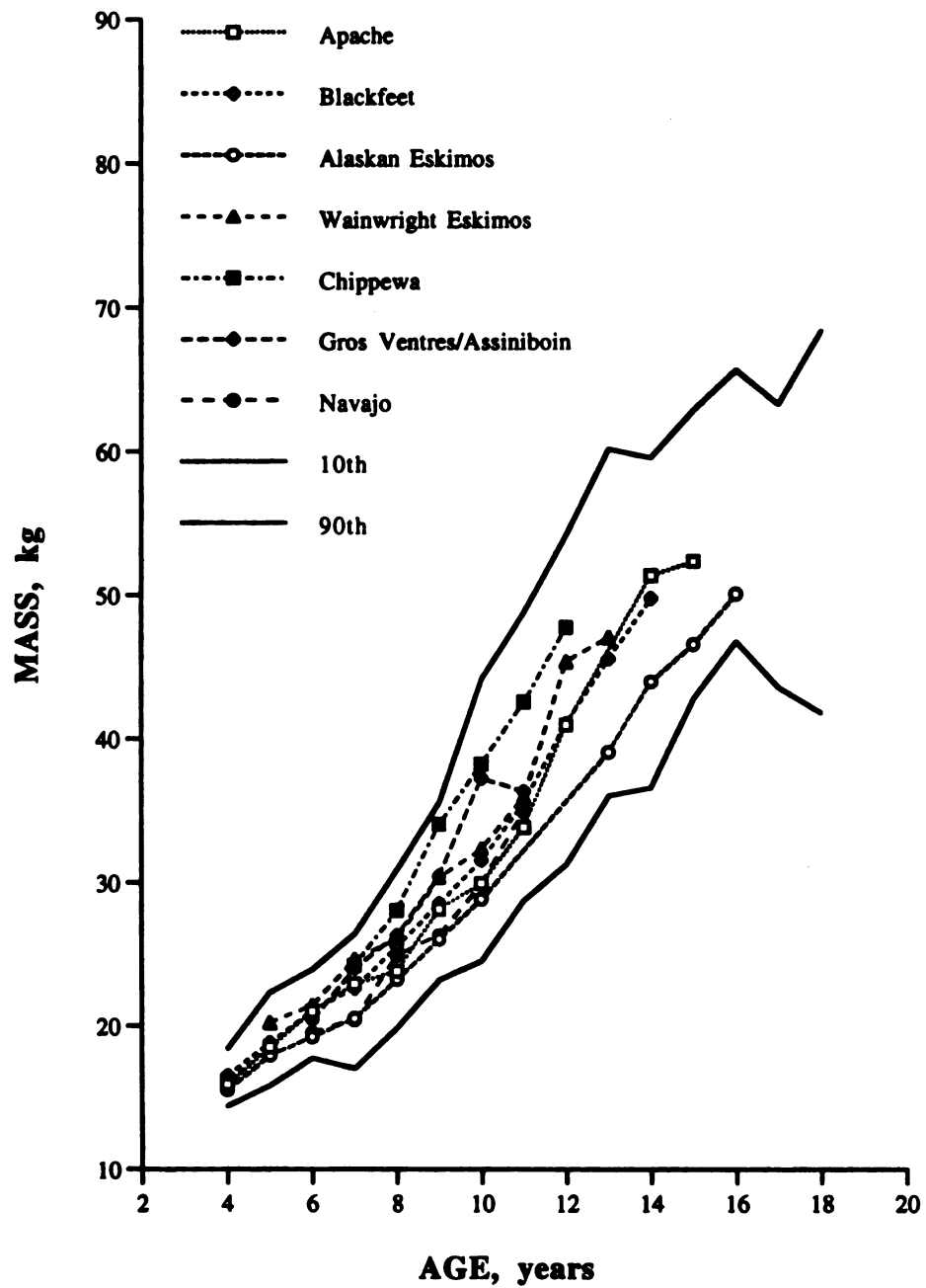
MASS: FEMALES

FIGURE 2.4 Body mass of Native North American females 4-18 years plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Solid lines represent 10th and 90th percentiles.

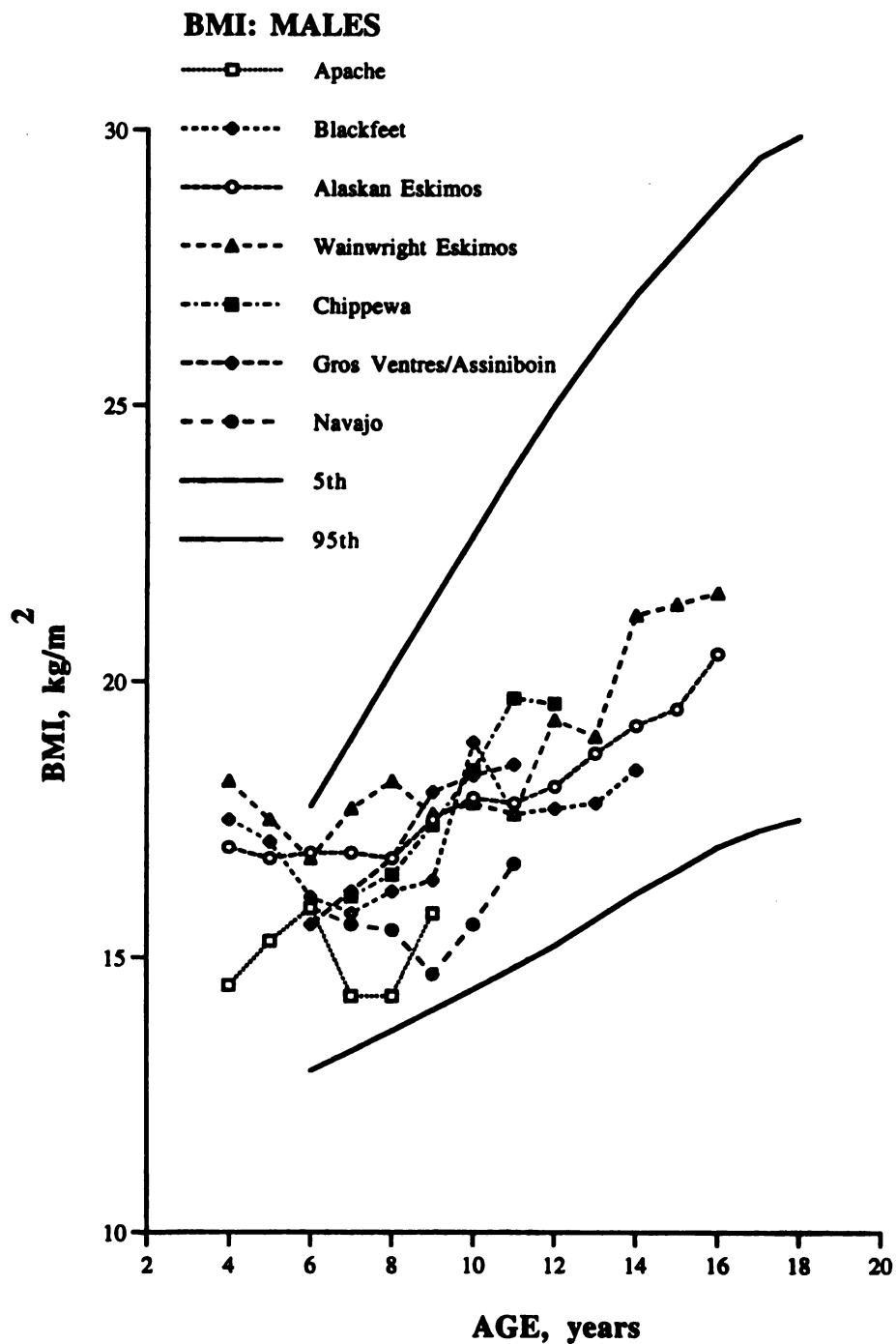


FIGURE 2.5 Estimated body mass index of Native North American males 4-18 years plotted relative to U.S. reference data (Must et al., 1991). Solid lines represent 5th and 95th percentiles.

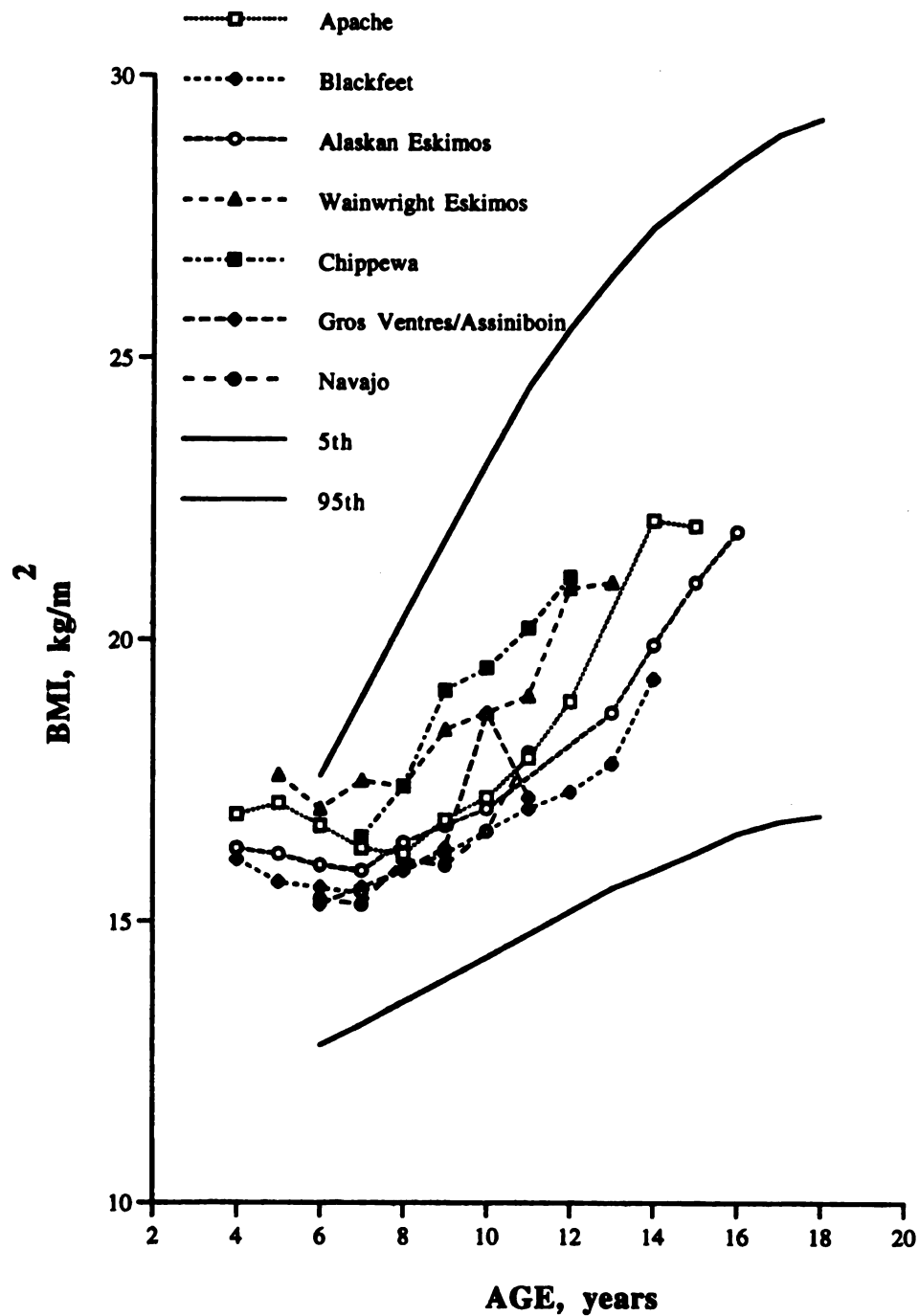
BMI: FEMALES

FIGURE 2.6 Estimated body mass index of Native North American females 4-18 years plotted relative to U.S. reference data (Must et al., 1991). Solid lines represent 5th and 95th percentiles.

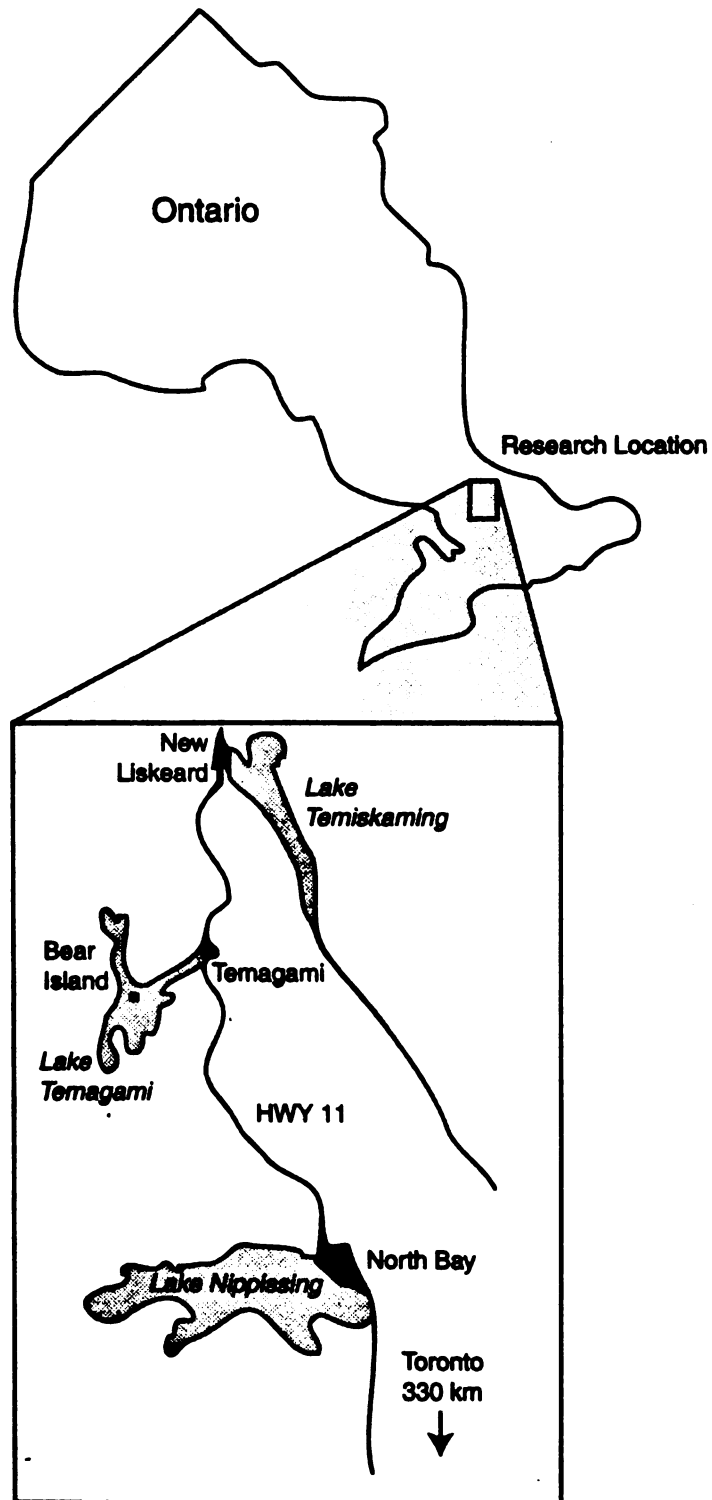


FIGURE 3.1 Map of research location in Northern Ontario.

STATURE: EA MALES 5-19 YEARS

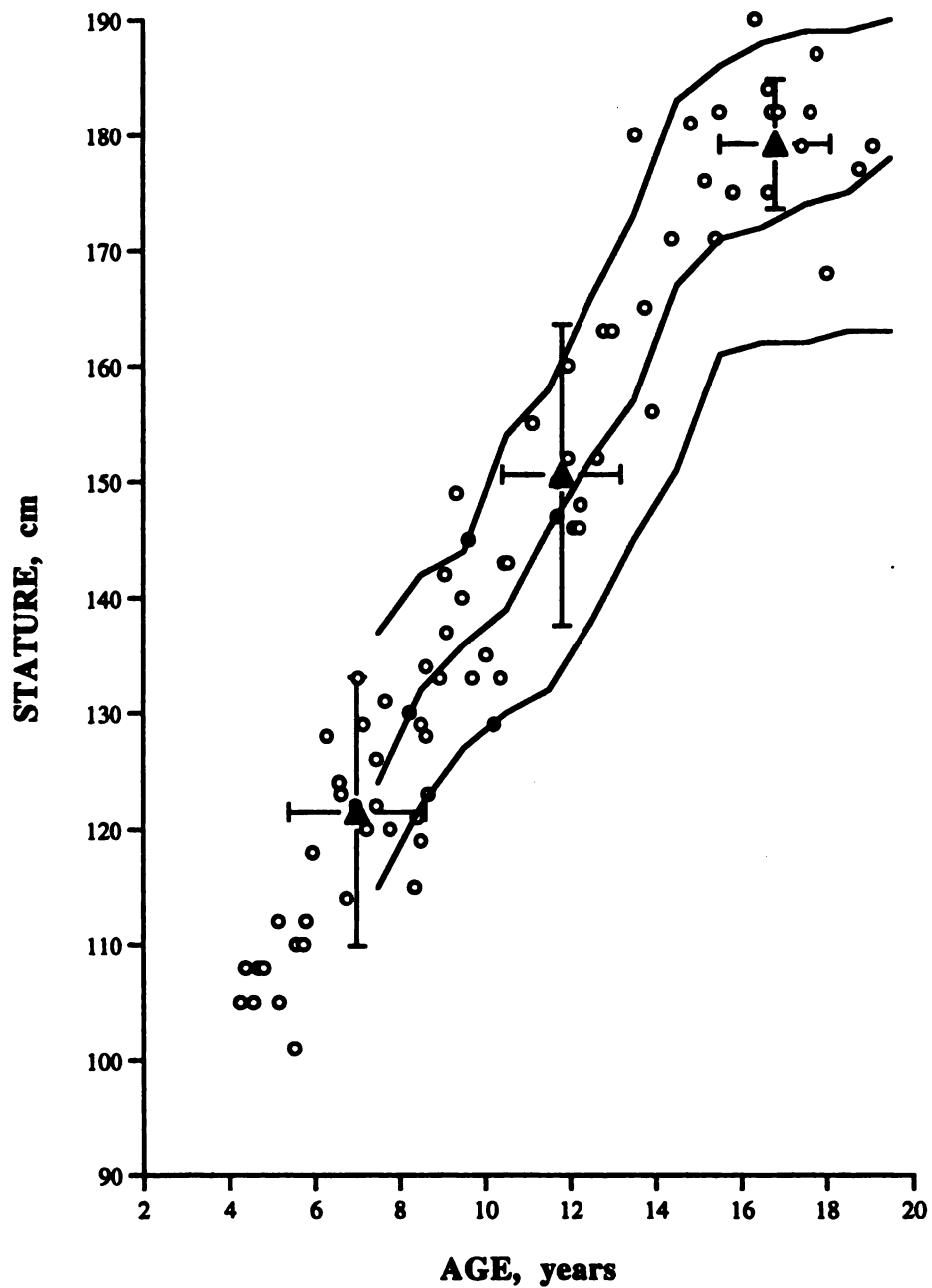


FIGURE 4.1 Stature of EA males (o) 5-19 years and five-year age group means (▲ ± SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

STATURE: FN MALES 5-19 YEARS

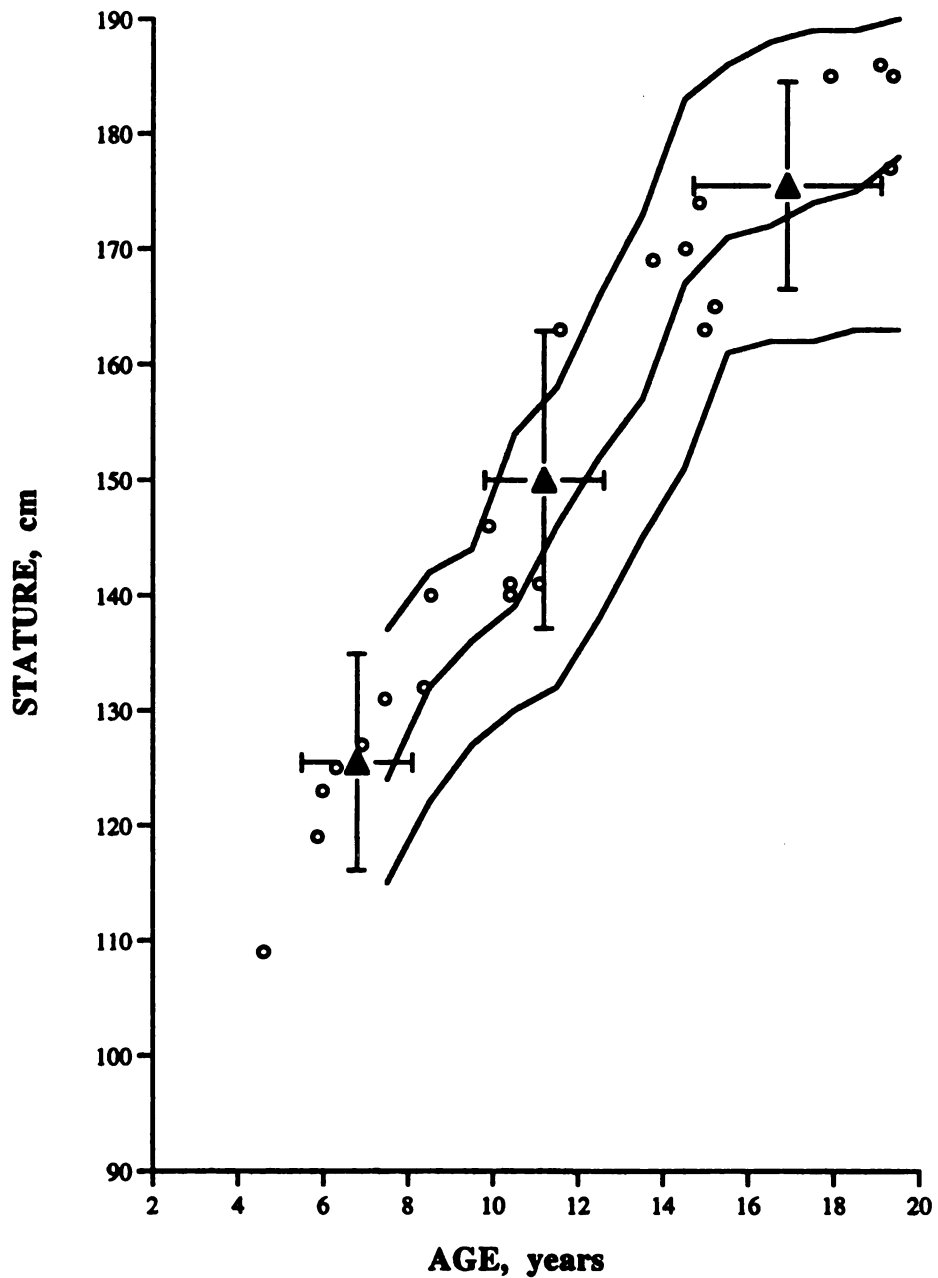


FIGURE 4.2 Stature of FN males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

STATURE: EA FEMALES 5-19 YEARS

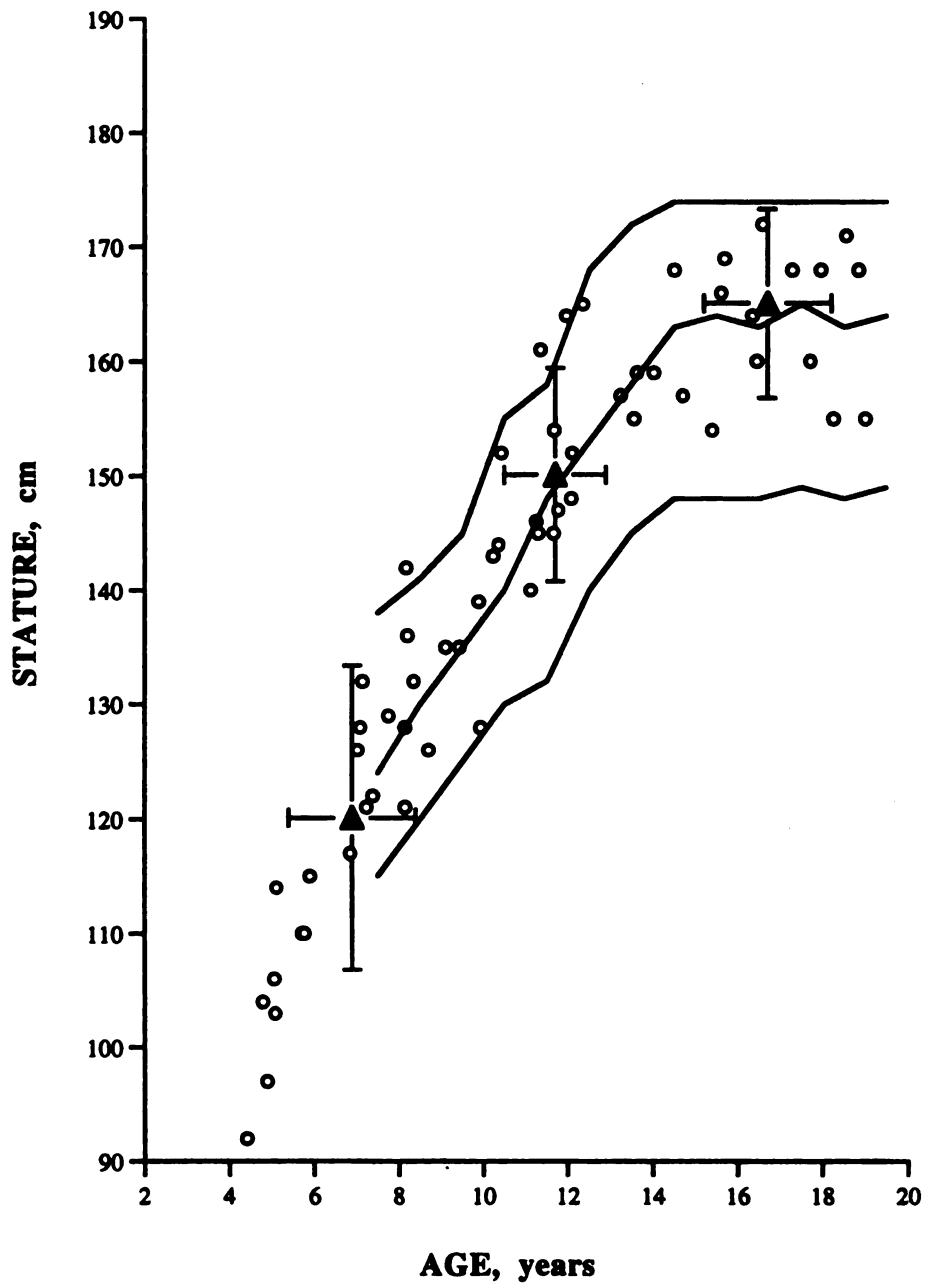


FIGURE 4.3 Stature of EA females (o) 5-19 years and five-year age group means ($\blacktriangle \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

STATURE: FN FEMALES 5-19 YEARS

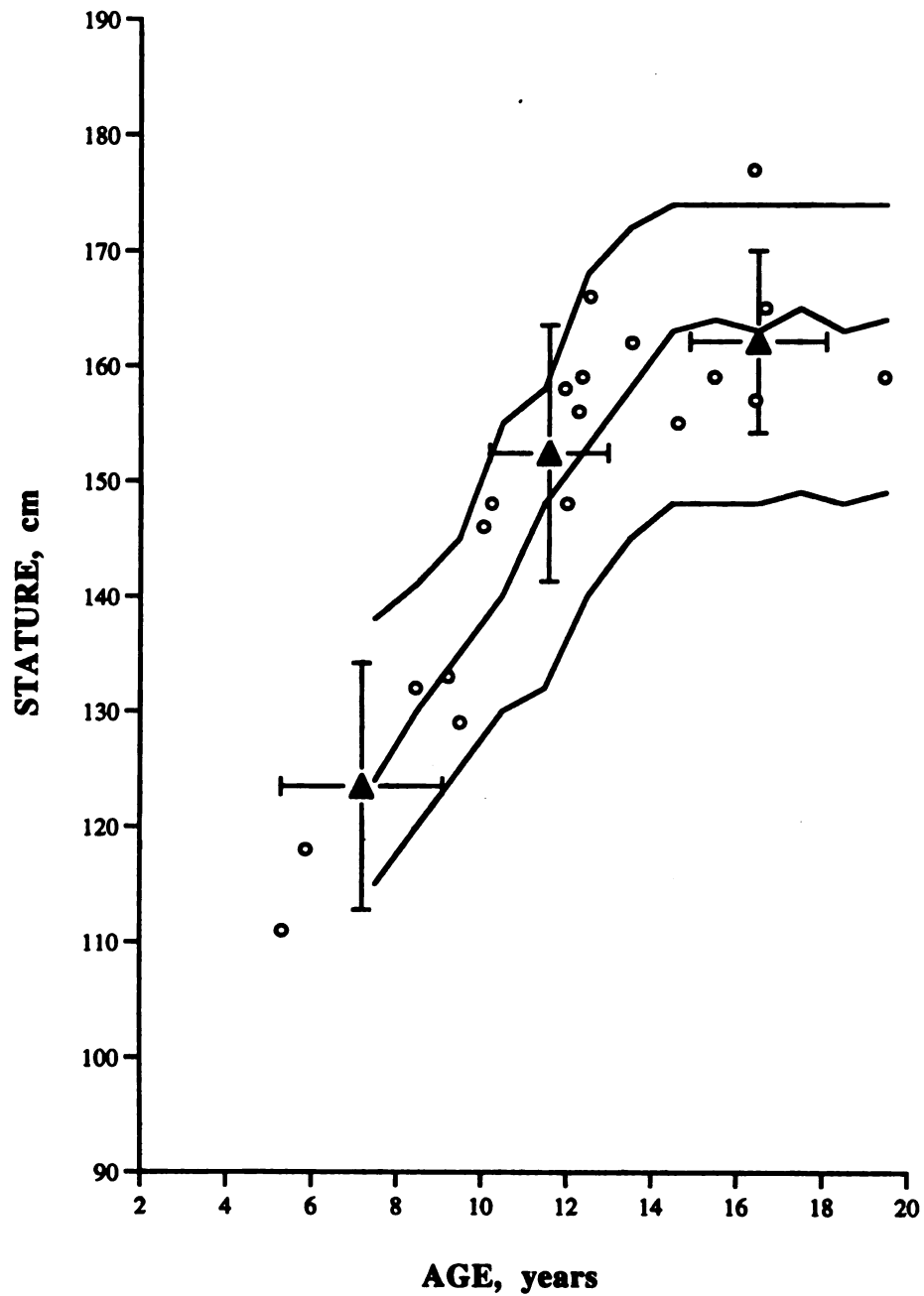


FIGURE 4.4 Stature of FN females (o) 5-19 years and five-year age group means (▲ ± SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

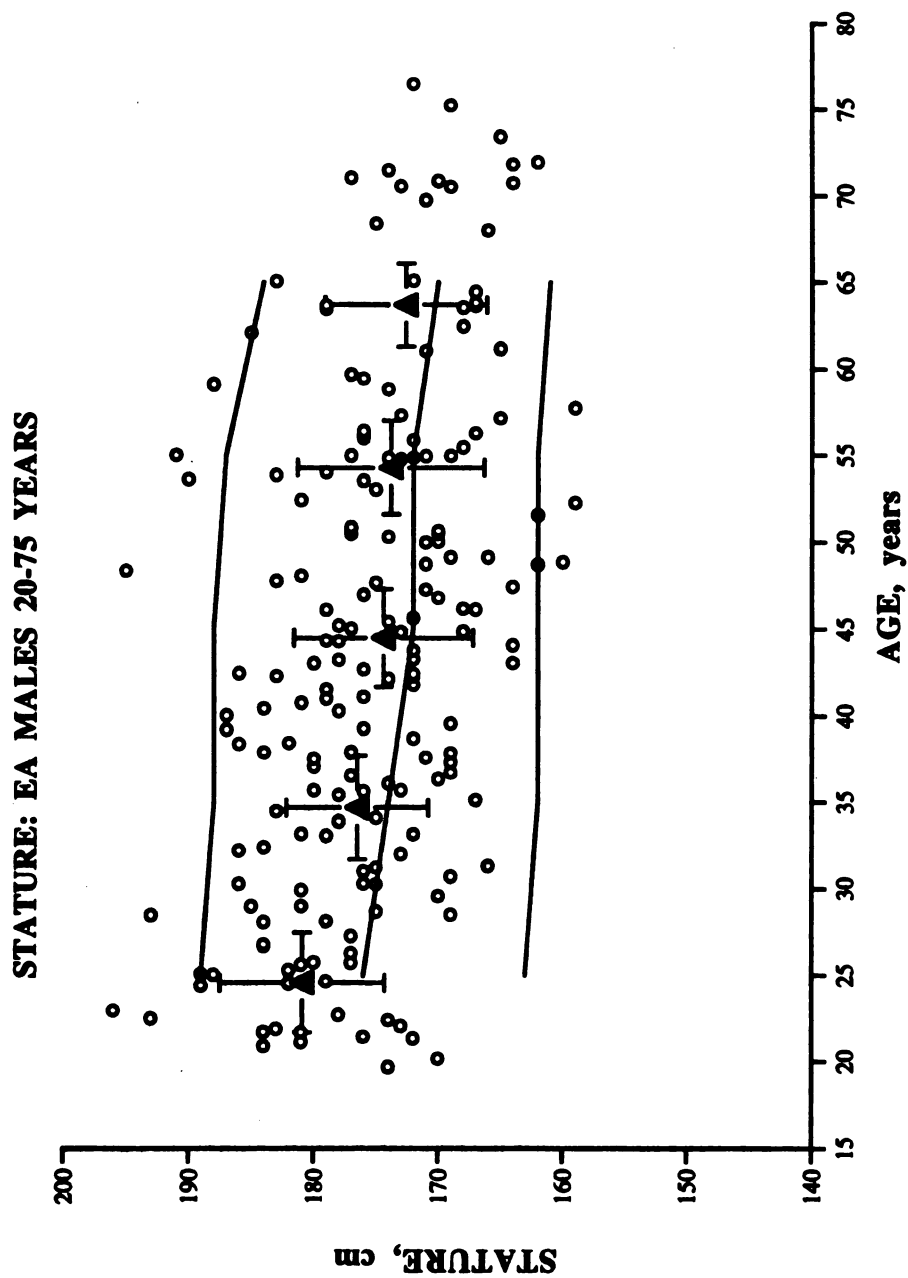


FIGURE 4.5 Stature of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

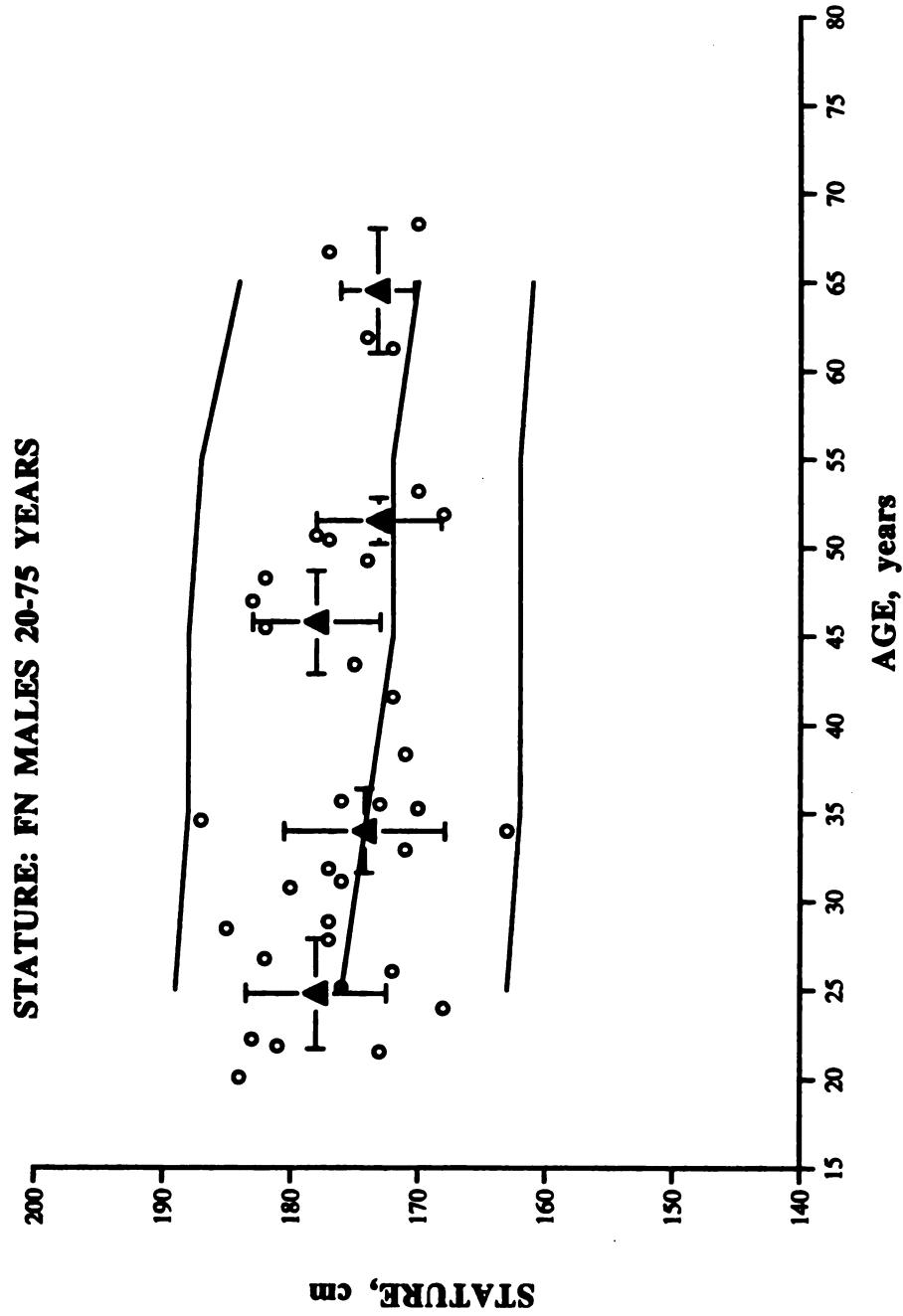


FIGURE 4.6 Stature of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

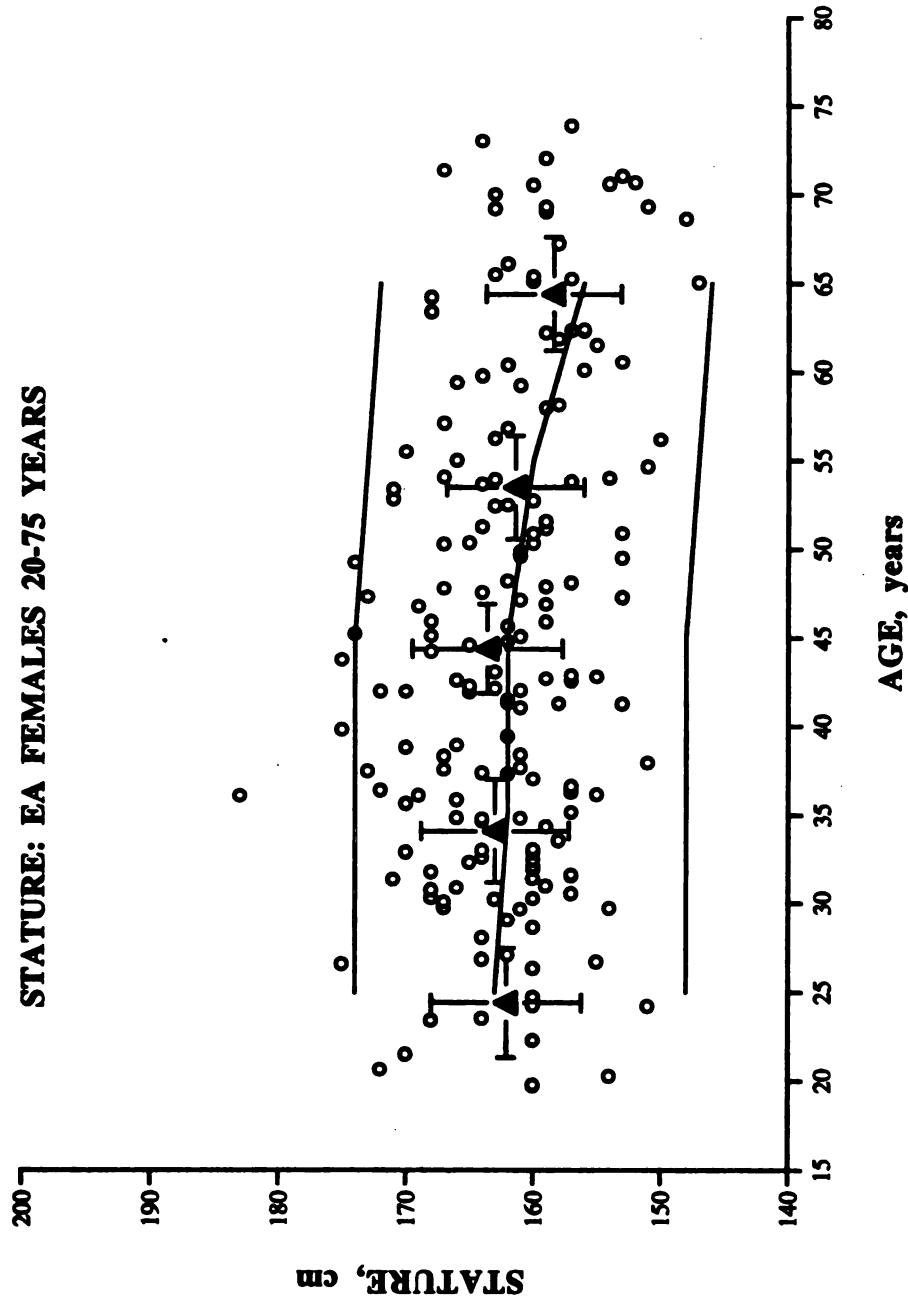


FIGURE 4.7 Stature of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

STATURE: FN FEMALES 20-75 YEARS

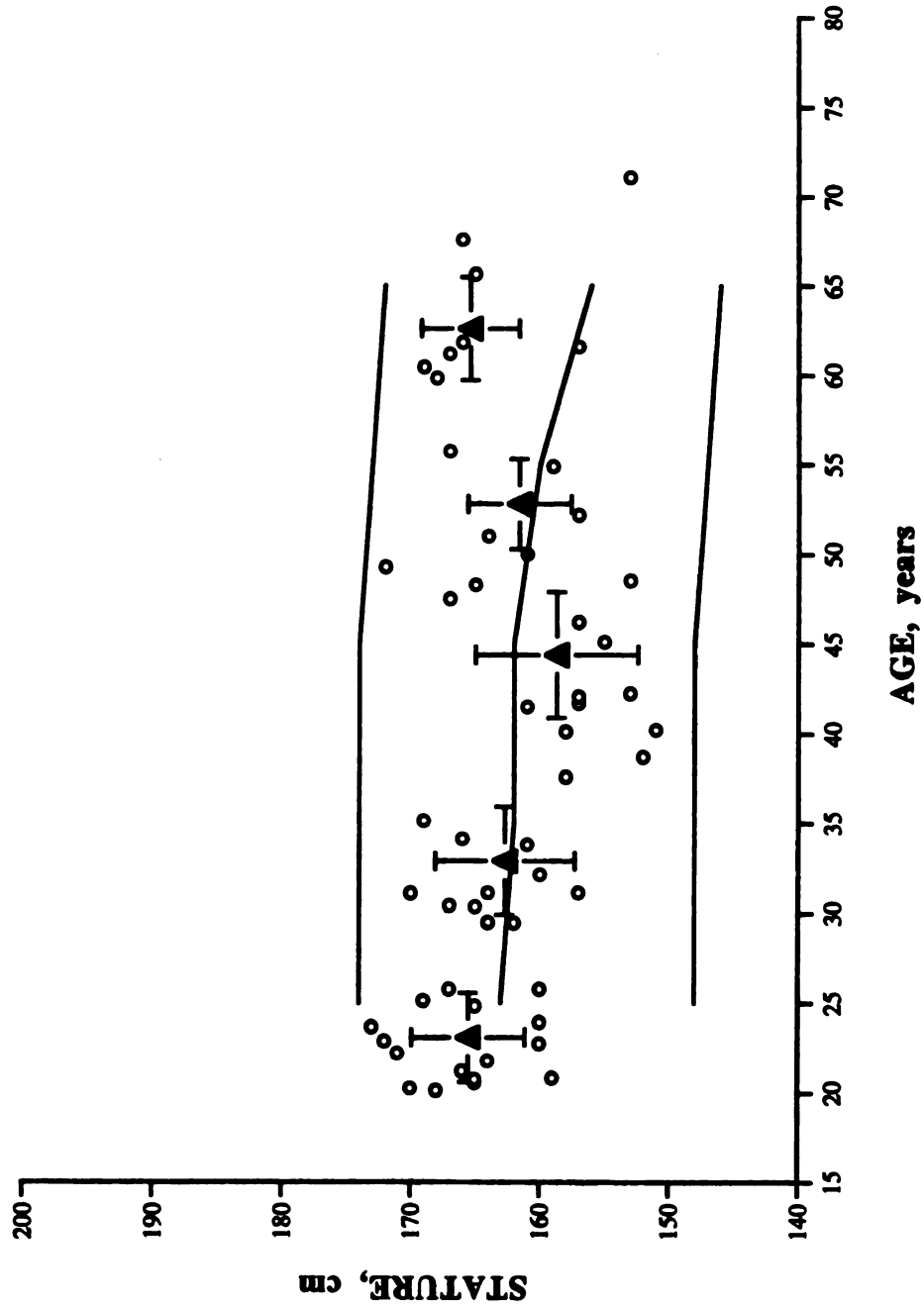


FIGURE 4.8 Stature of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

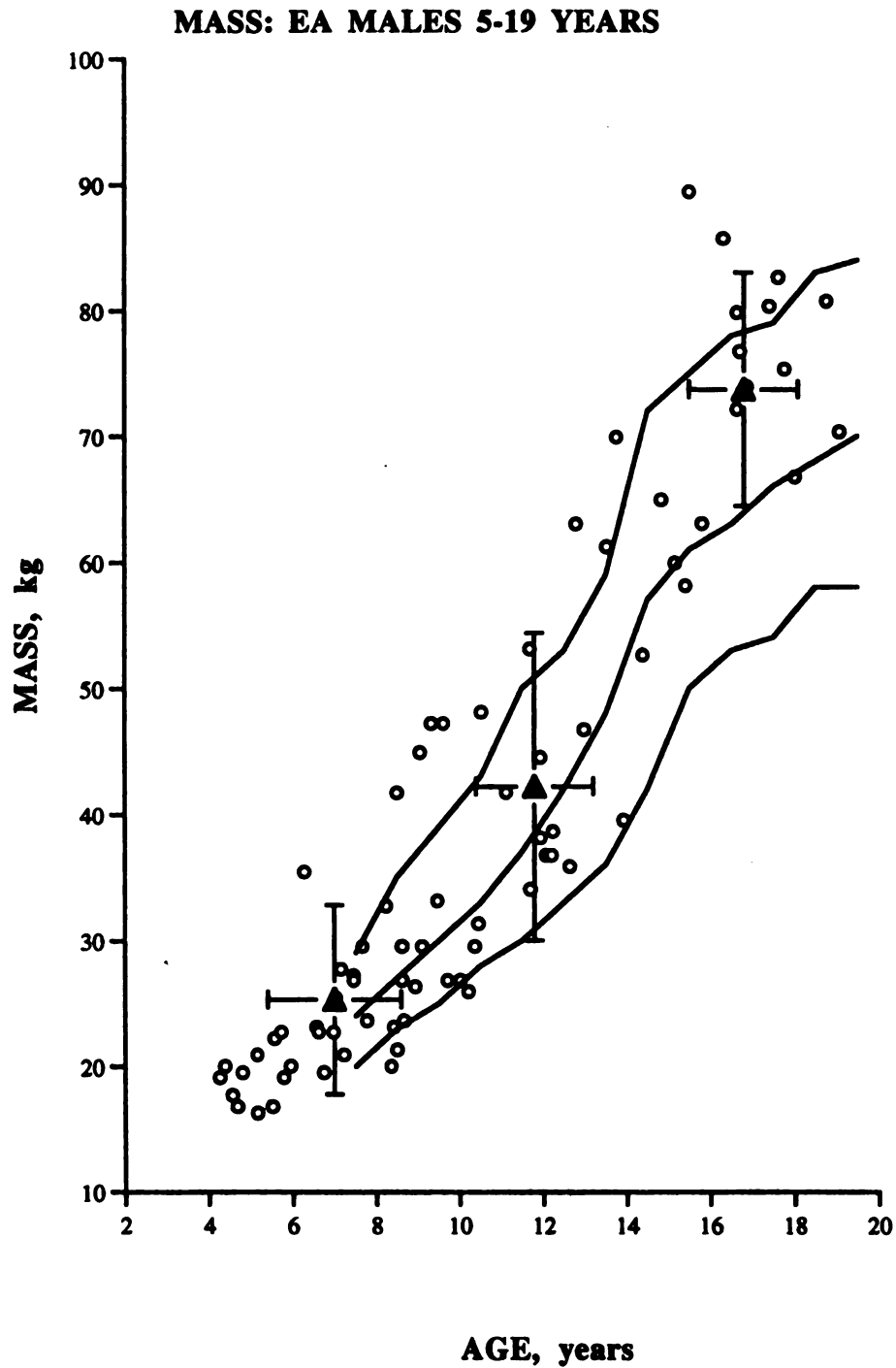


FIGURE 4.9 Body mass of EA males (o) 5-19 years and five-year age group means (▲ $\pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

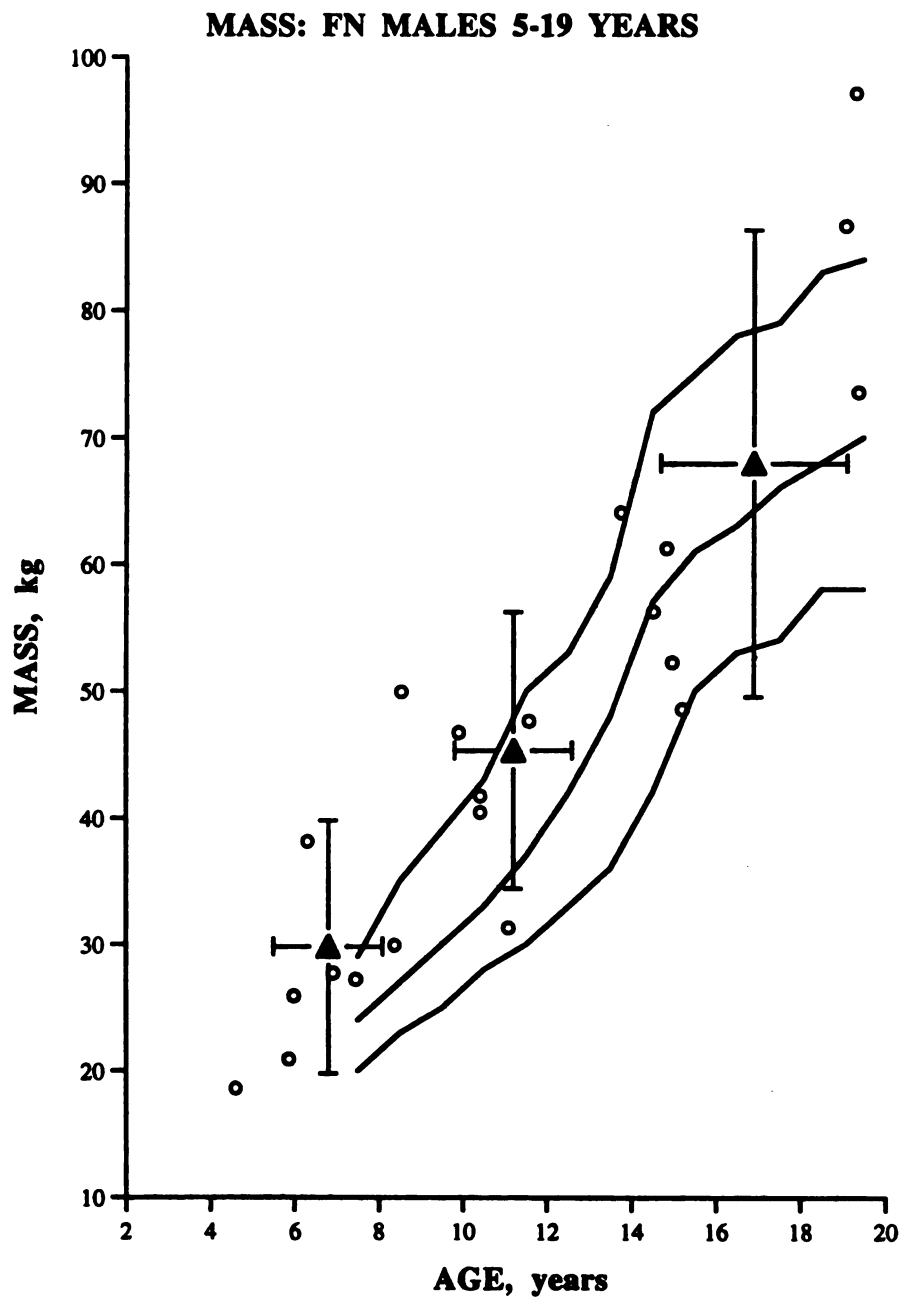


FIGURE 4.10 Body mass of FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

MASS: EA FEMALES 5-19 YEARS

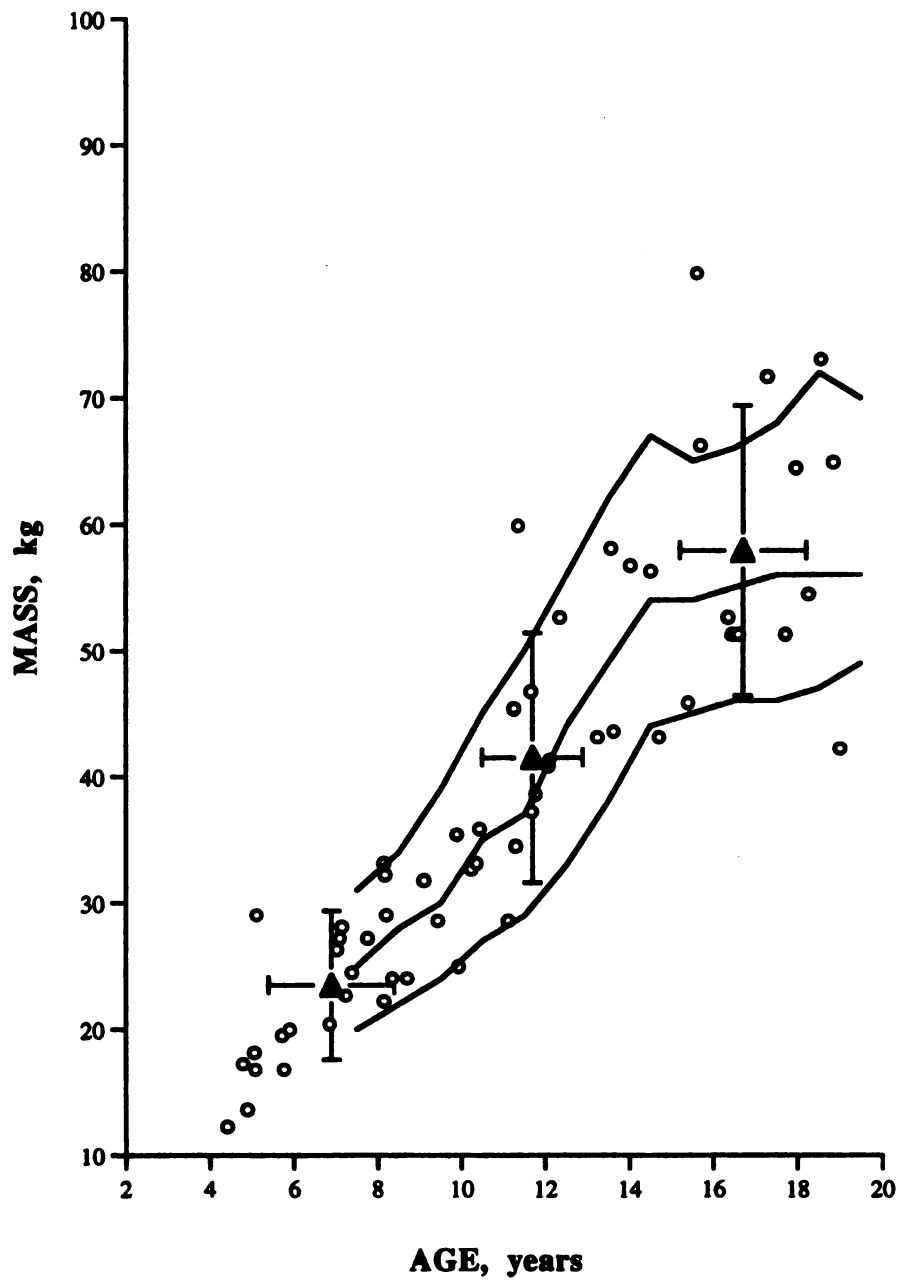


FIGURE 4.11 Body mass of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

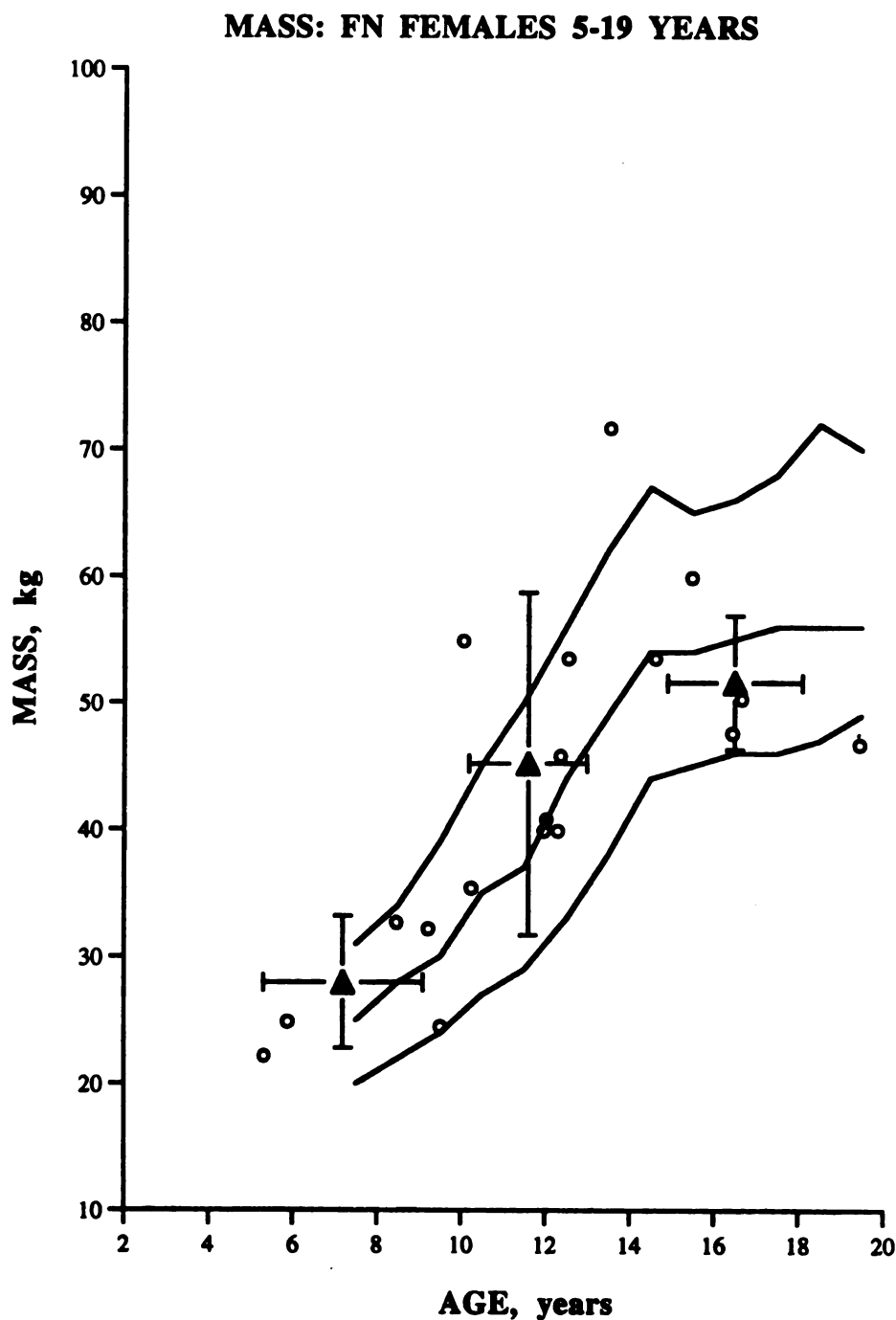


FIGURE 4.12 Body mass of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

MASS: EA MALES 20-75 YEARS

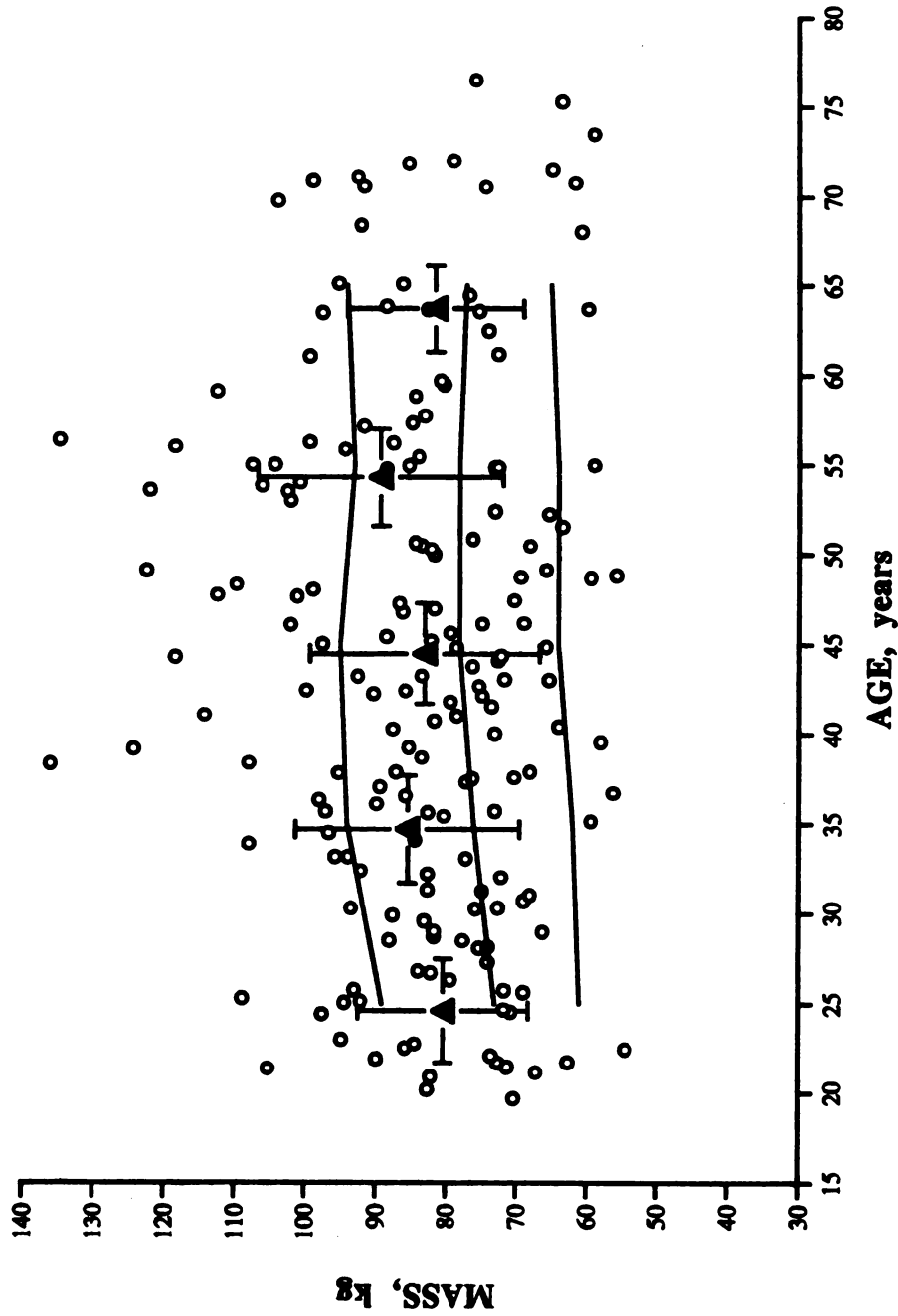


FIGURE 4.13 Body mass of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

MASS: FN MALES 20-75 YEARS

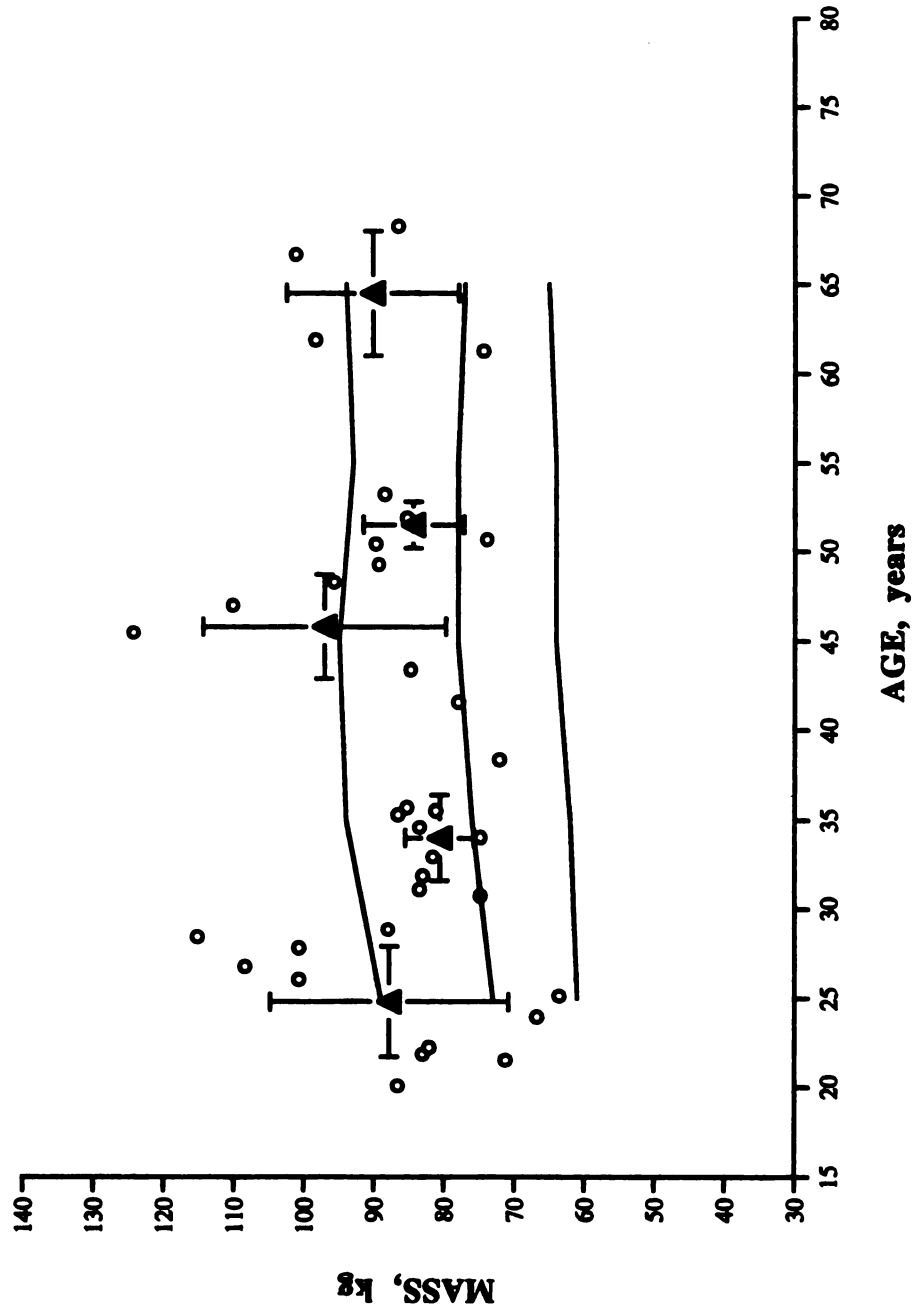


FIGURE 4.14 Body mass of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

MASS: EA FEMALES 20-75 YEARS

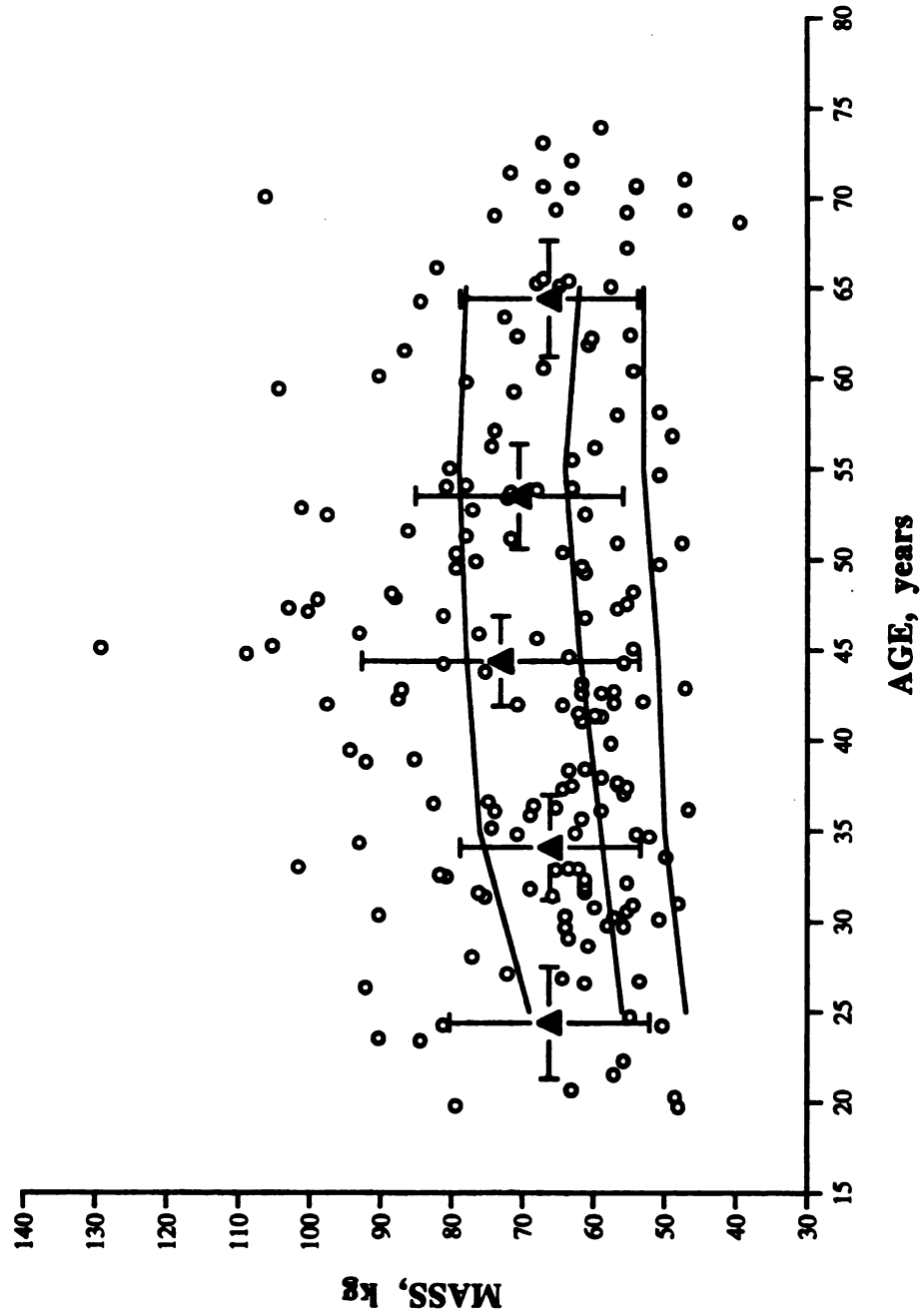


FIGURE 4.15 Body mass of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

MASS: FN FEMALES 20-75 YEARS

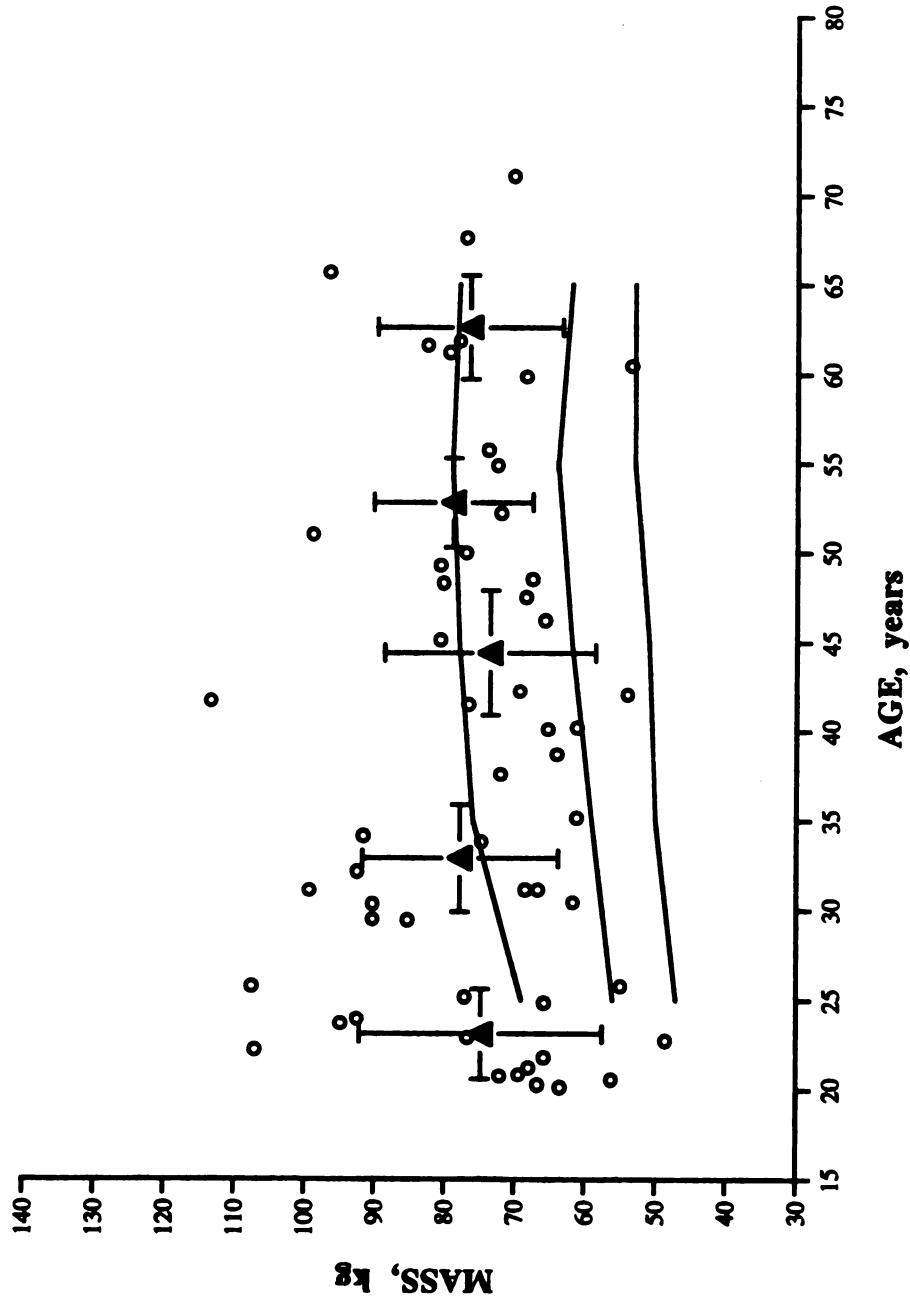


FIGURE 4.16 Body mass of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

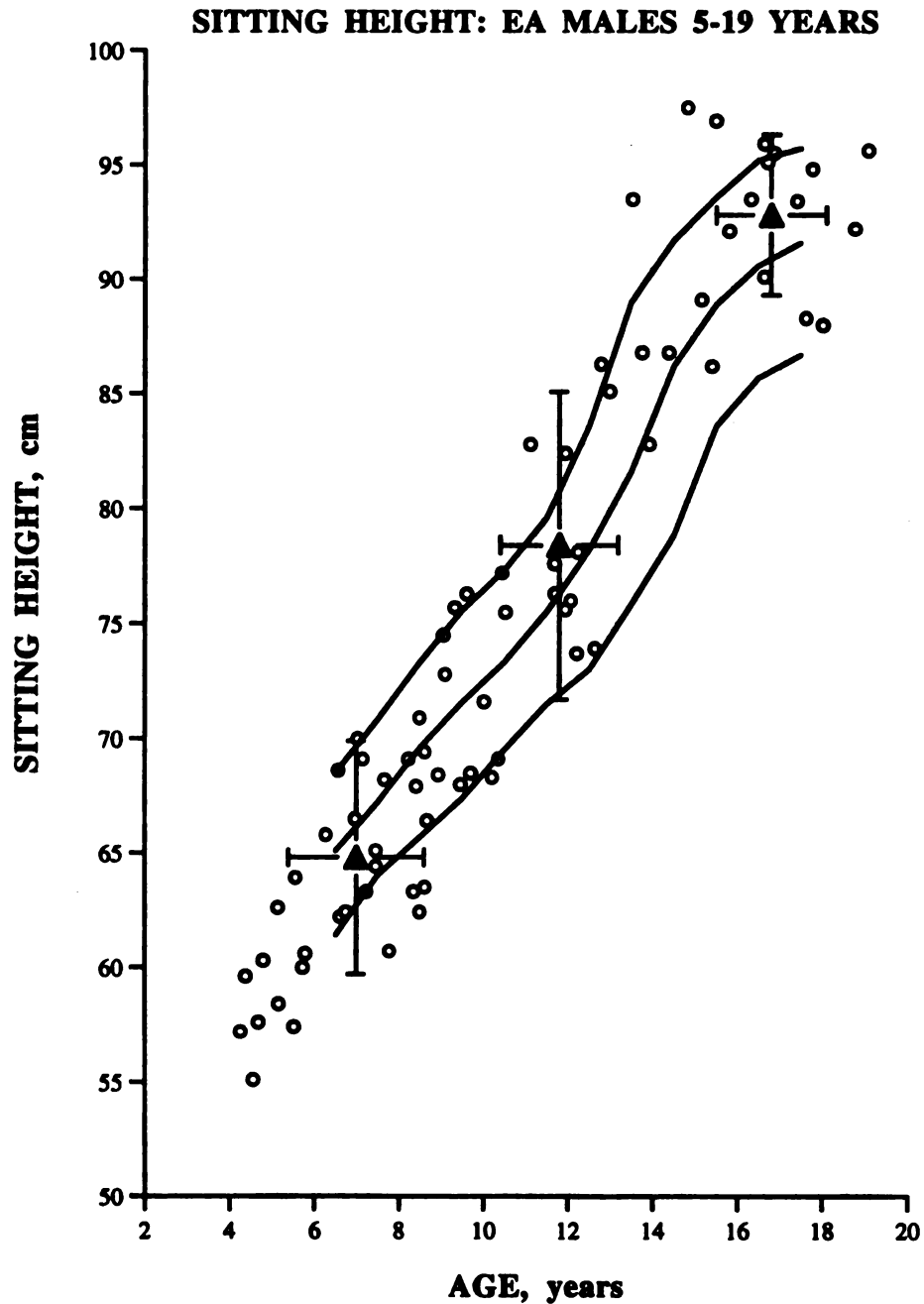


FIGURE 4.17 Sitting height of EA males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

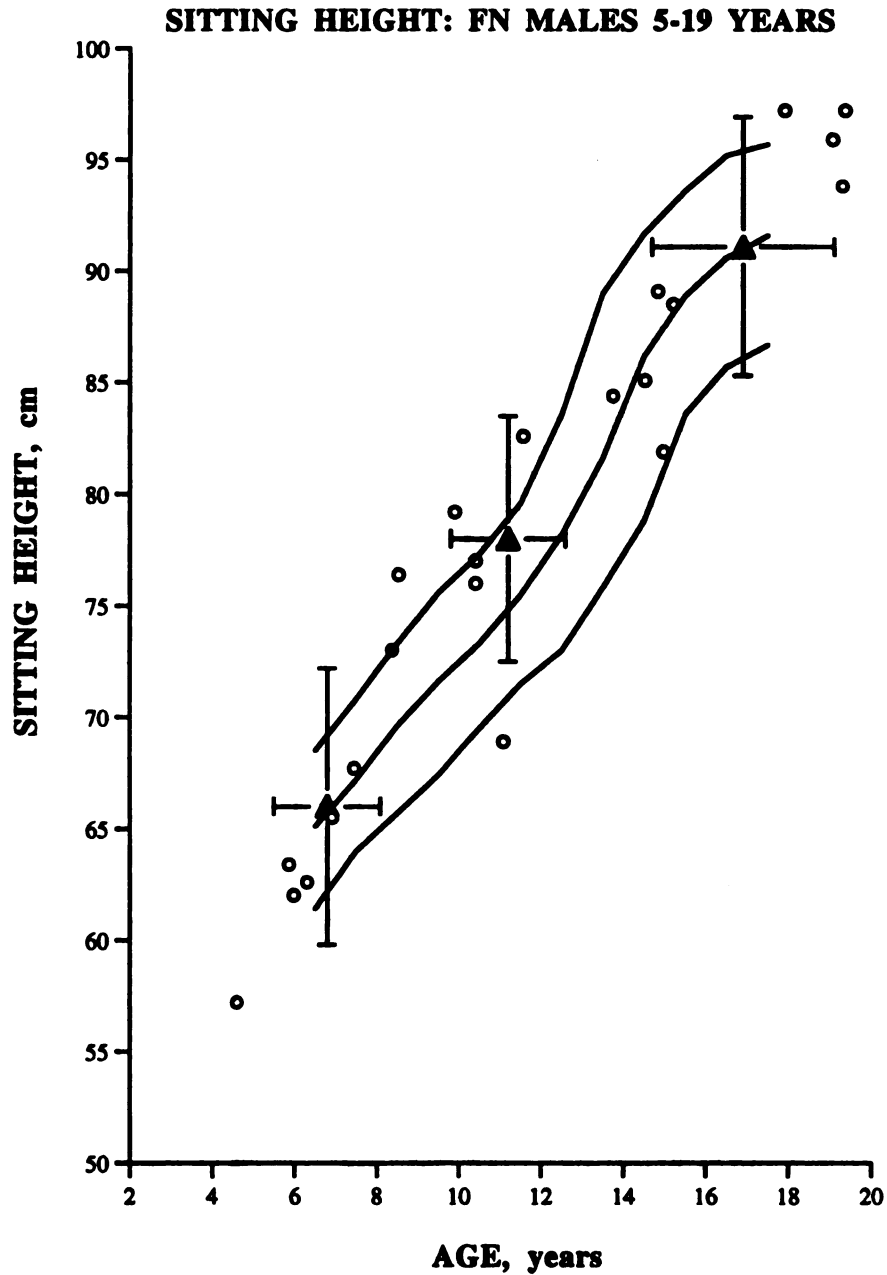


FIGURE 4.18 Sitting height of FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

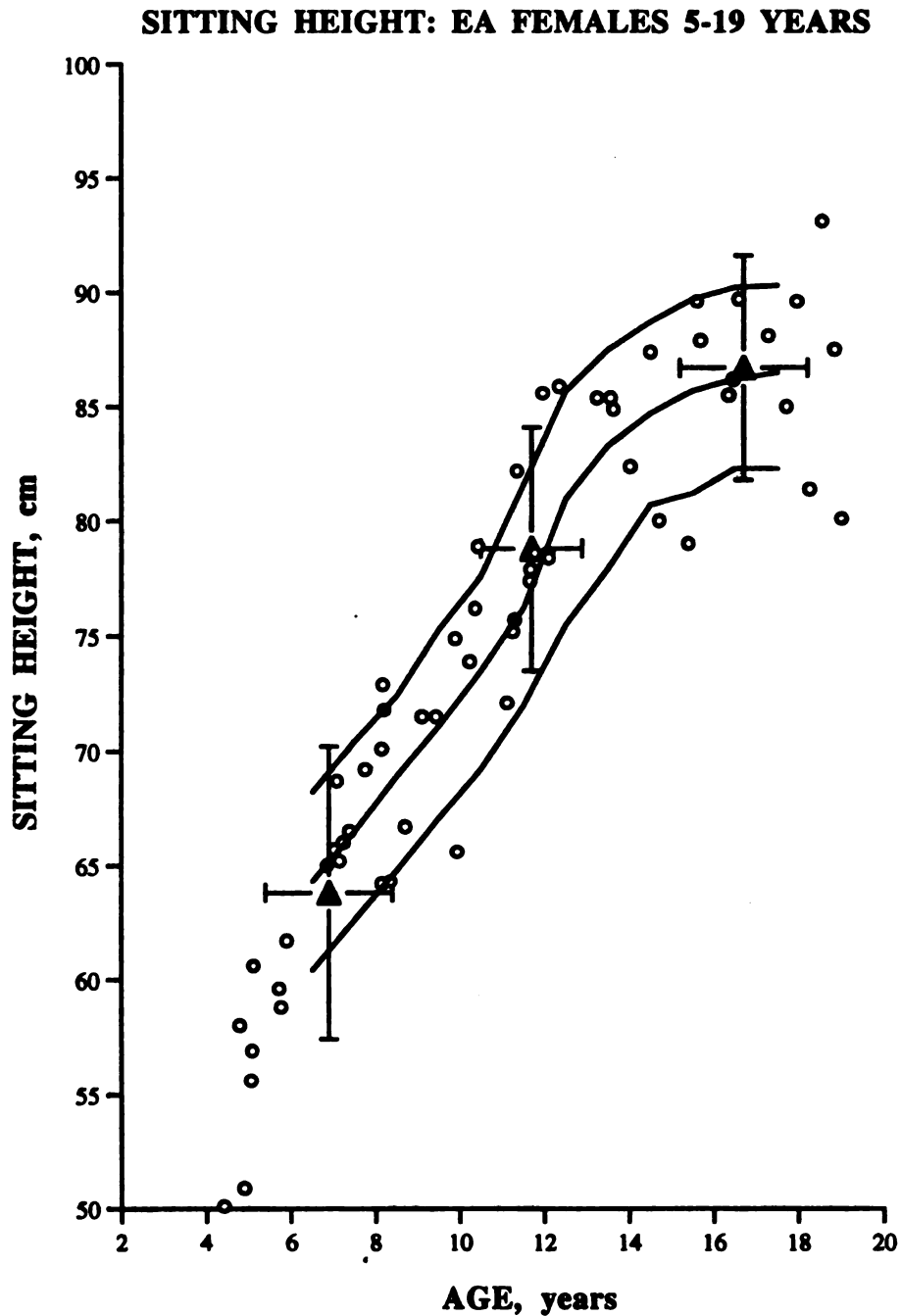


FIGURE 4.19 Sitting height of EA females (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

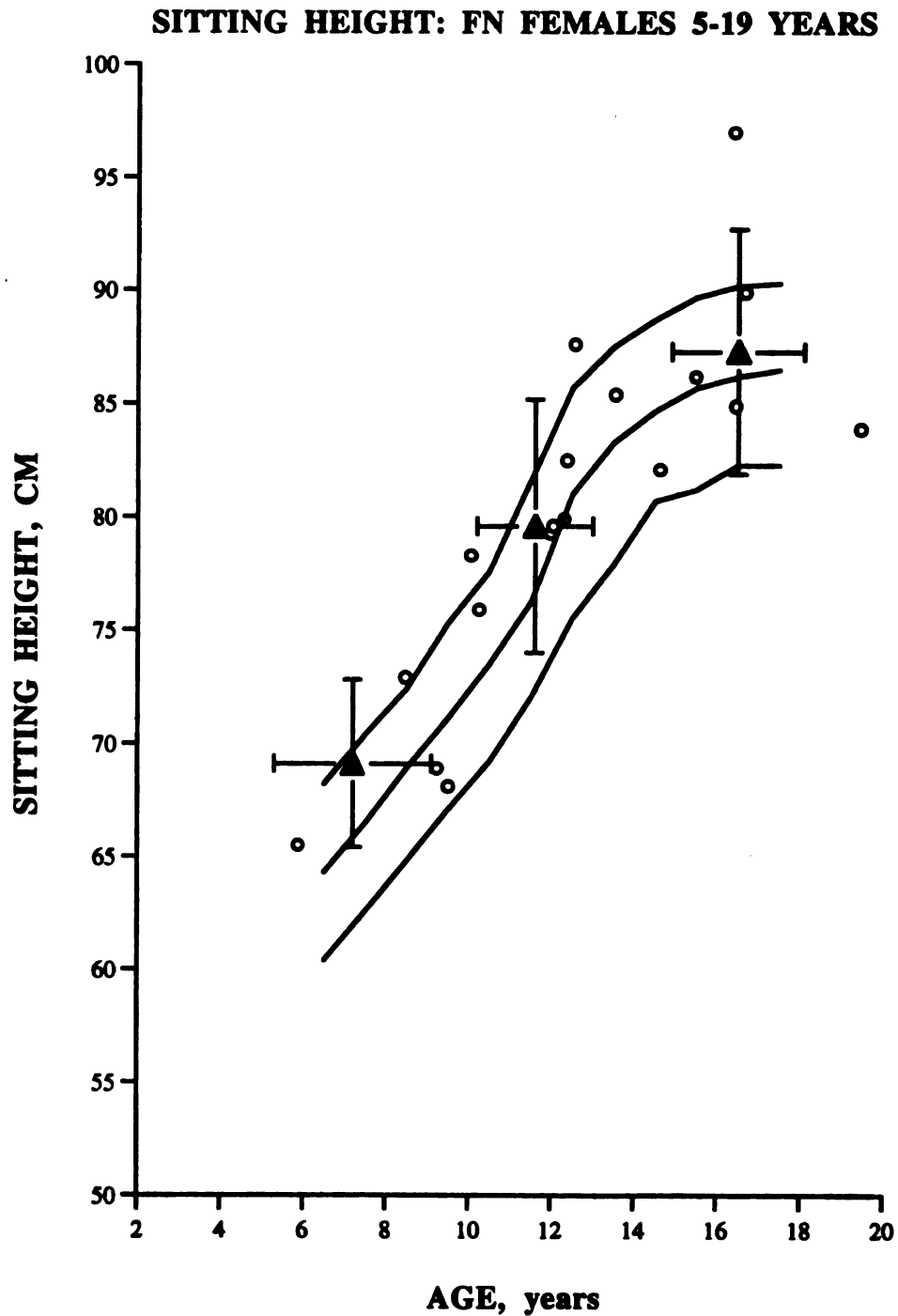


FIGURE 4.20 Sitting height of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

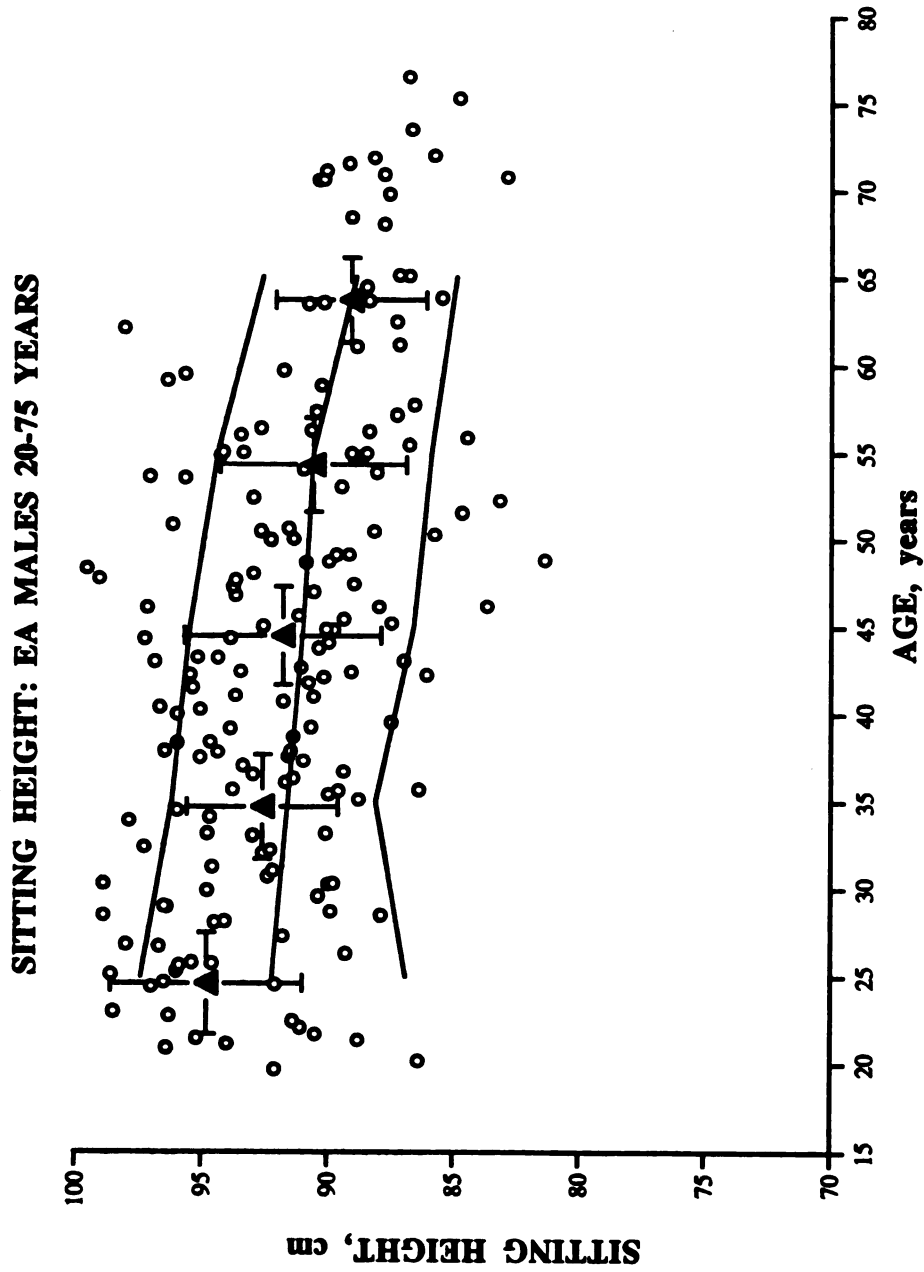


FIGURE 4.21 Sitting height of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SITTING HEIGHT: FN MALES 20-75 YEARS

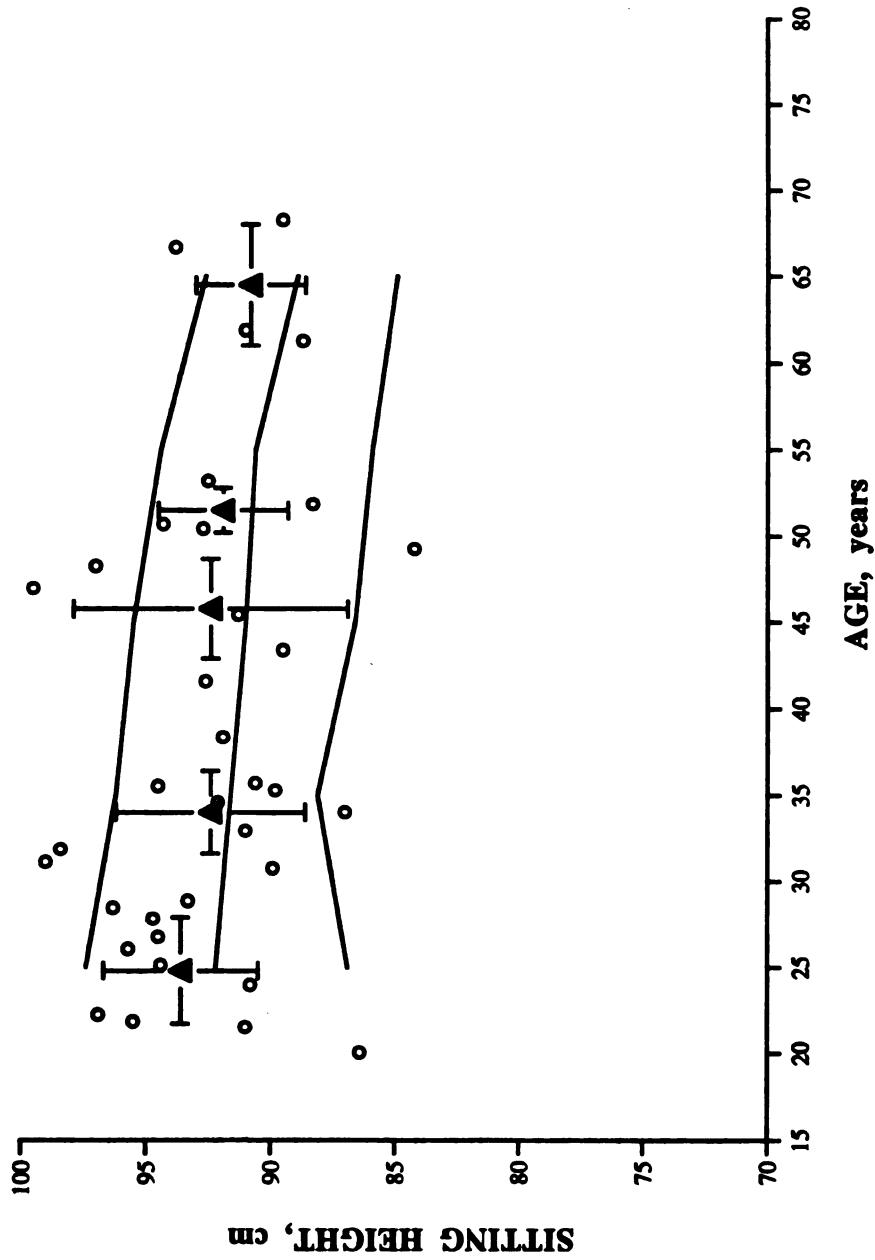


FIGURE 4.22 Sitting height of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SITTING HEIGHT: EA FEMALES 20-75 YEARS

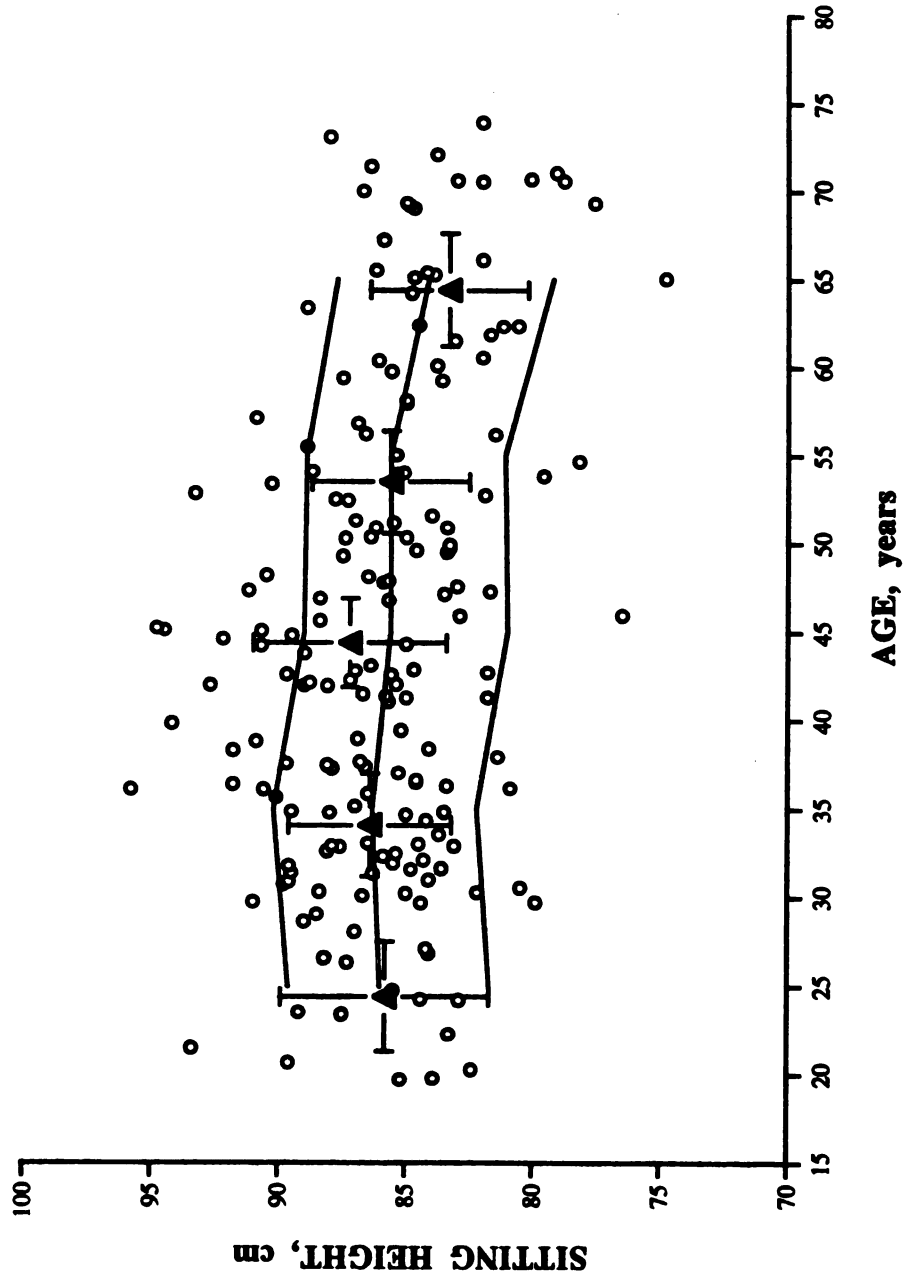


FIGURE 4.23 Sitting height of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

SITTING HEIGHT: FN FEMALES 20-75 YEARS

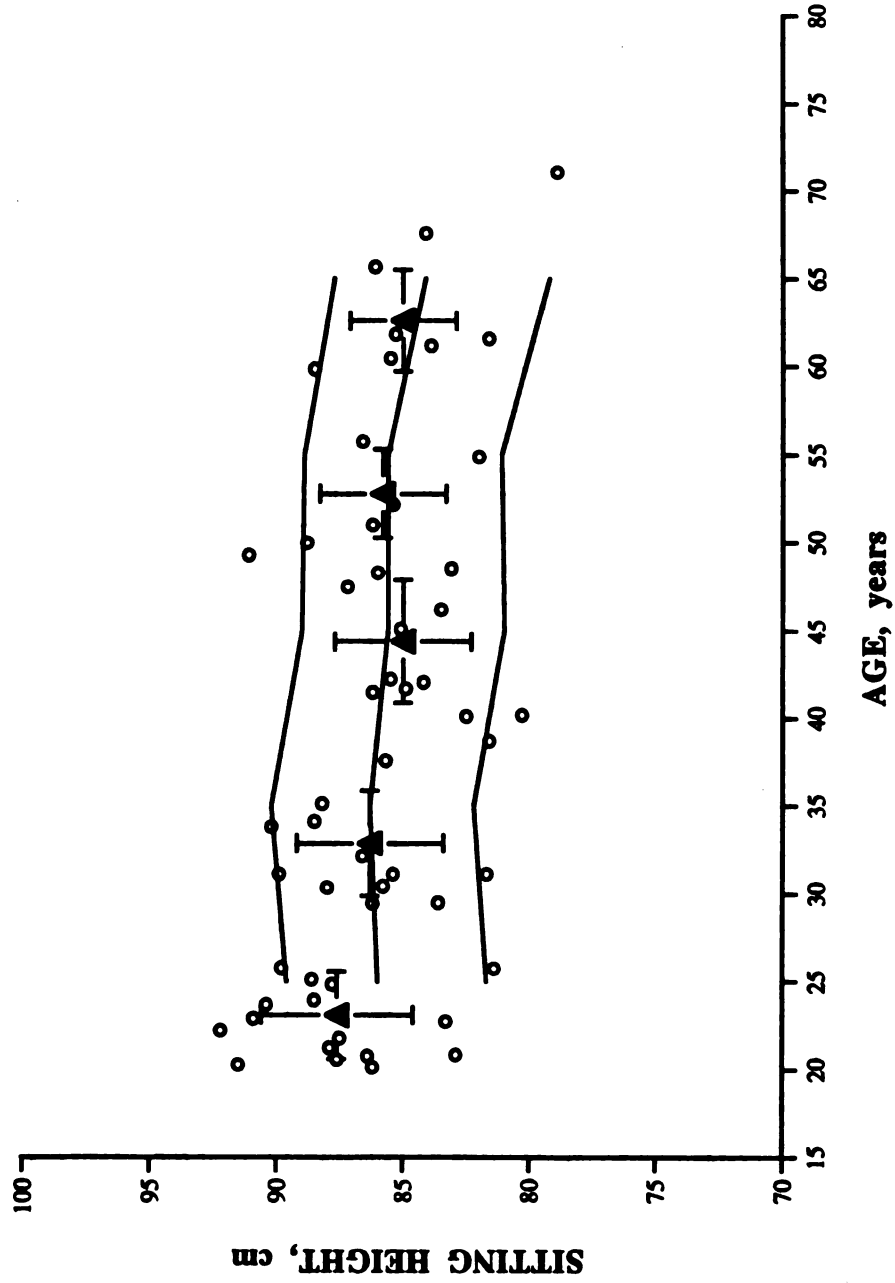


FIGURE 4.24 Sitting height of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBISCHIAL LENGTH: EA MALES 5-19 YEARS

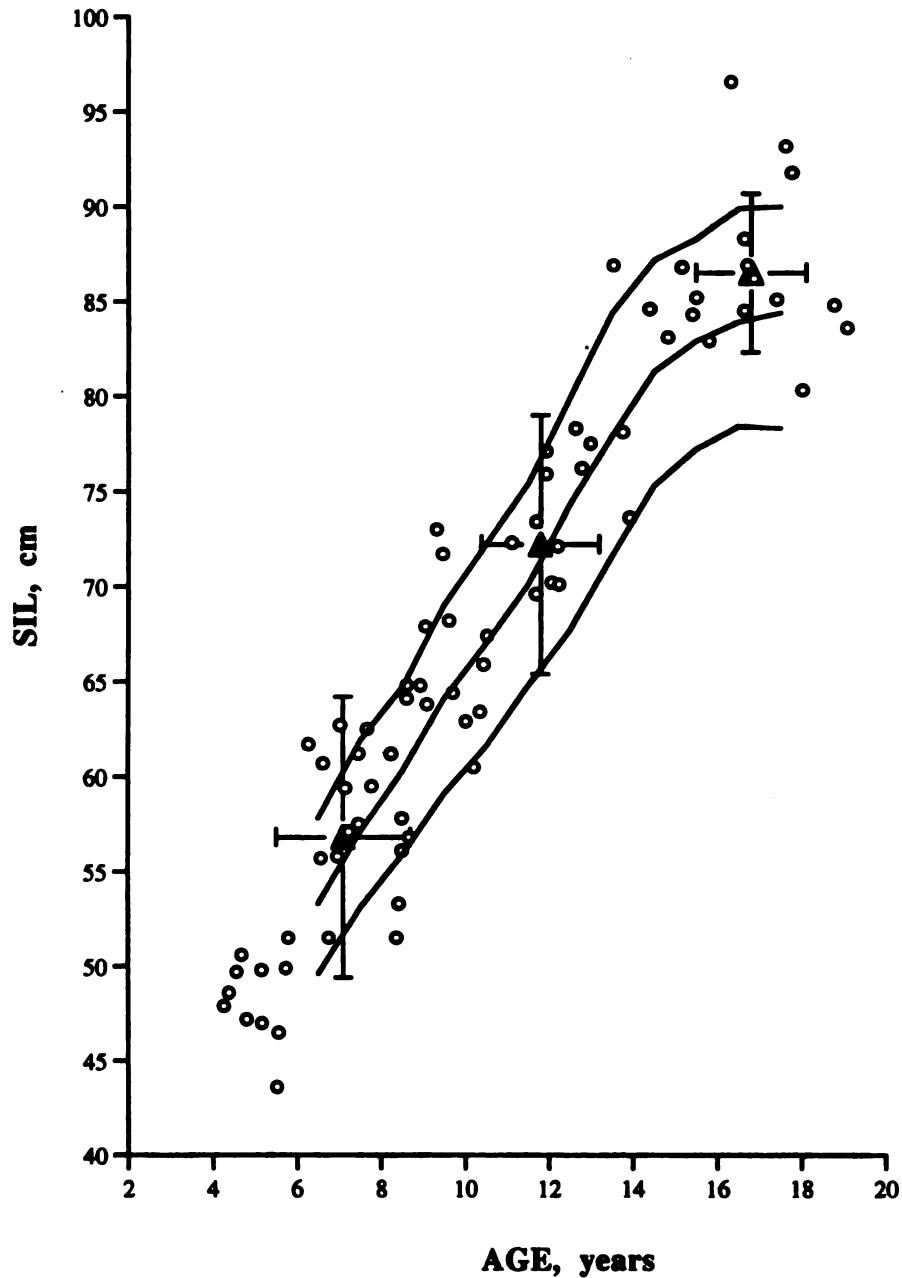


FIGURE 4.25 Estimated subischial length of EA males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBISCHIAL LENGTH: FN MALES 5-19 YEARS

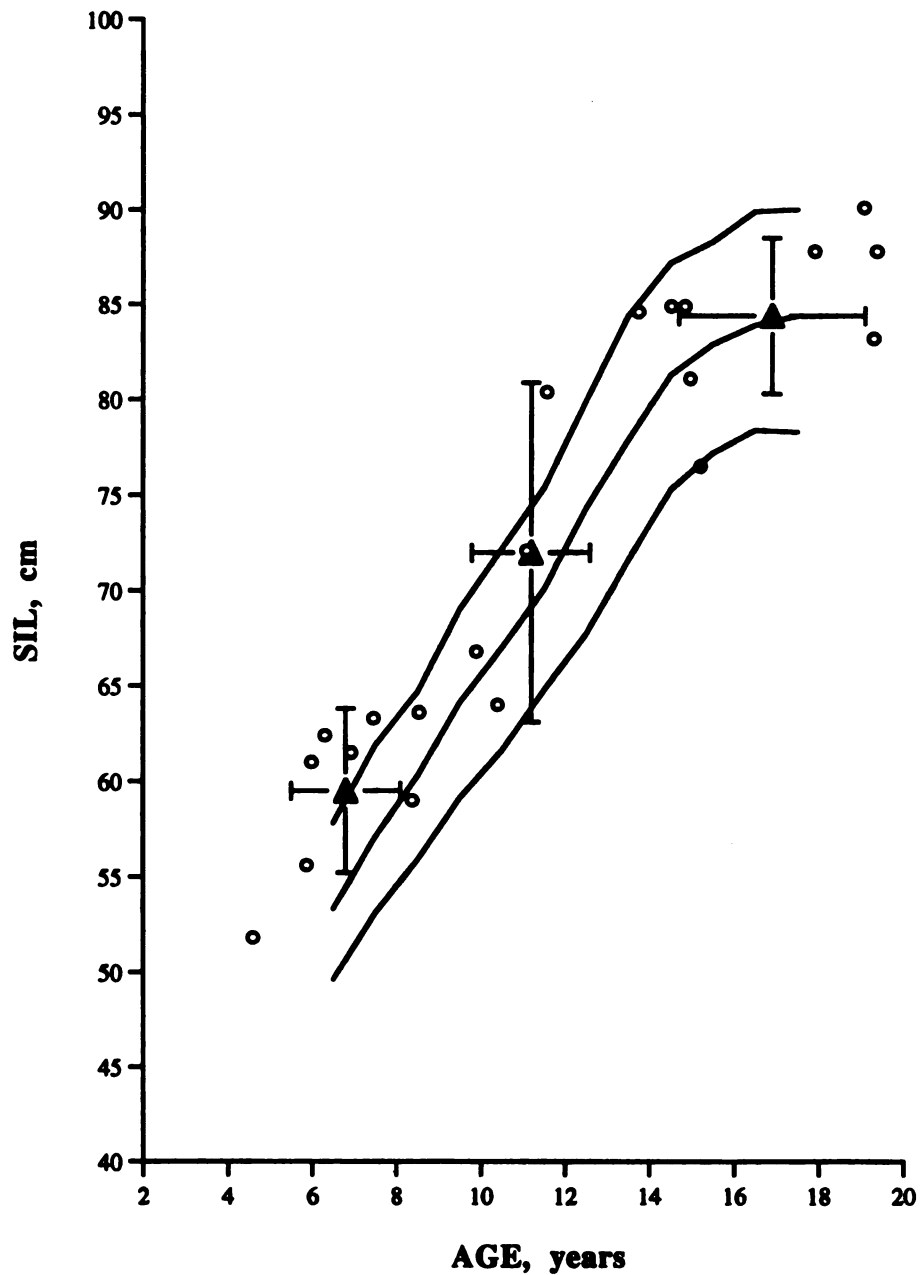


FIGURE 4.26 Estimated subischial length of FN males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBISCHIAL LENGTH: EA FEMALES 5-19 YEARS

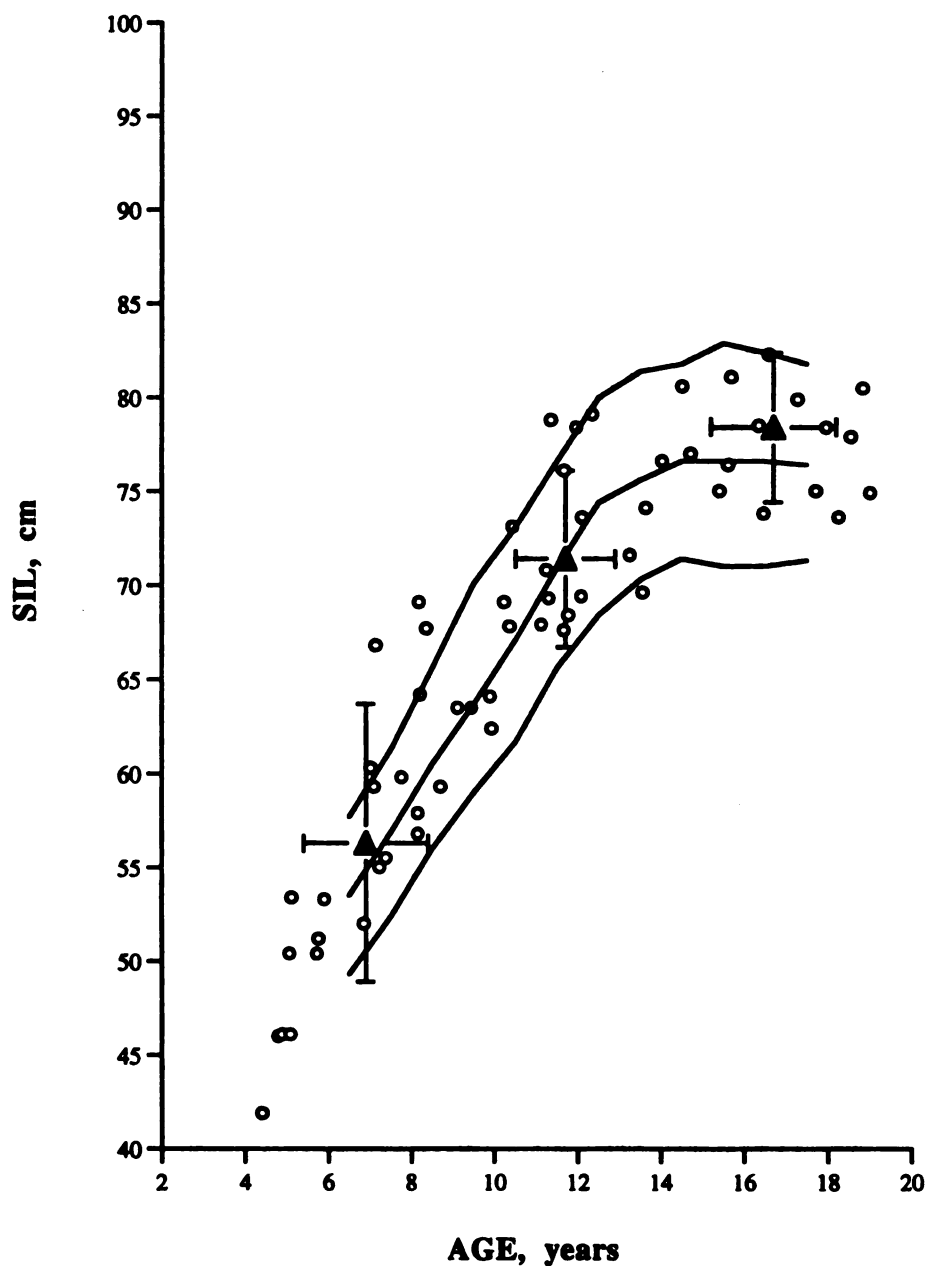


FIGURE 4.27 Estimated subischial length of EA females (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

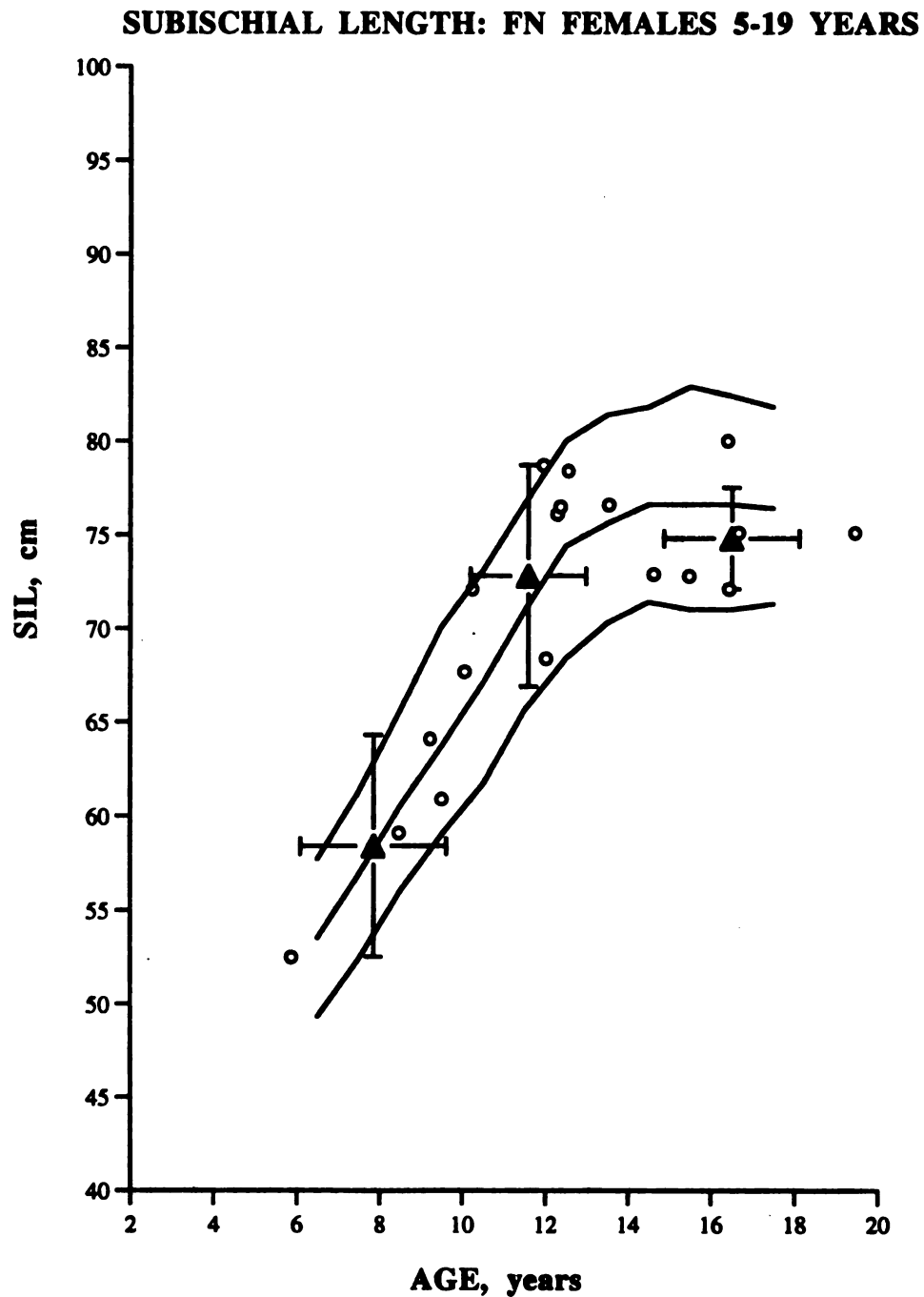


FIGURE 4.28 Estimated subischial length of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

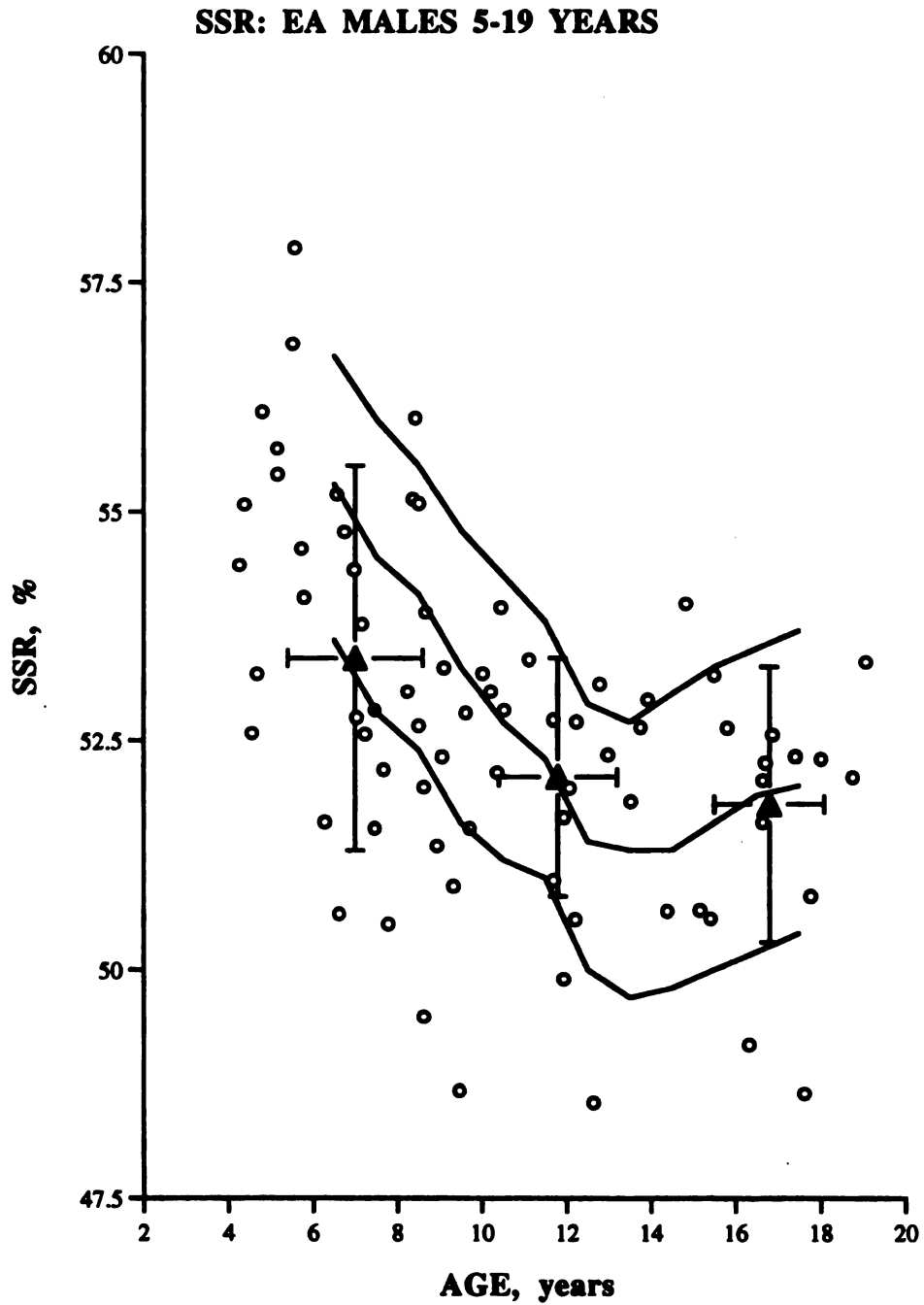


FIGURE 4.29 Sitting height/stature ratio of EA males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

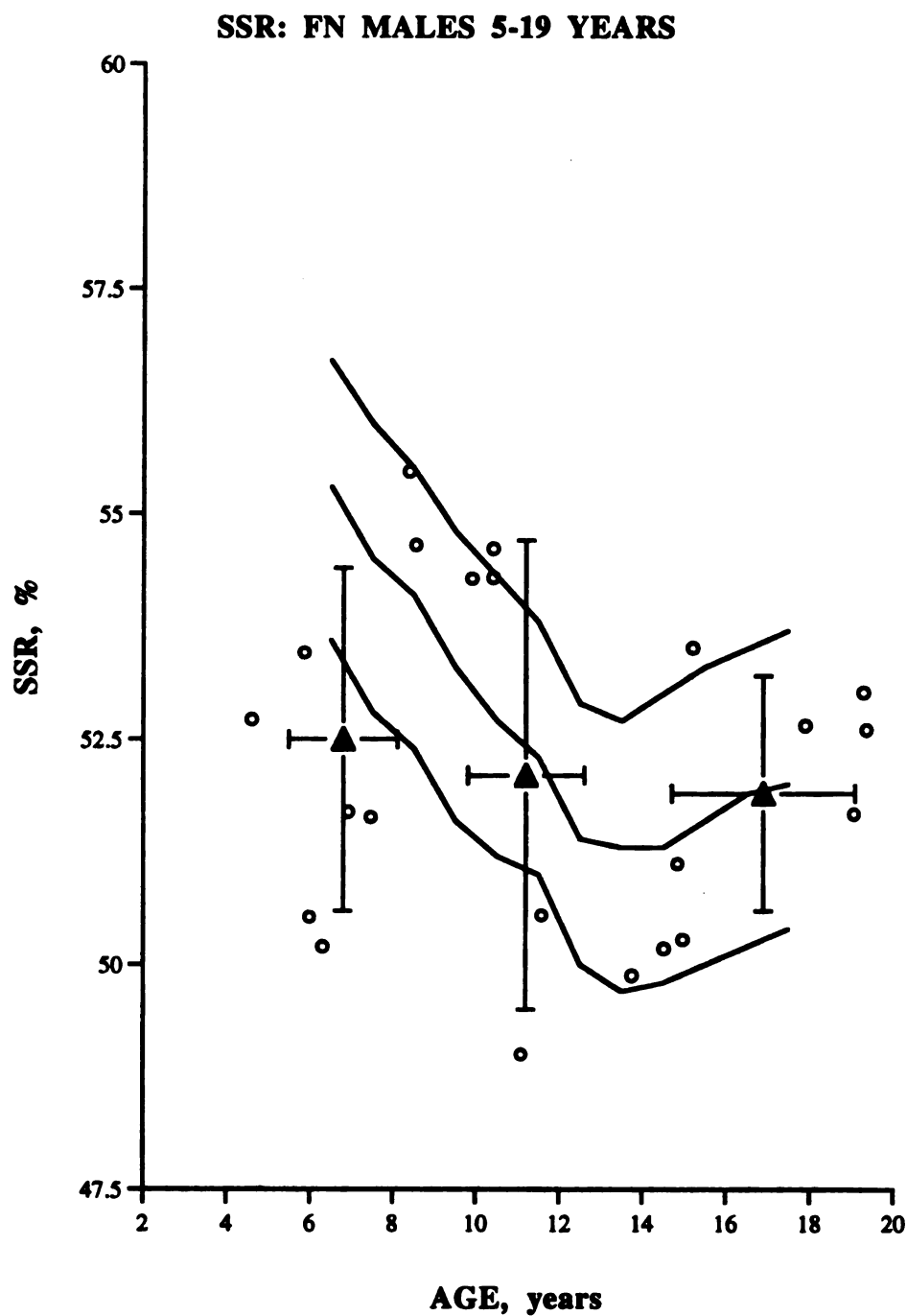


FIGURE 4.30 Sitting height/stature ratio of FN males (o) 5-19 years and five-year age group means (▲ ± SD) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

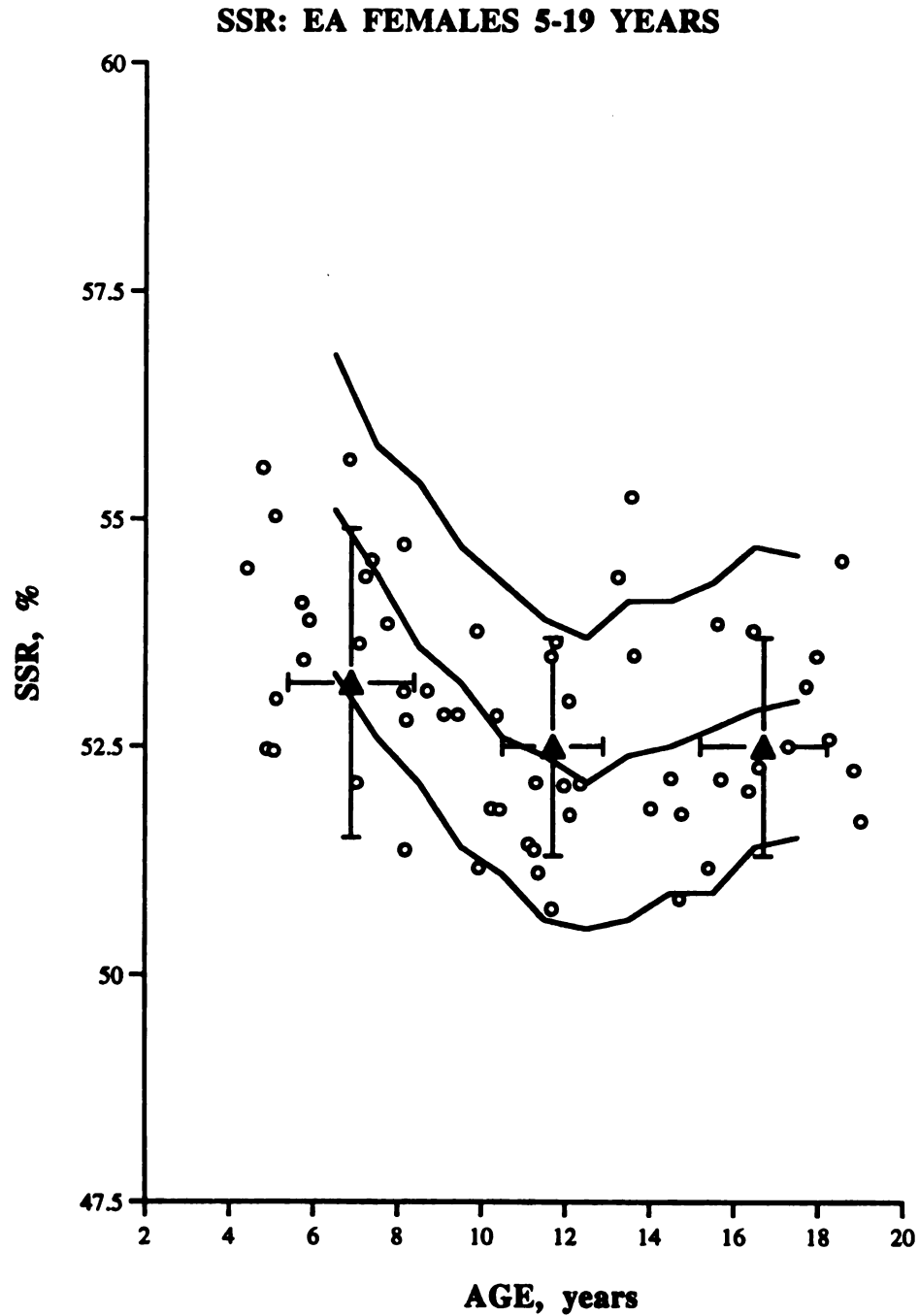


FIGURE 4.31 Sitting height/stature ratio of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

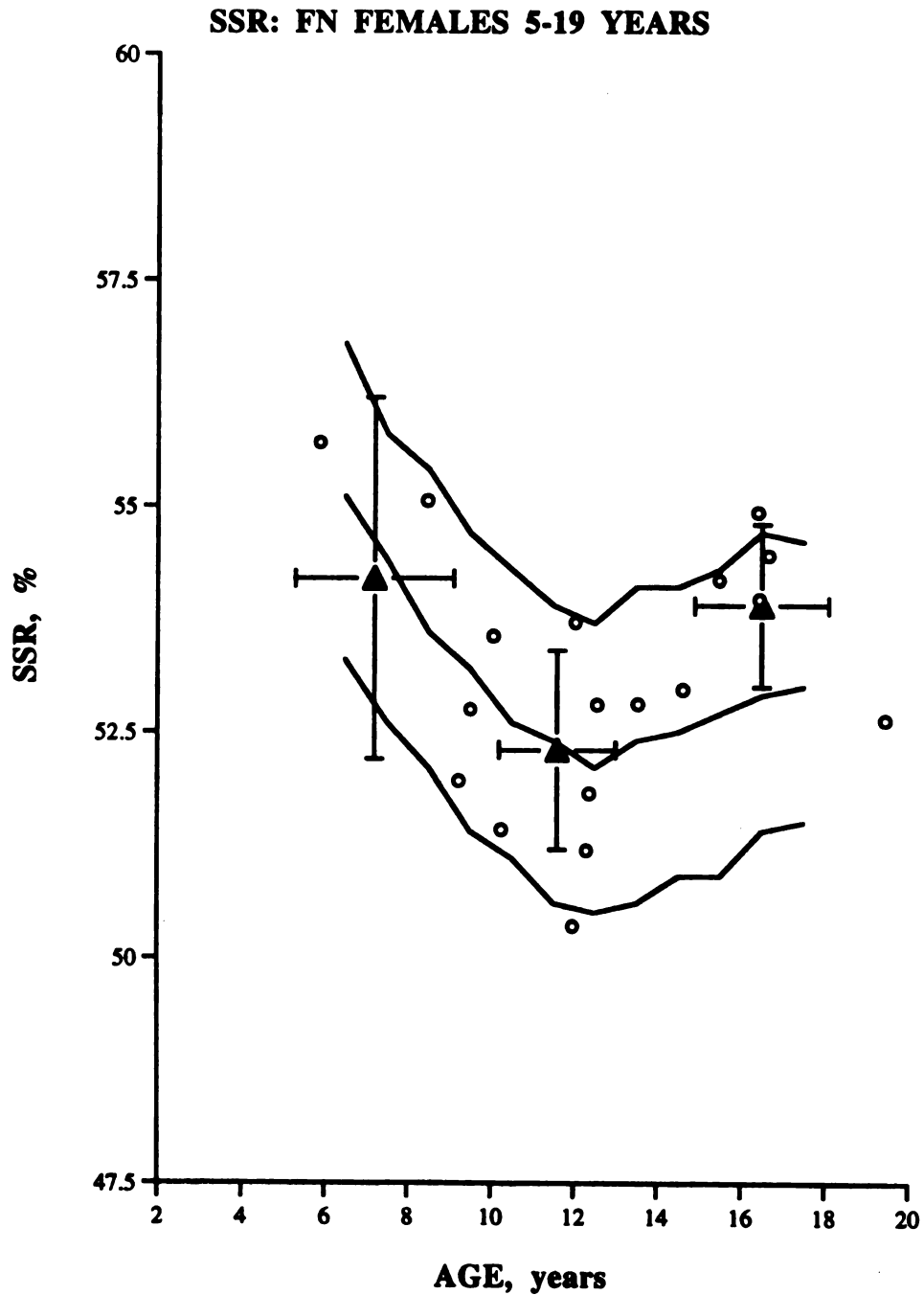


FIGURE 4.32 Sitting height/stature ratio of FN females (o) 5-19 years and five-year age group means ($\blacktriangle \pm$ SD) plotted relative to U.S. reference data (Hamill et al., 1973; Malina et al., 1974). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

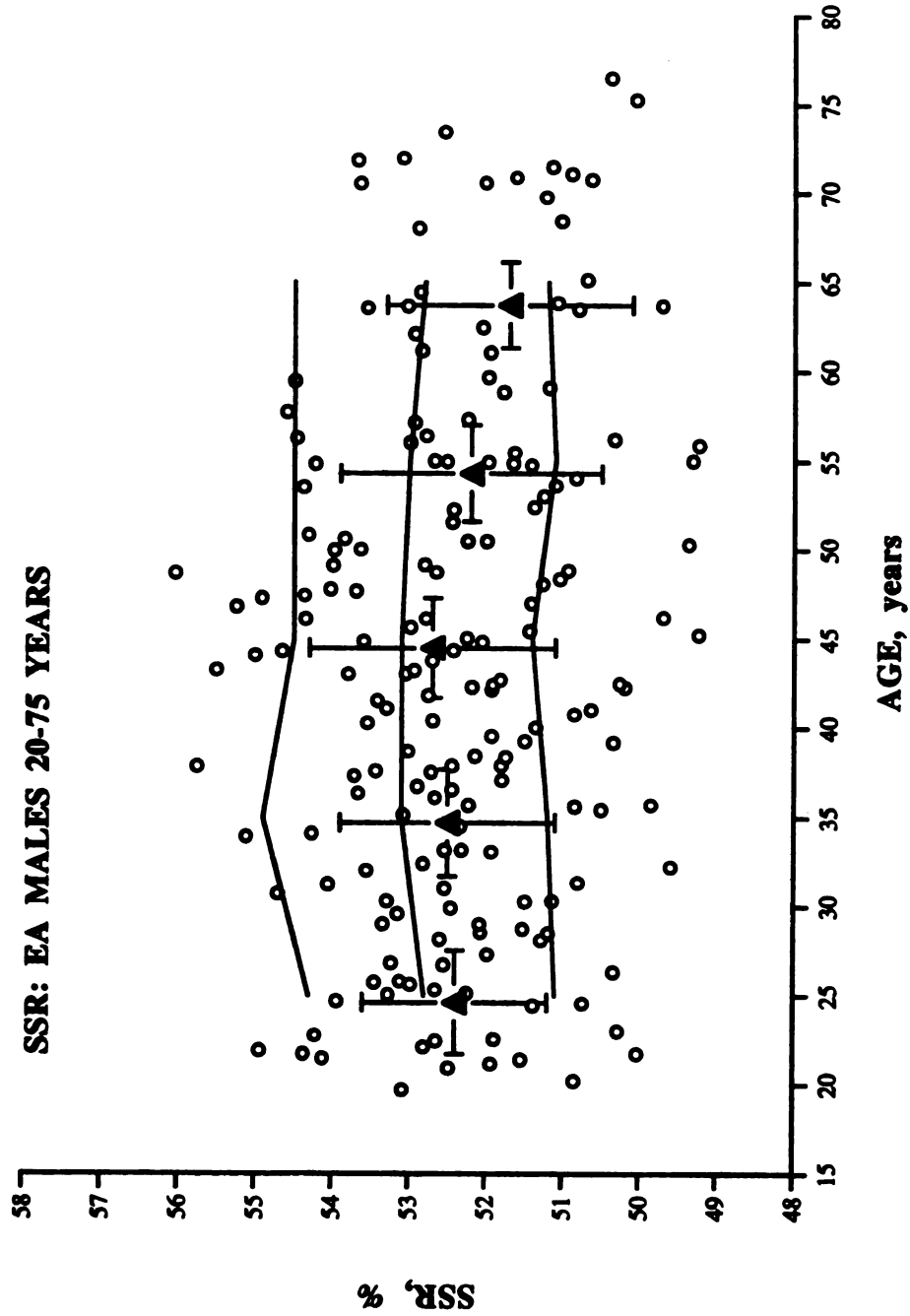


FIGURE 4.33 Sitting height/stature ratio of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) groups plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SSR: FN MALES 20-75 YEARS

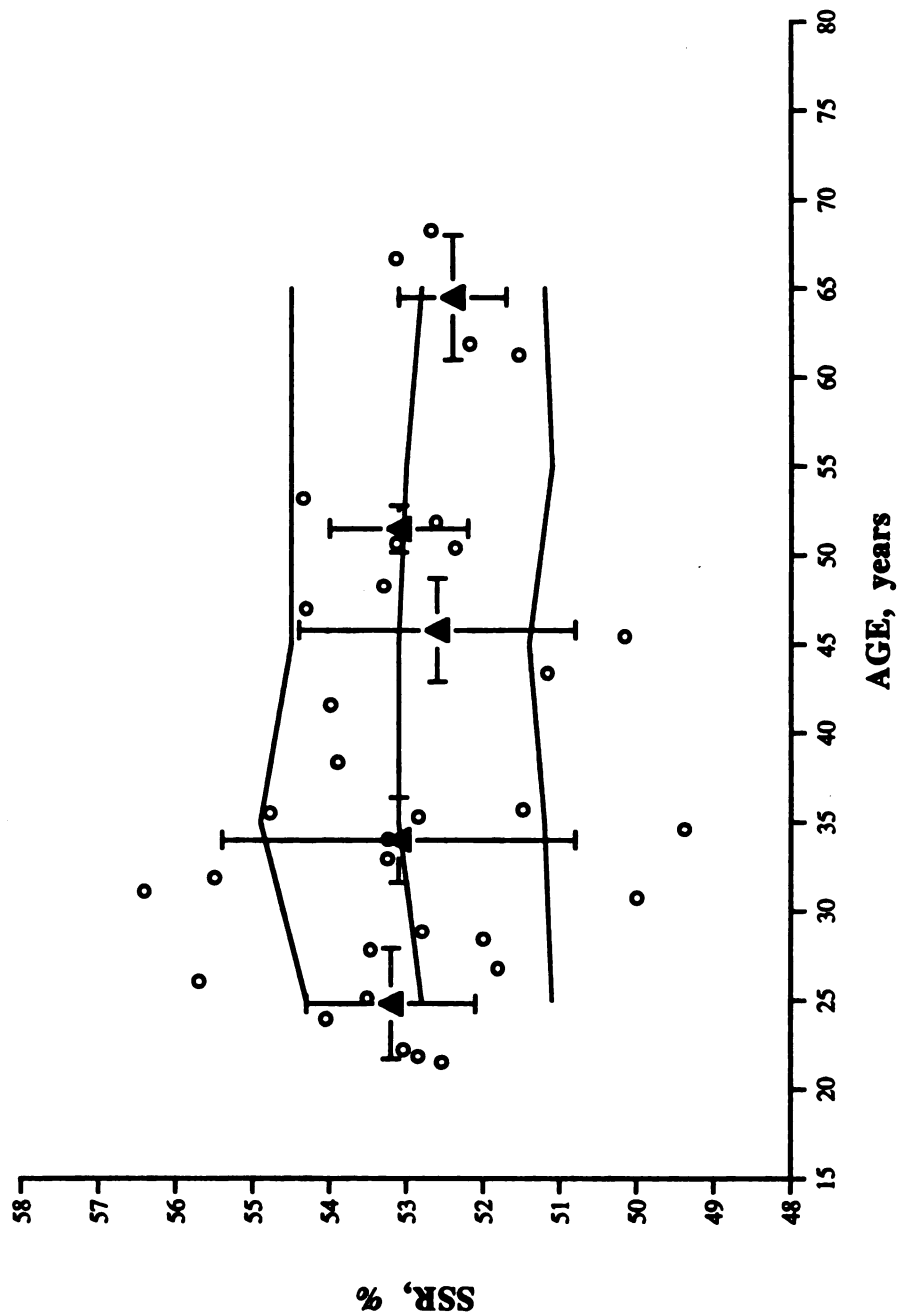


FIGURE 4.34 Sitting height/stature ratio of FN males (o) 20-75 years and ten-year age group means (▲ ± SD) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

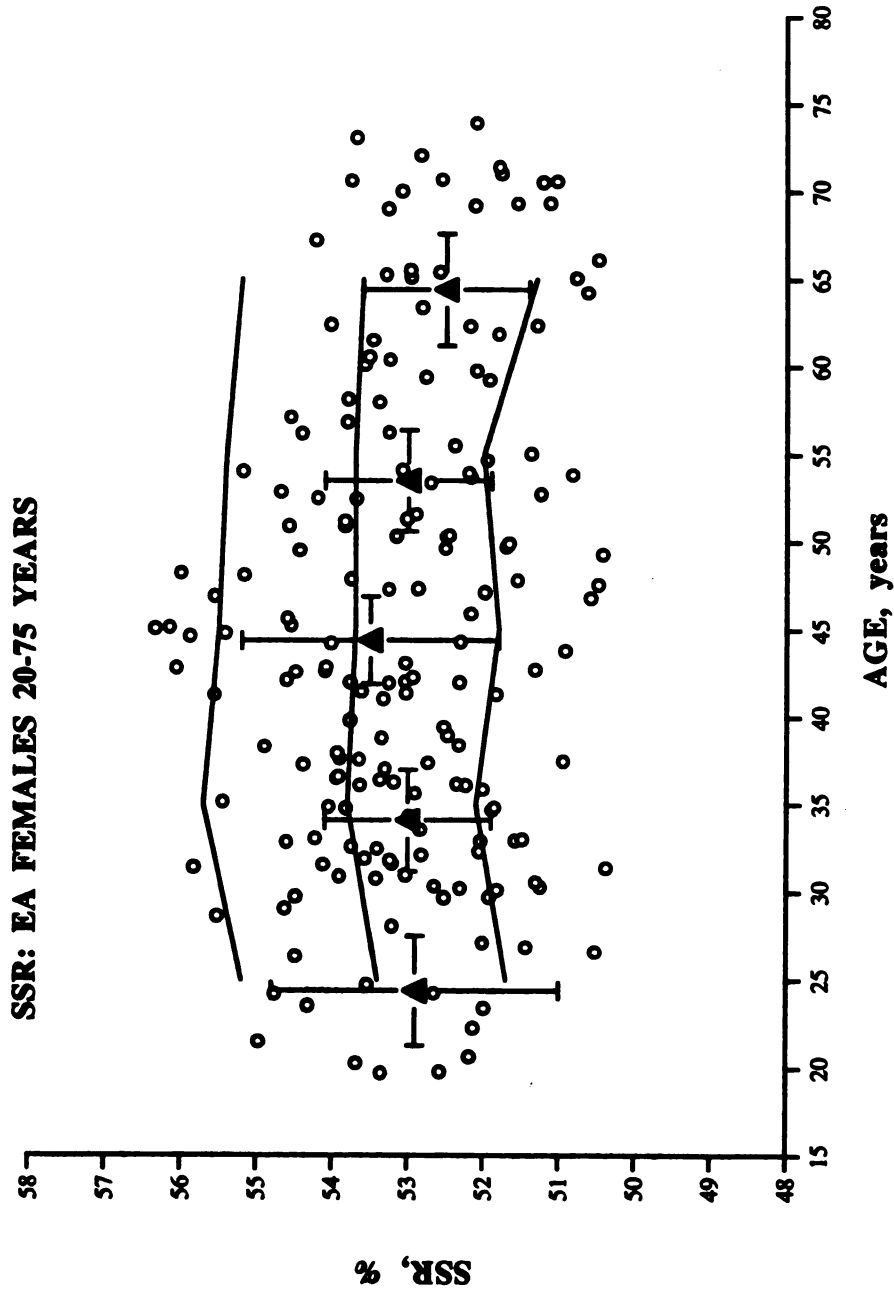


FIGURE 4.35 Sitting height/stature ratio of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

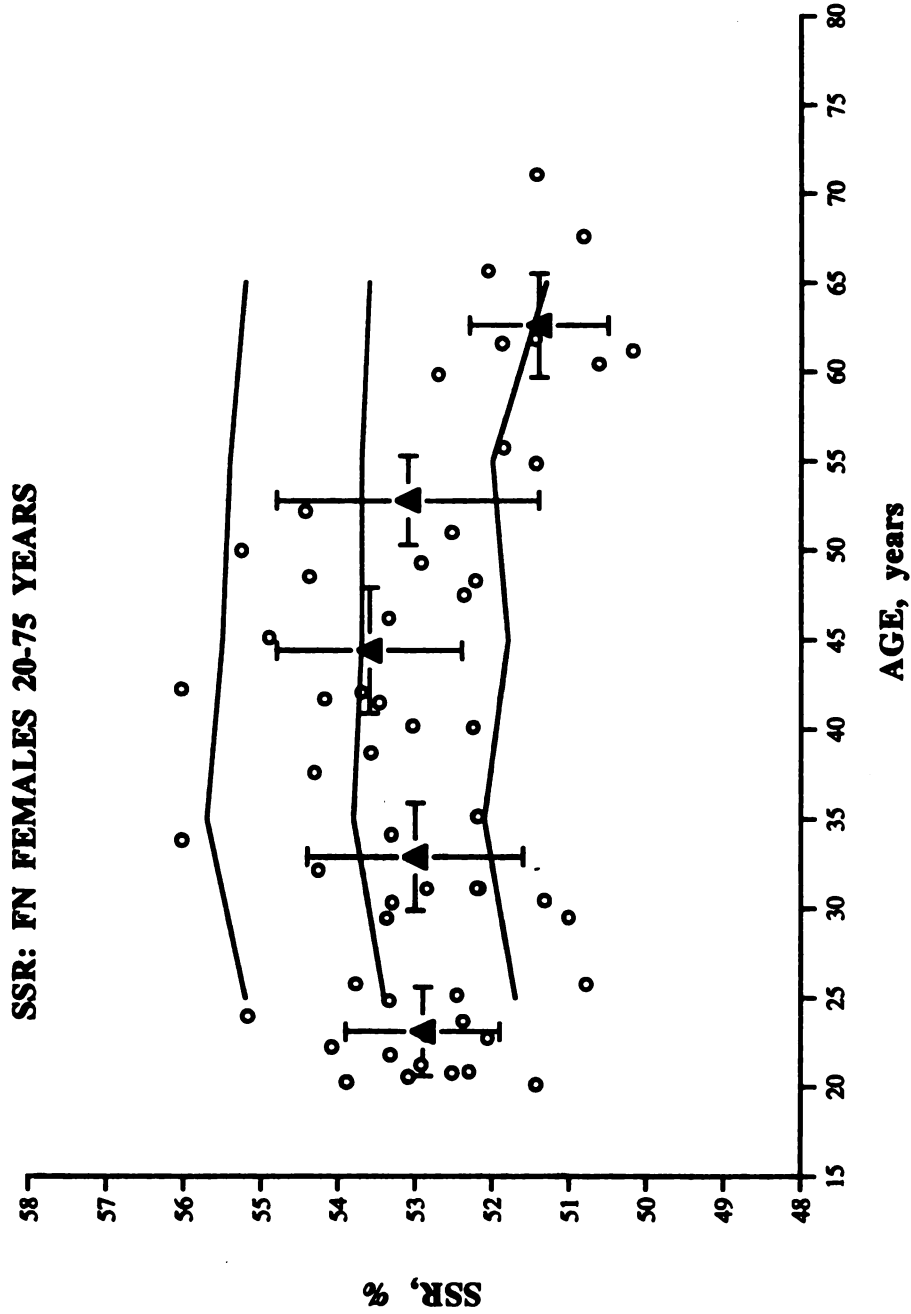


FIGURE 4.36 Sitting height/stature ratio of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Health and Welfare Canada, 1980). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

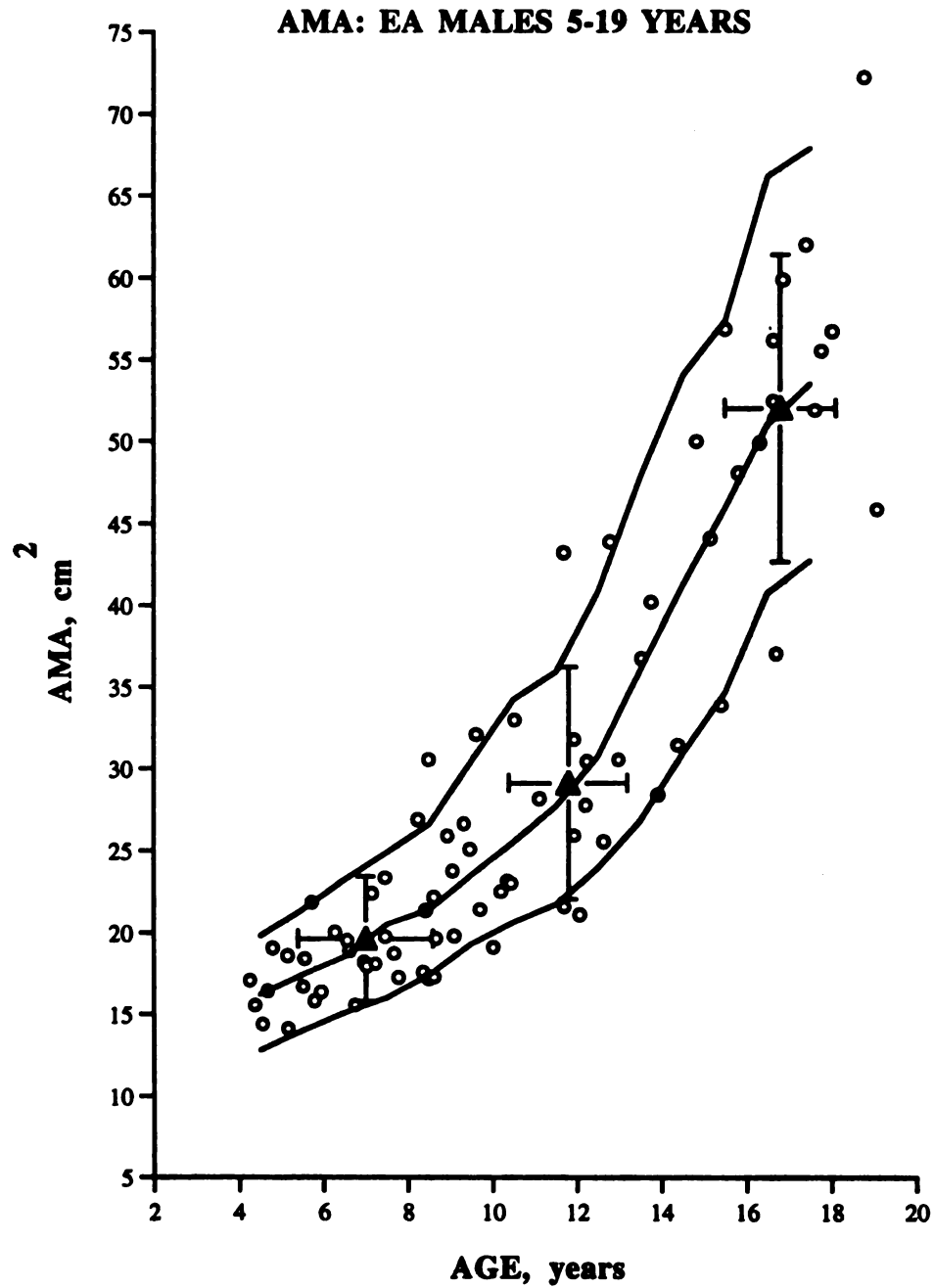


FIGURE 4.37 Estimated arm muscle area of EA males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

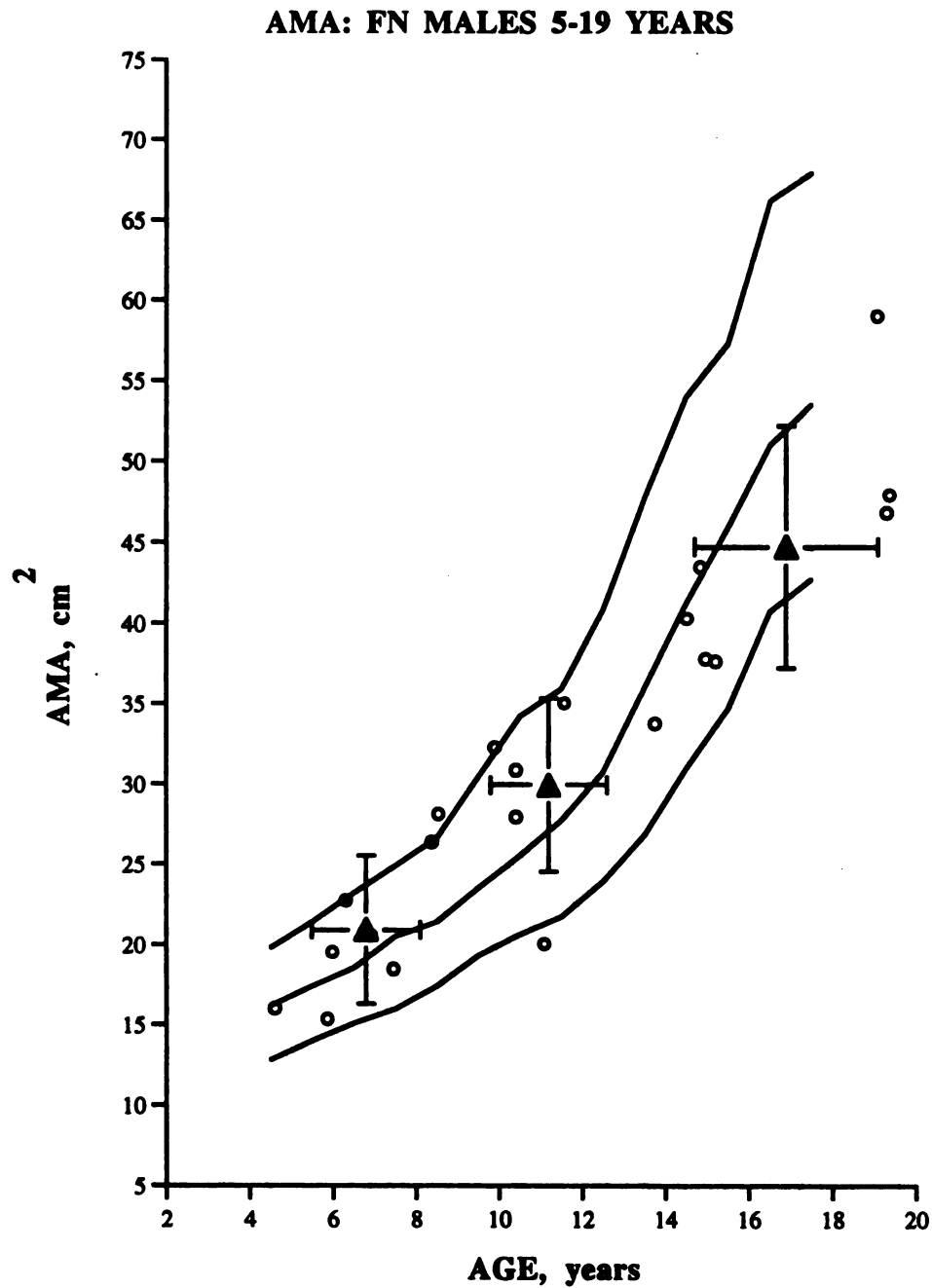


FIGURE 4.38 Estimated arm muscle area of FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

AMA: EA FEMALES 5-19 YEARS

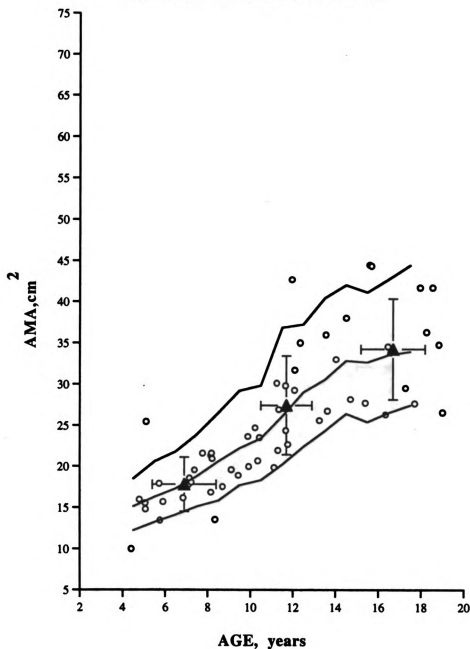


FIGURE 4.39 Estimated arm muscle area of EA females (o) 5-19 years and five-year age group means ($\blacktriangle \pm \text{SD}$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

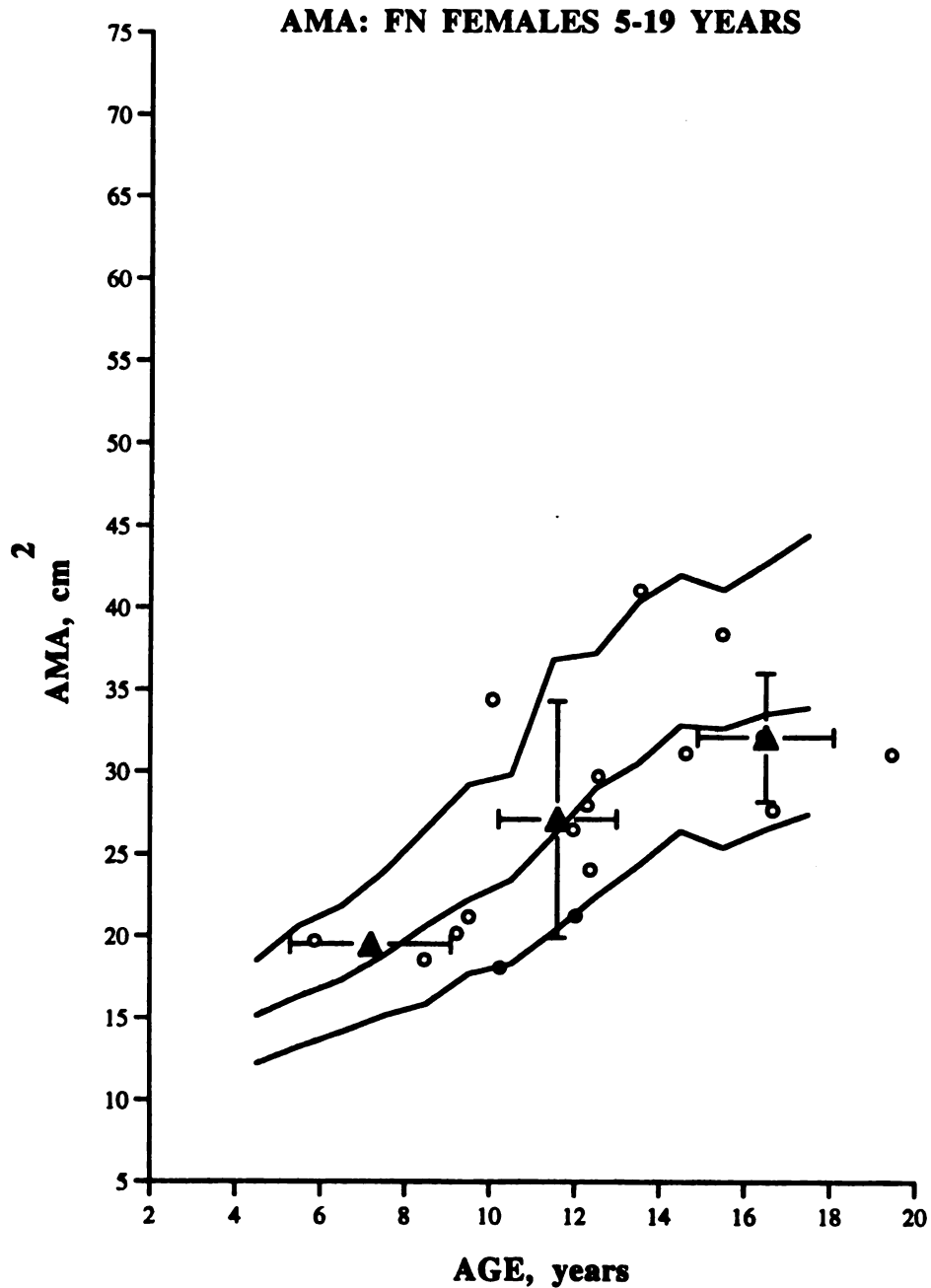


FIGURE 4.40 Estimated arm muscle area of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

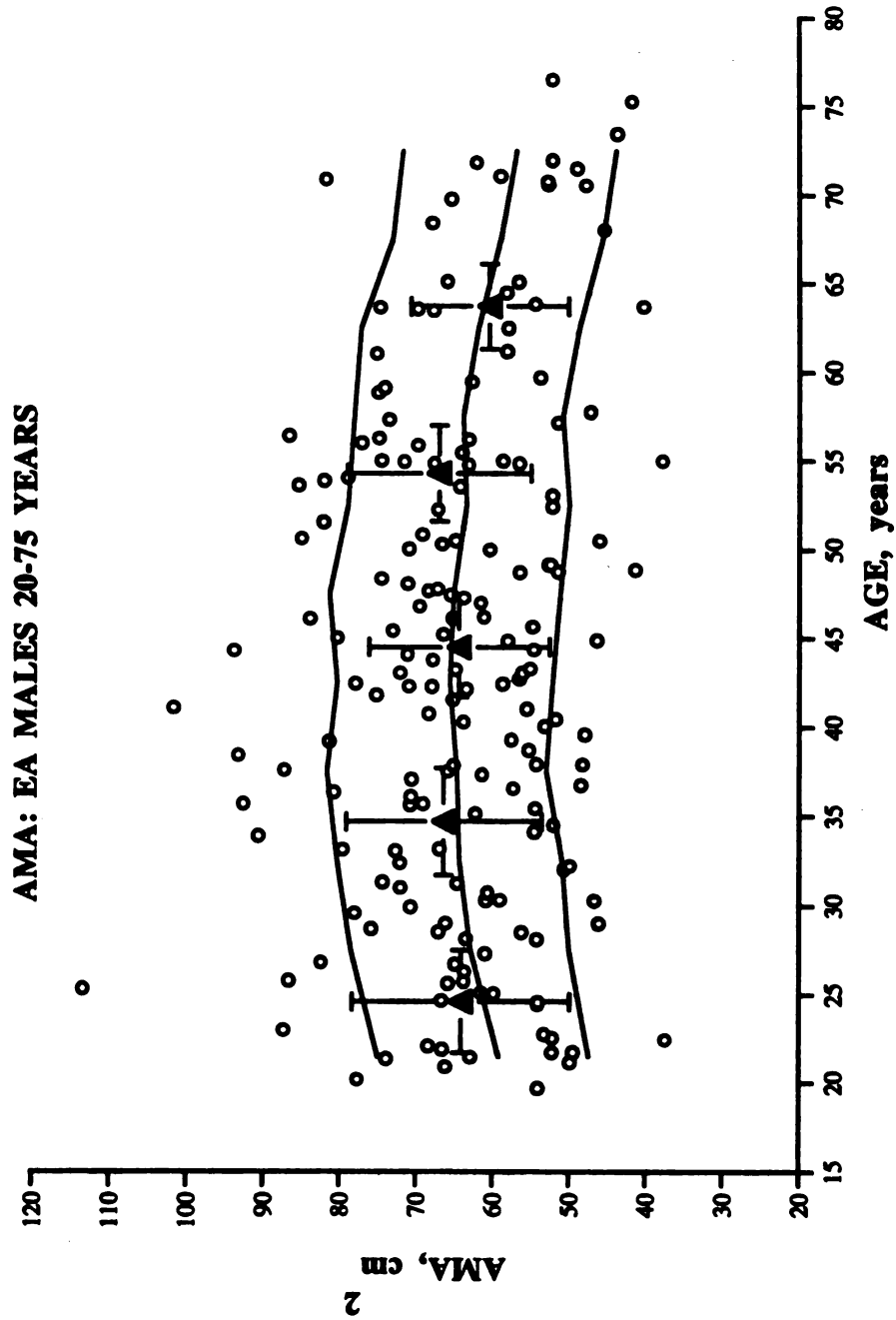


FIGURE 4.41 Estimated arm muscle area of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

AMA: FN MALES 20-75 YEARS

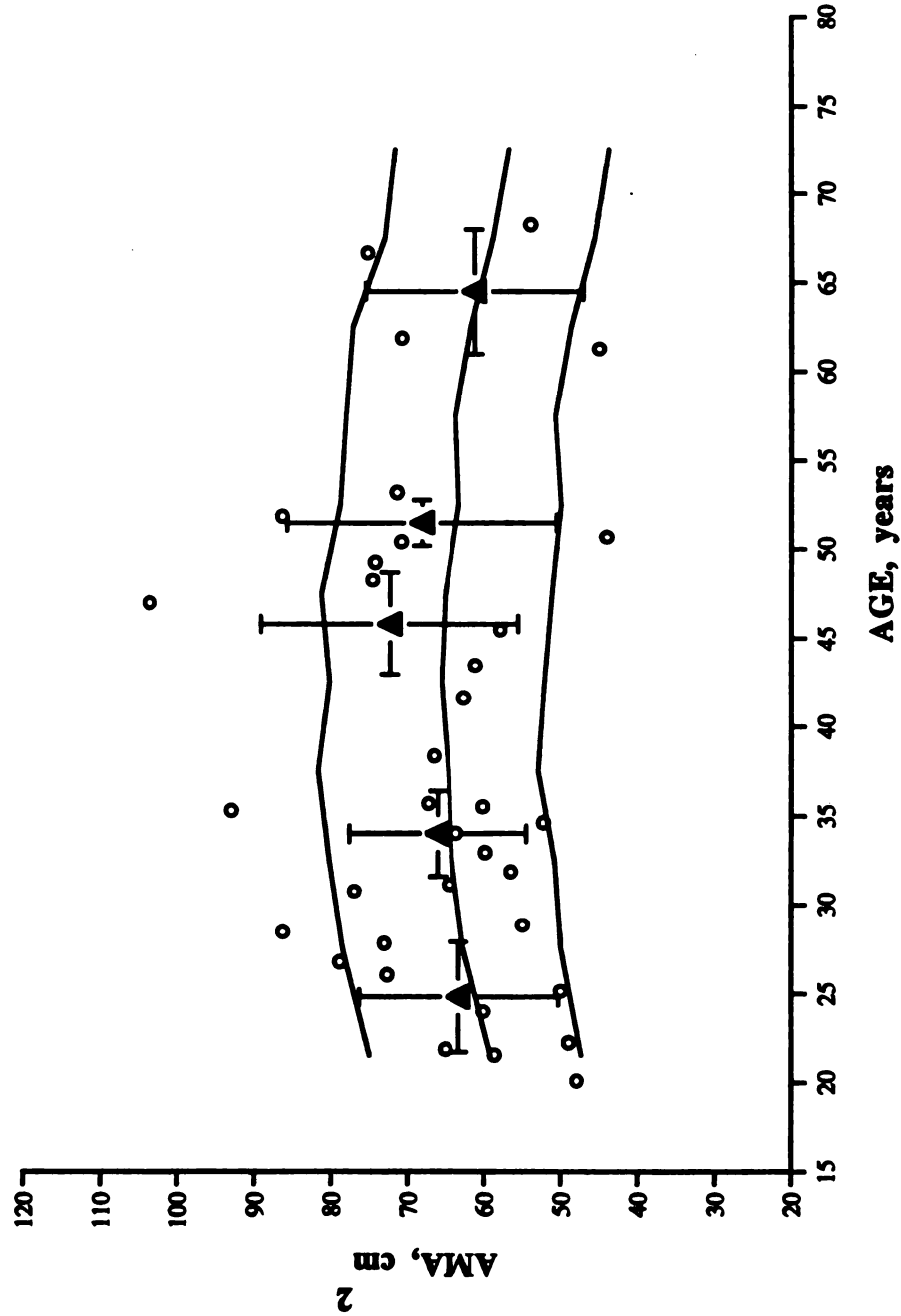


FIGURE 4.42 Estimated arm muscle area of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

AMA: EA FEMALES 20-75 YEARS

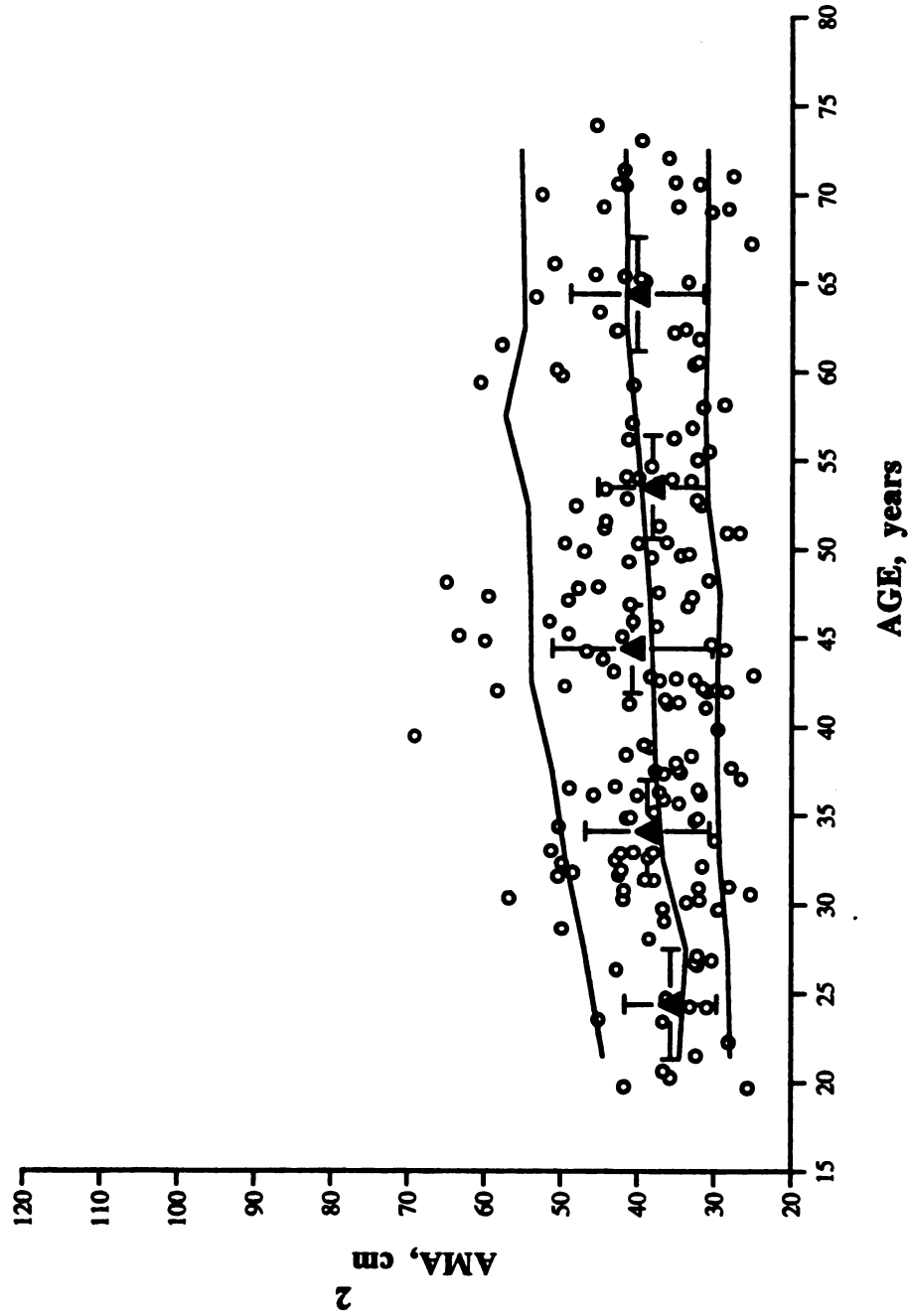


FIGURE 4.43 Estimated arm muscle area of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

AMA: FN FEMALES 20-75 YEARS

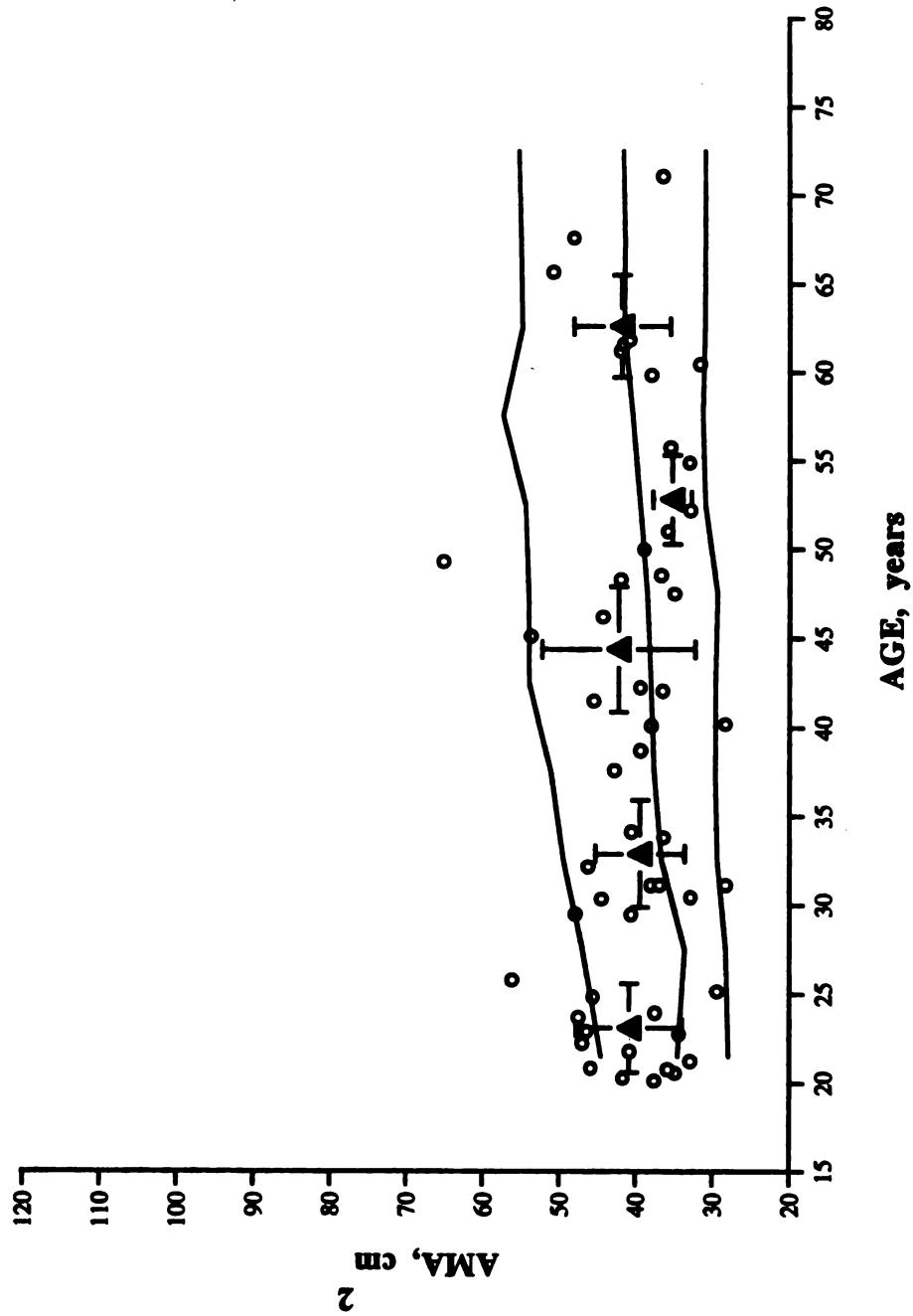


FIGURE 4.44 Estimated arm muscle area of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to U.S. reference data (Frisancho, 1990). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

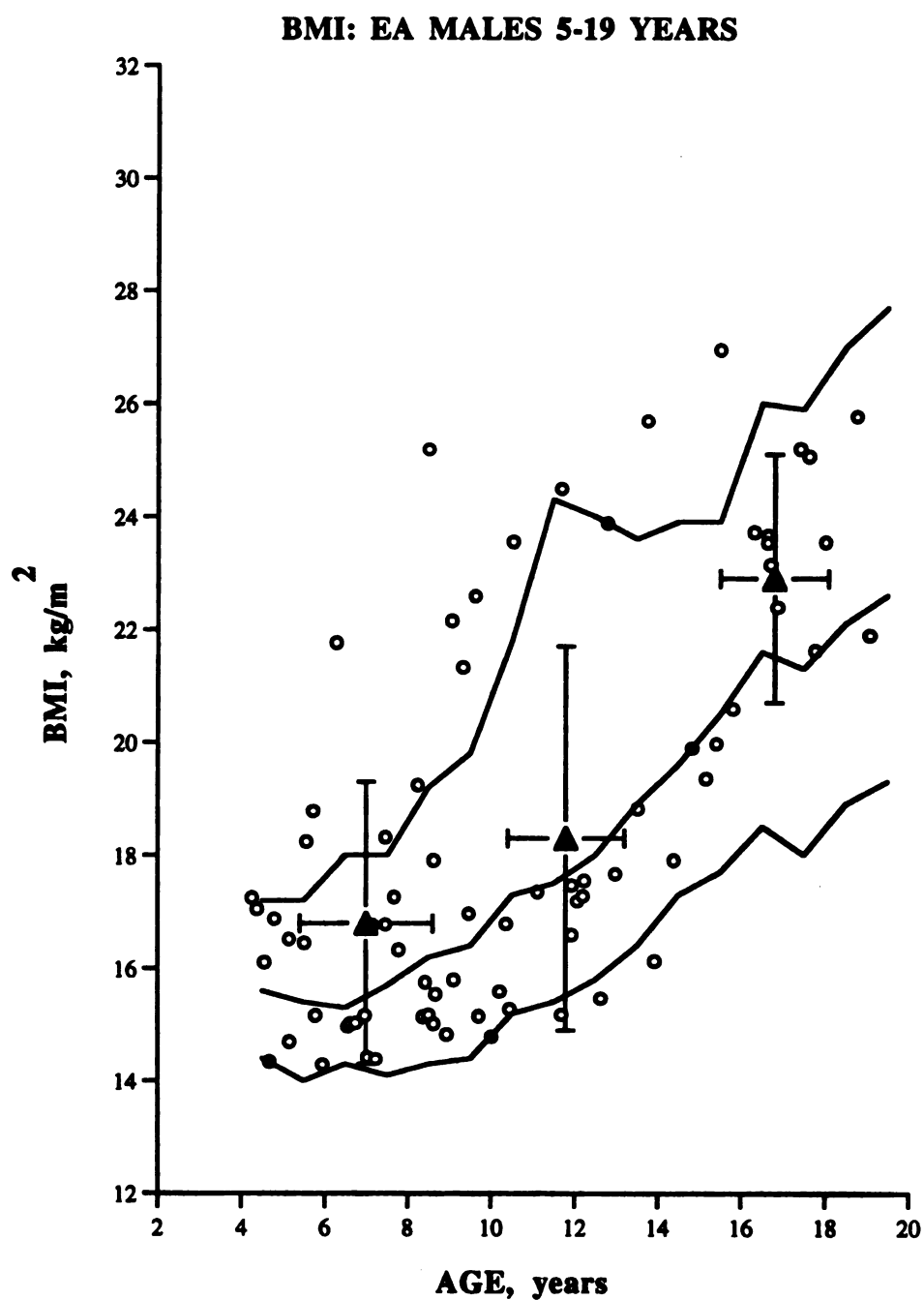


FIGURE 4.45 BMI of EA males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

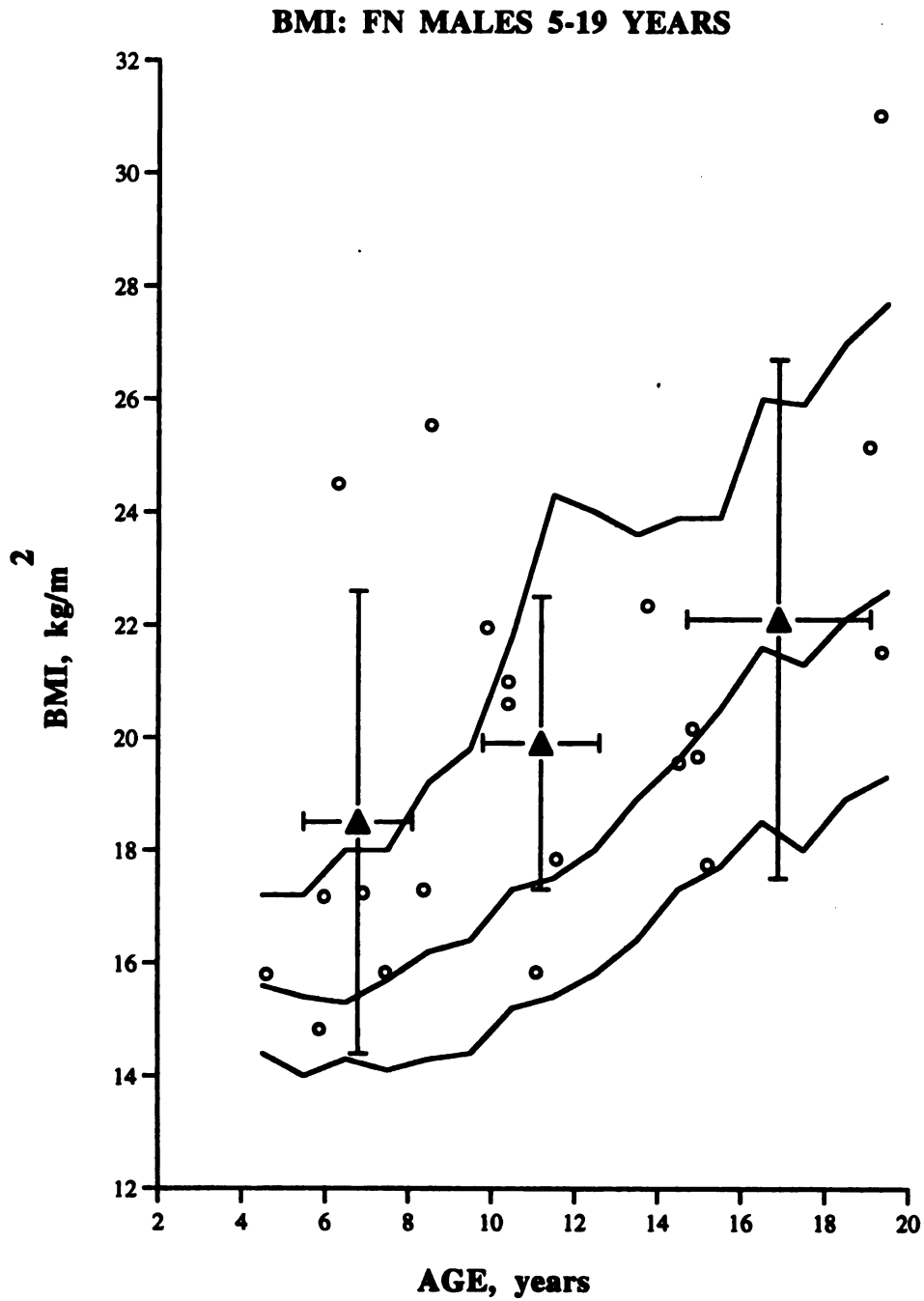


FIGURE 4.46 BMI of FN males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

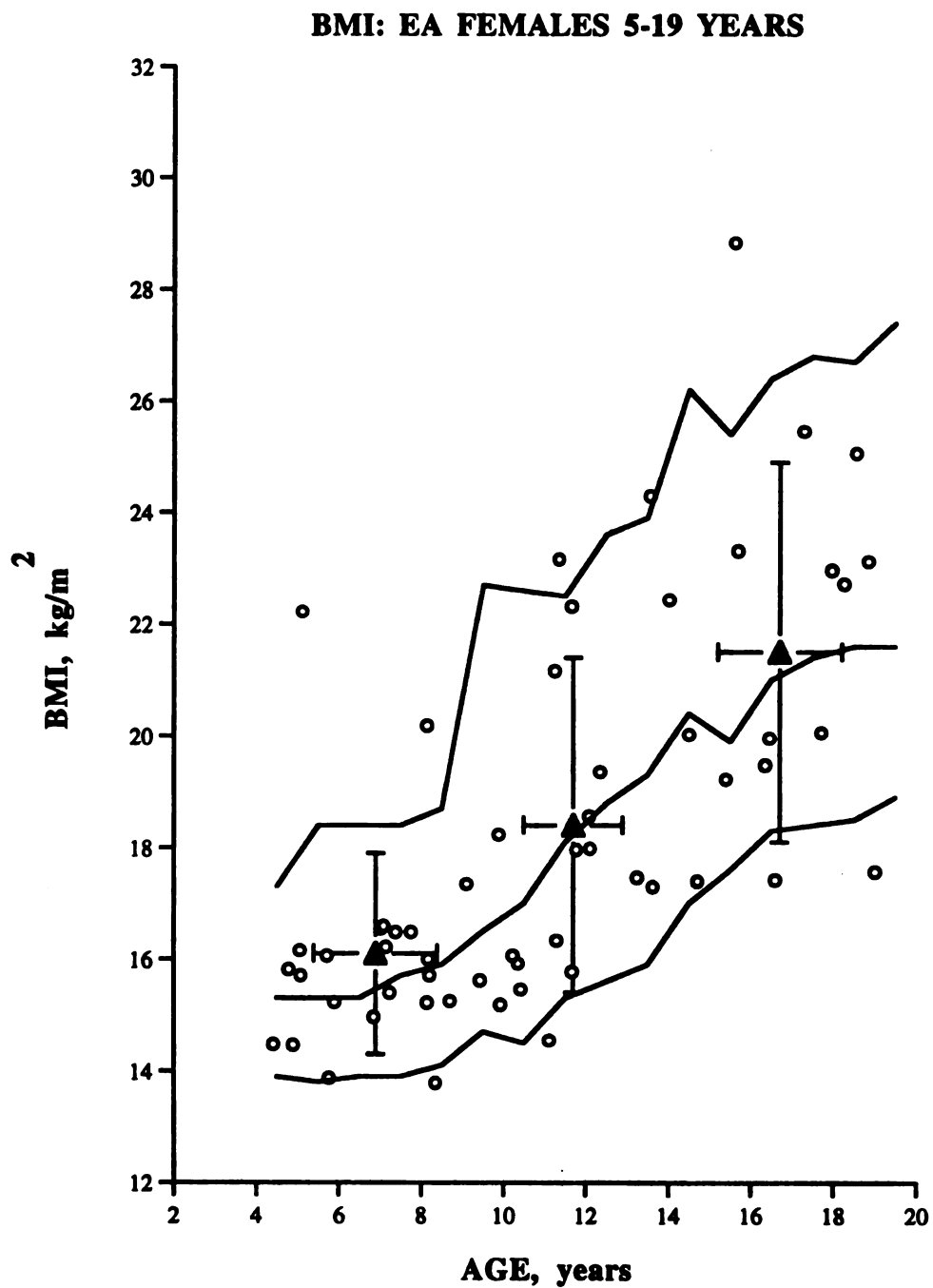


FIGURE 4.47 BMI of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

BMI: FN FEMALES 5-19 YEARS

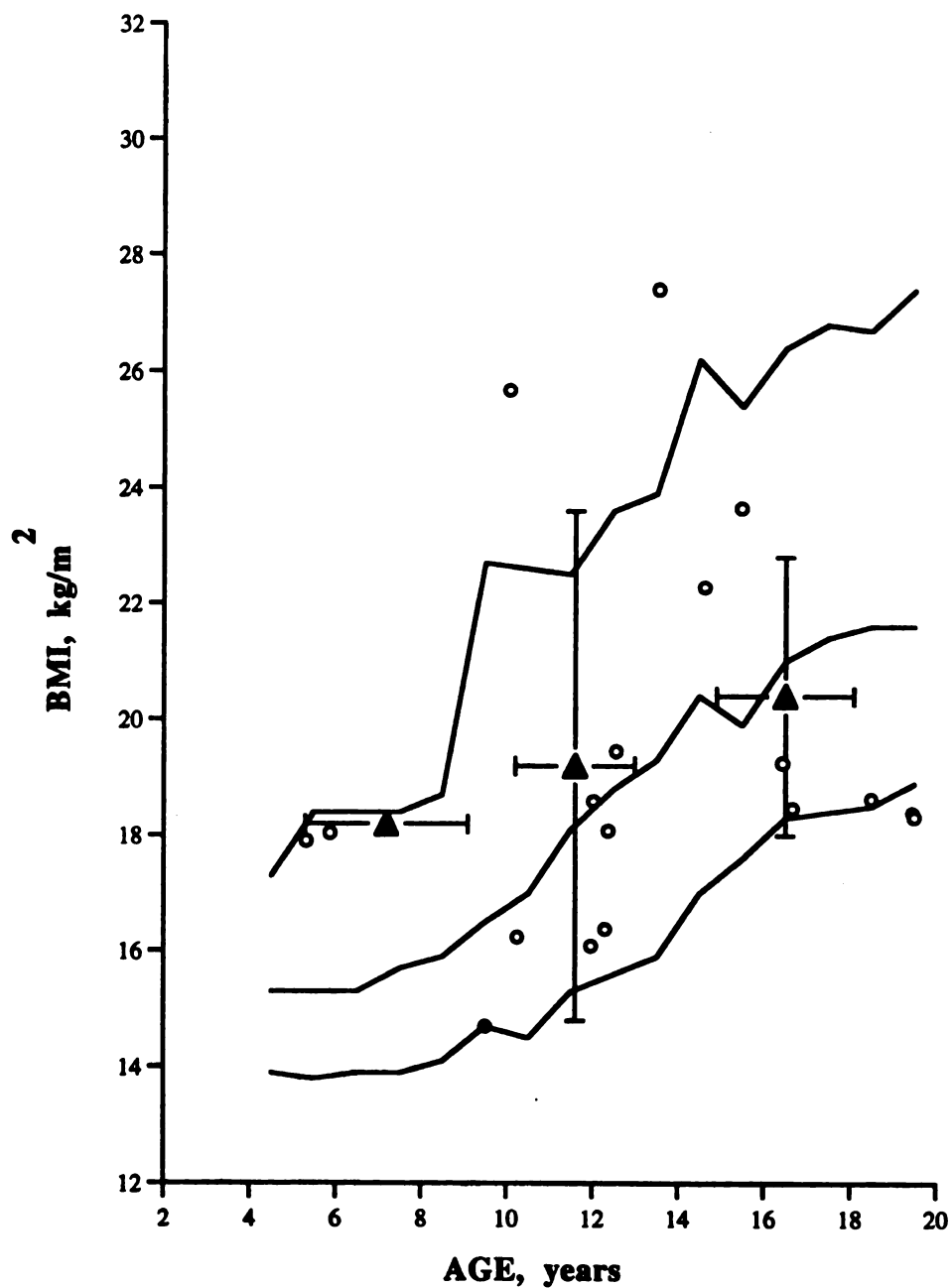


FIGURE 4.48 BMI of FN females (o) 5-19 years and five-year age group means (▲ ± SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

BMI: EA MALES 20-75 YEARS

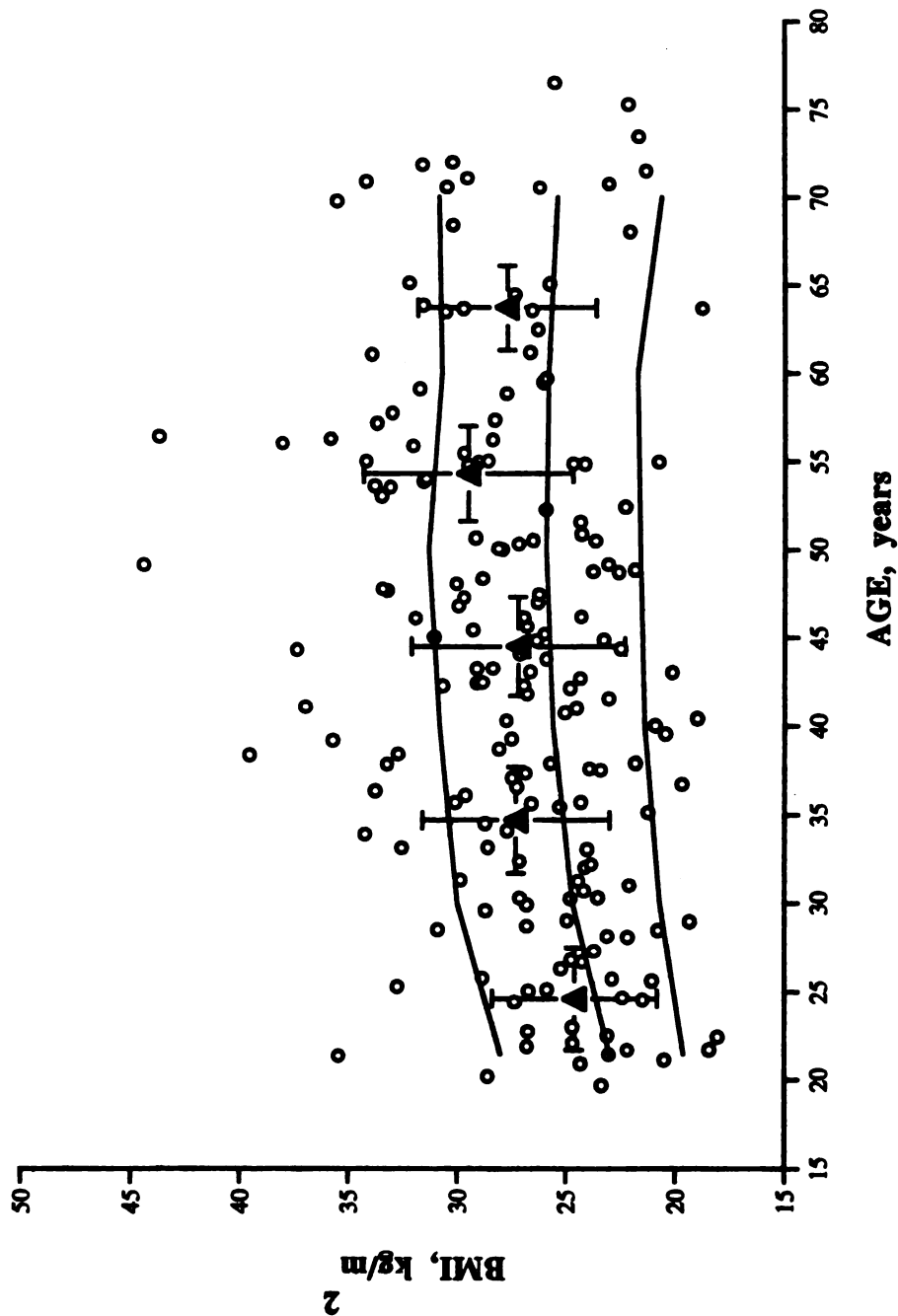


FIGURE 4.49 BMI of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

BMI: FN MALES 20-75 YEARS

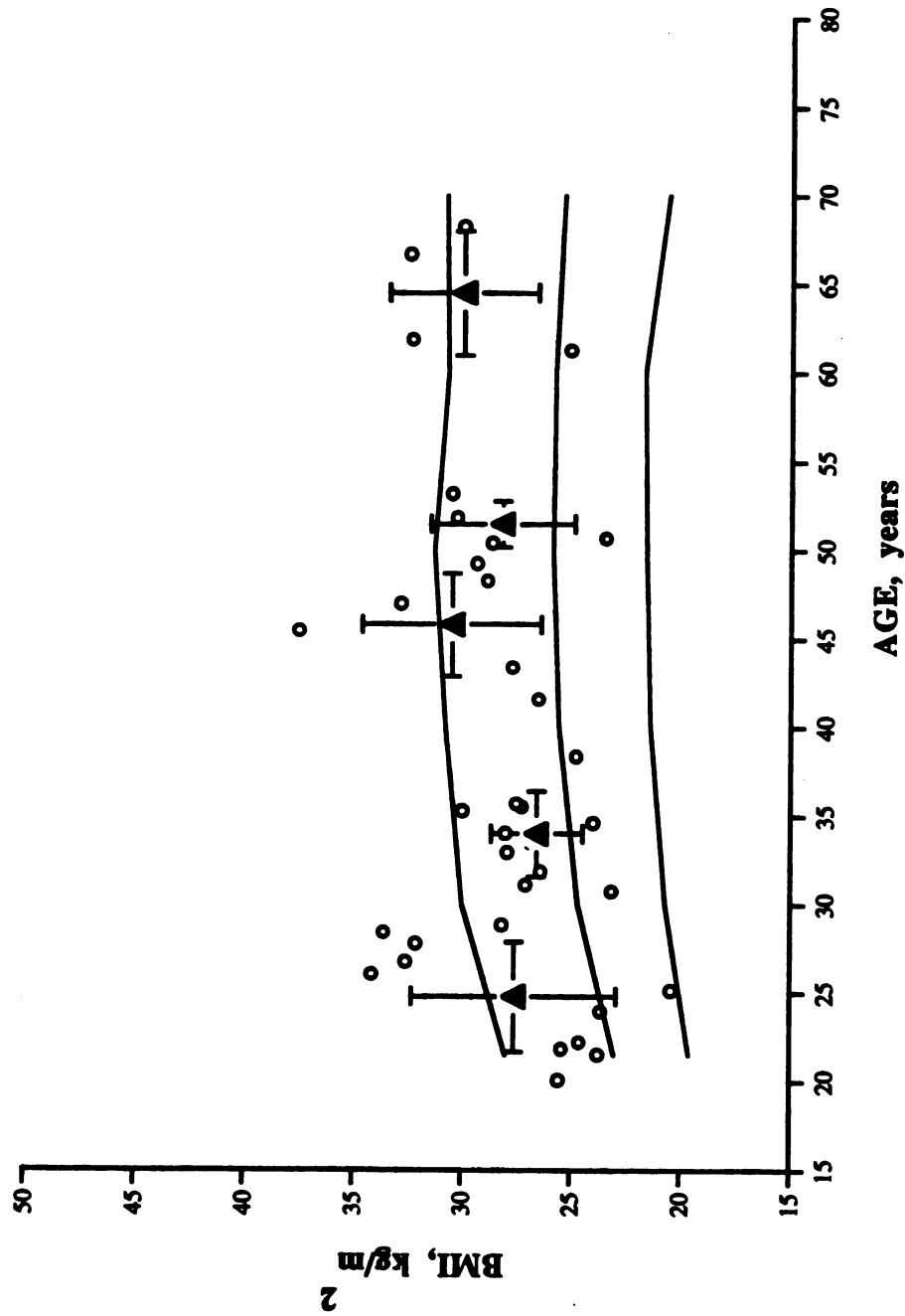


FIGURE 4.50 BMI of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

BMI: EA FEMALES 20-75 YEARS

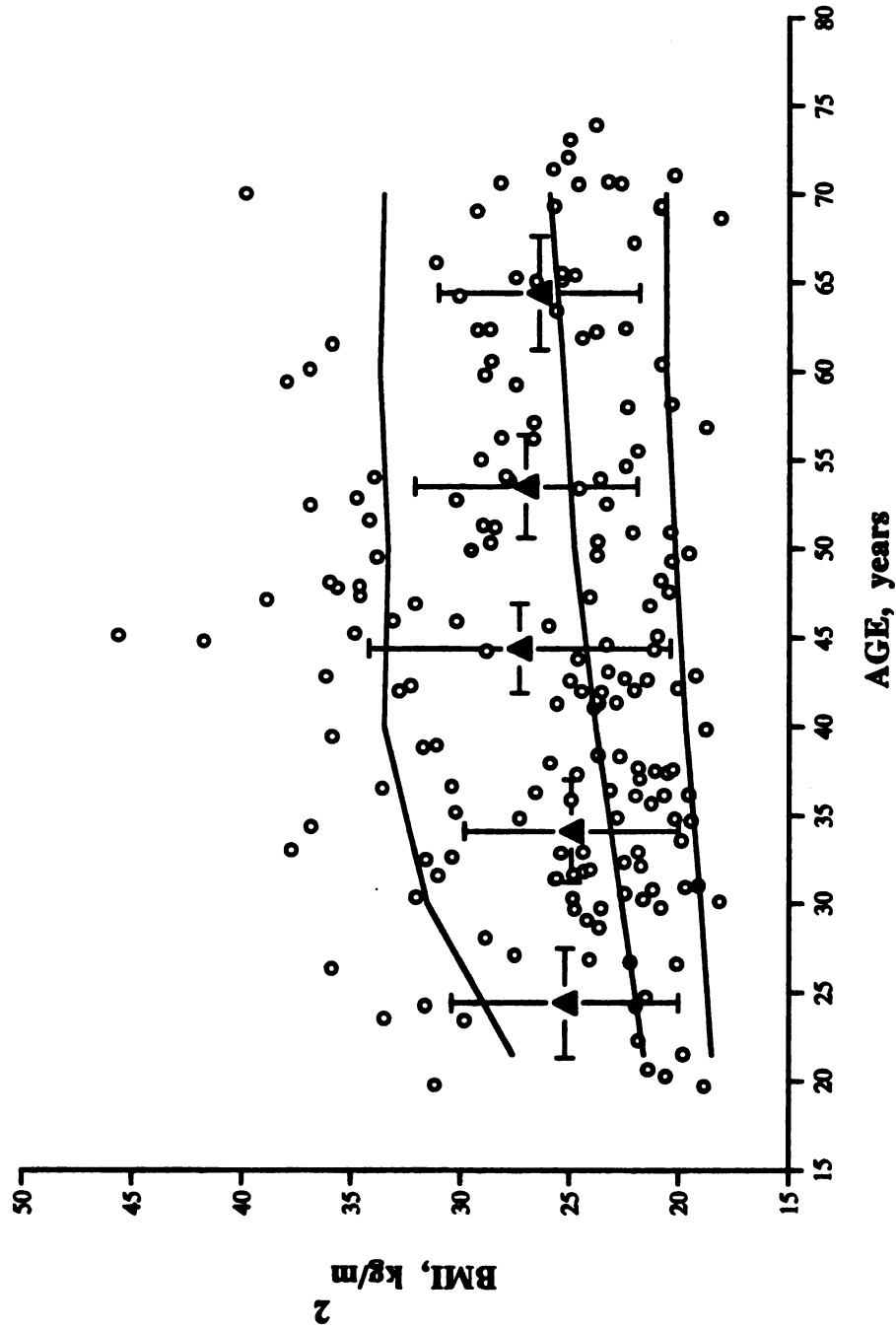


FIGURE 4.51 BMI of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

BMI: FN FEMALES 20-75 YEARS

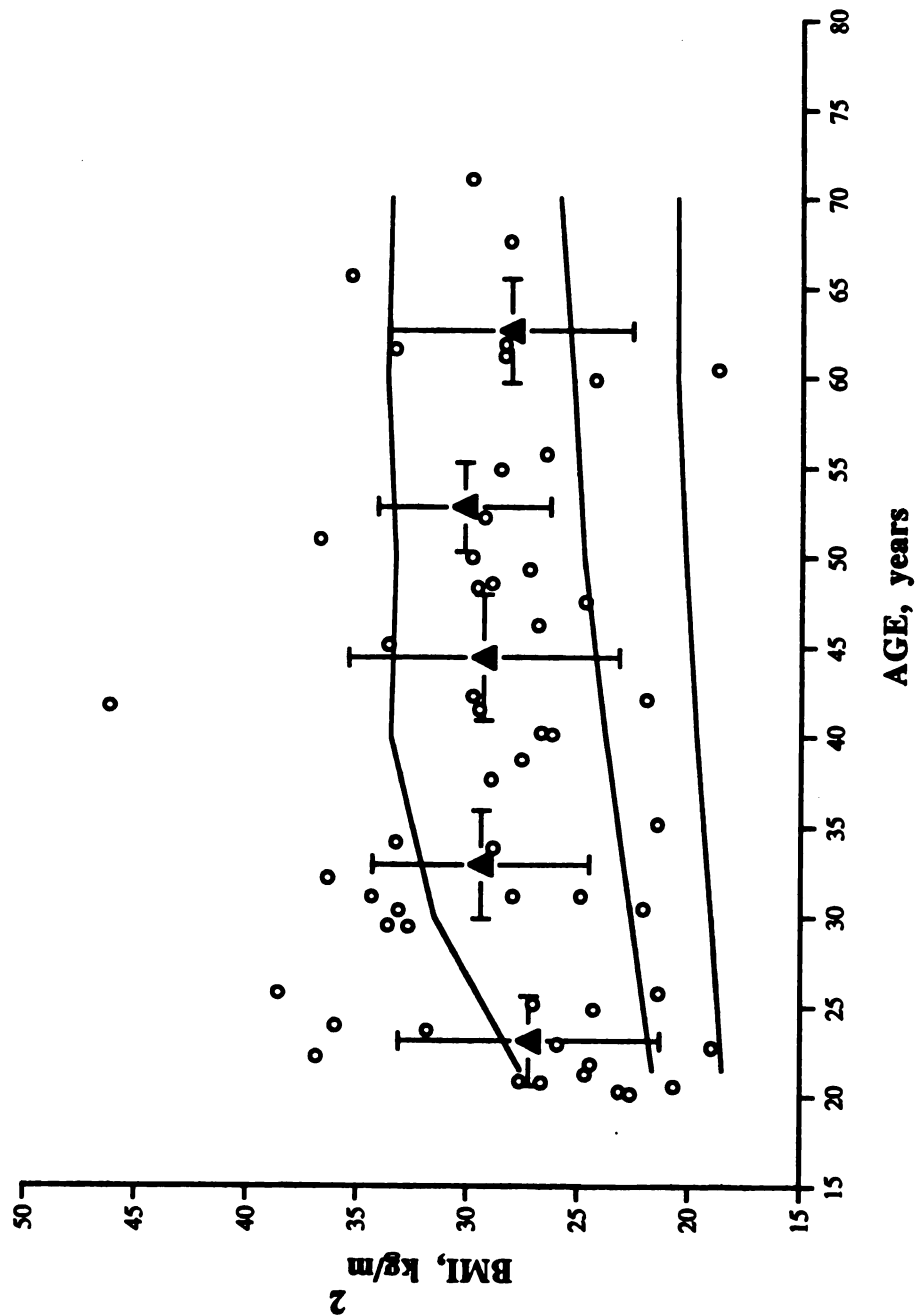


FIGURE 4.52 BMI of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

TRICEPS SKINFOLD: EA MALES 5-19 YEARS

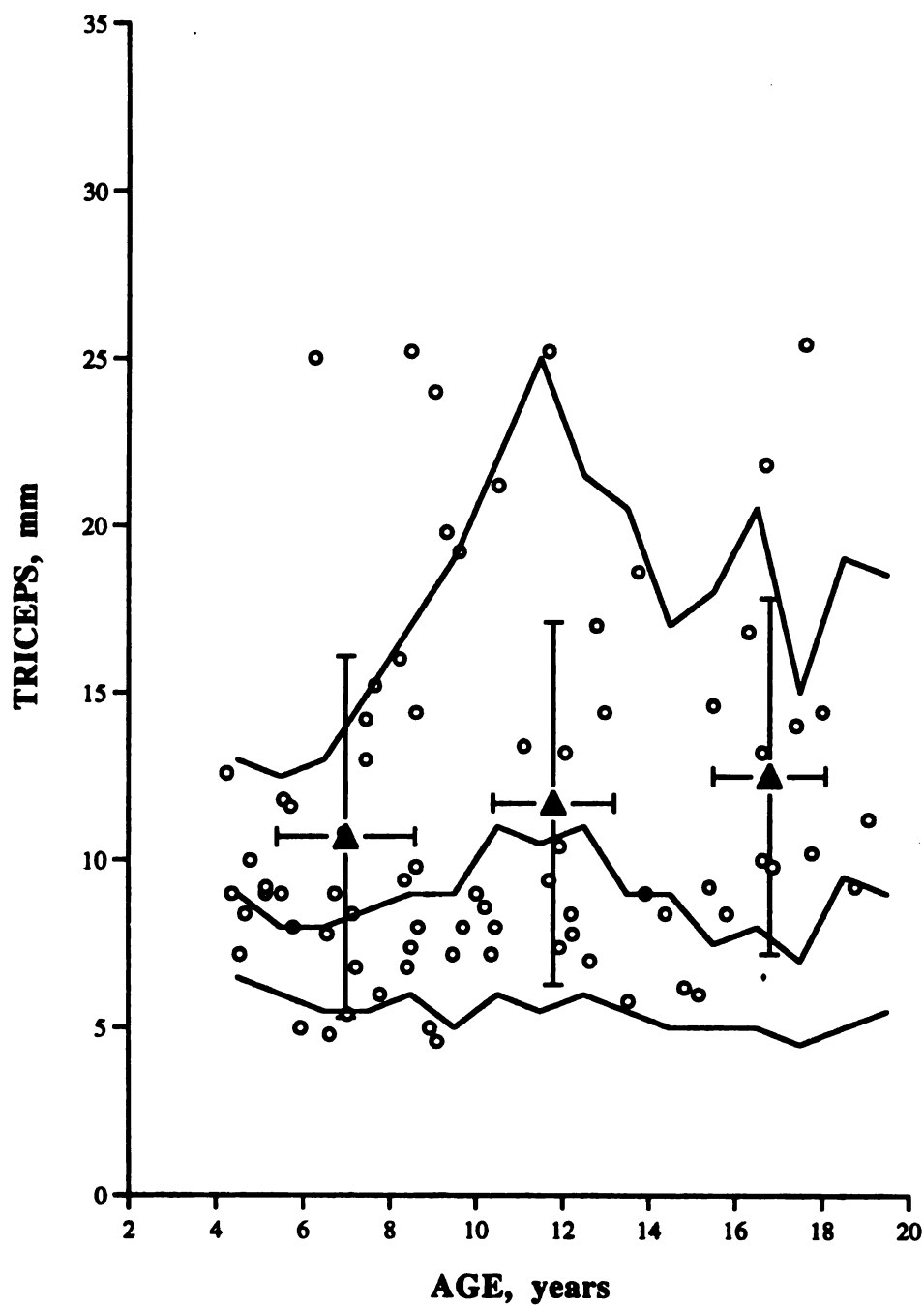


FIGURE 4.53 Triceps skinfold of EA males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

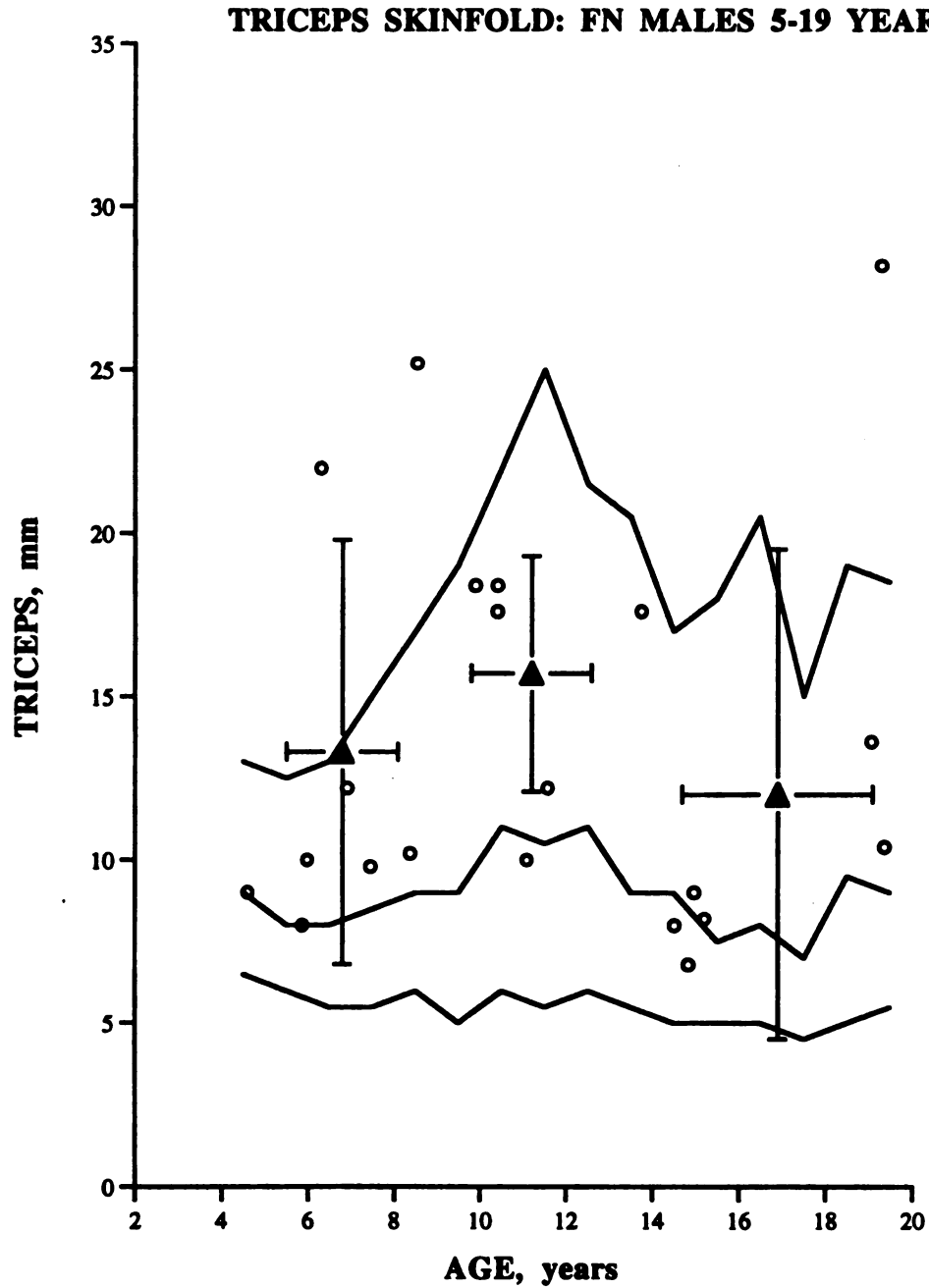


FIGURE 4.54 Triceps skinfold of FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

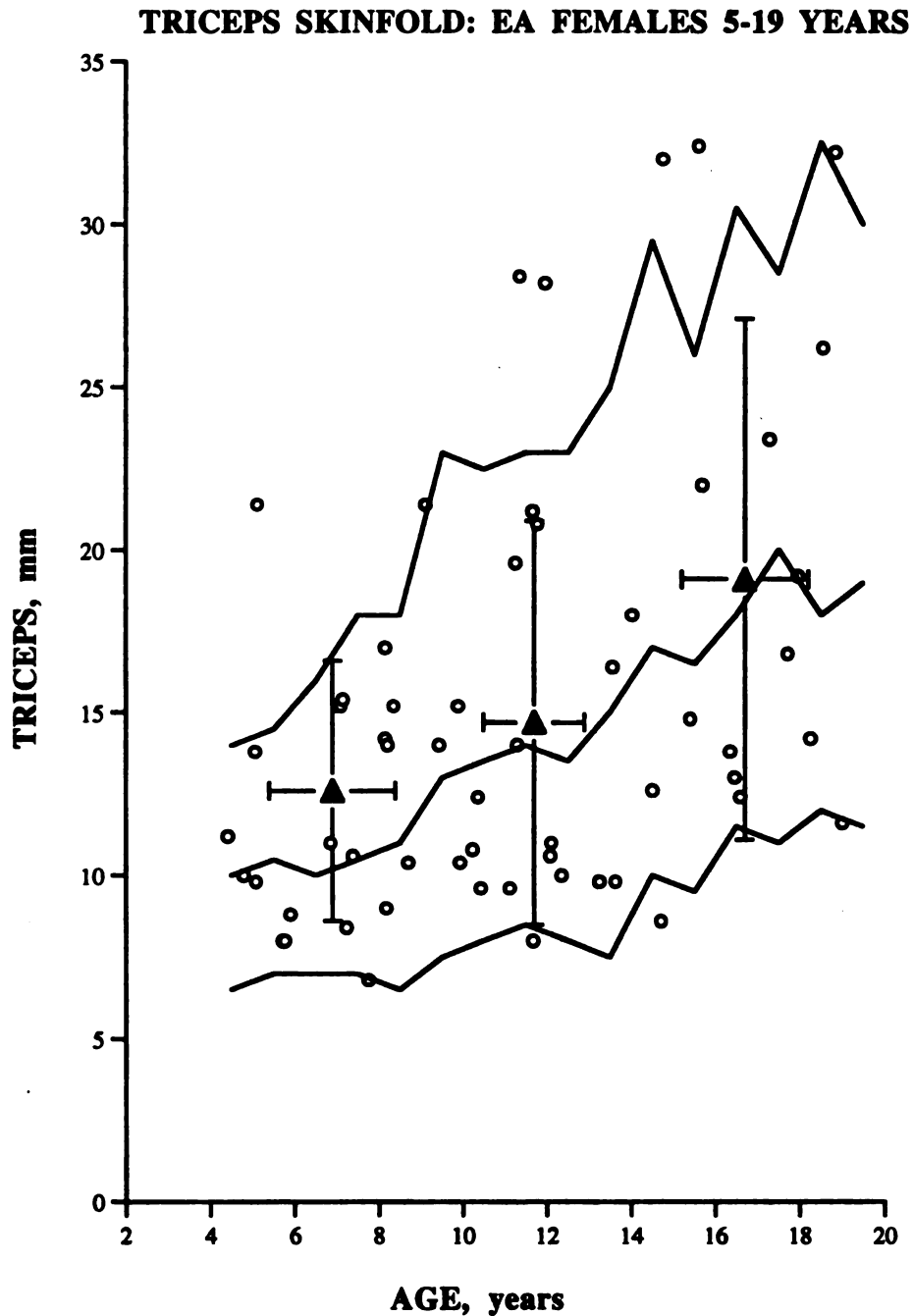


FIGURE 4.55 Triceps skinfold of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

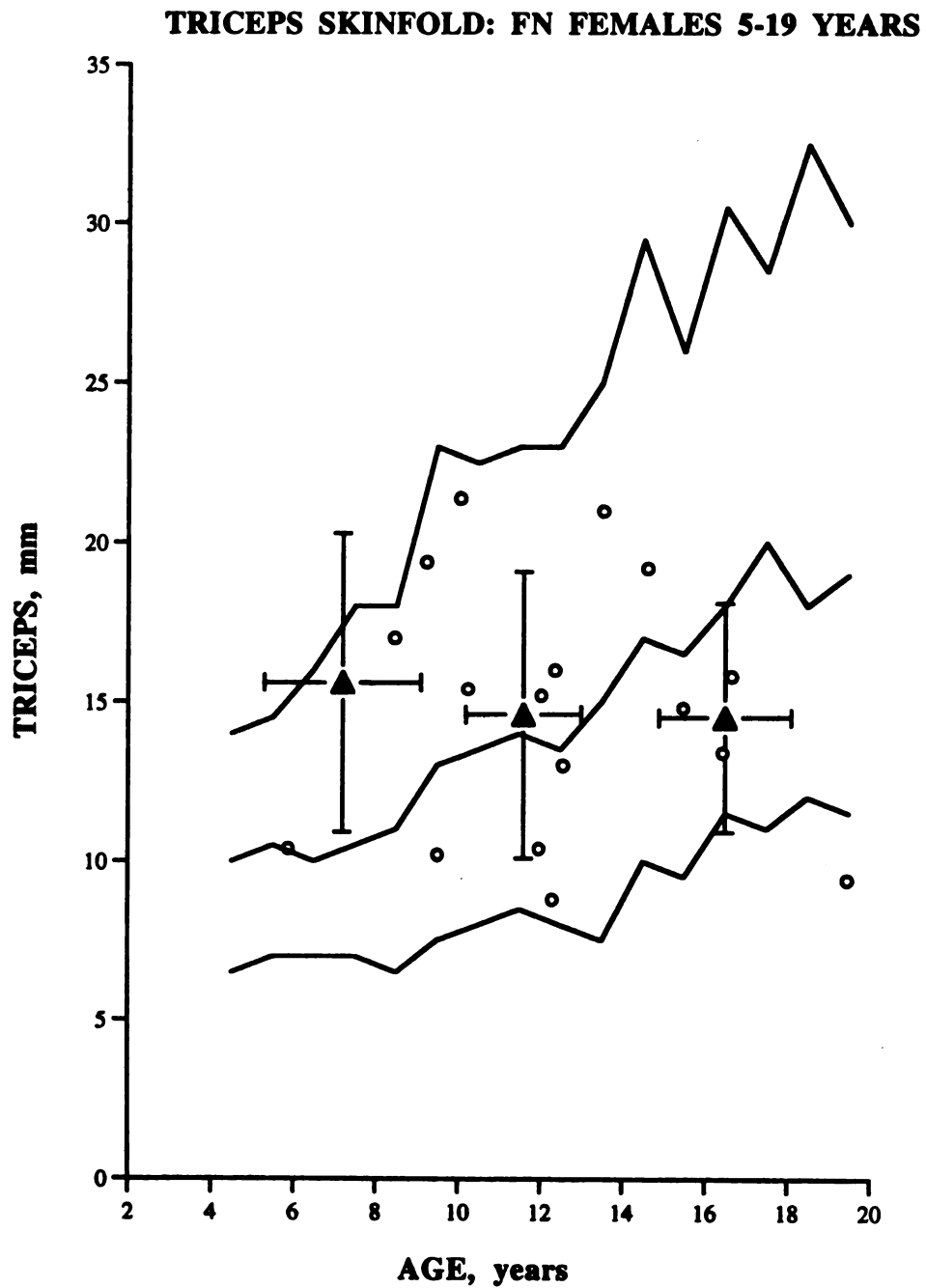


FIGURE 4.56 Triceps skinfold of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

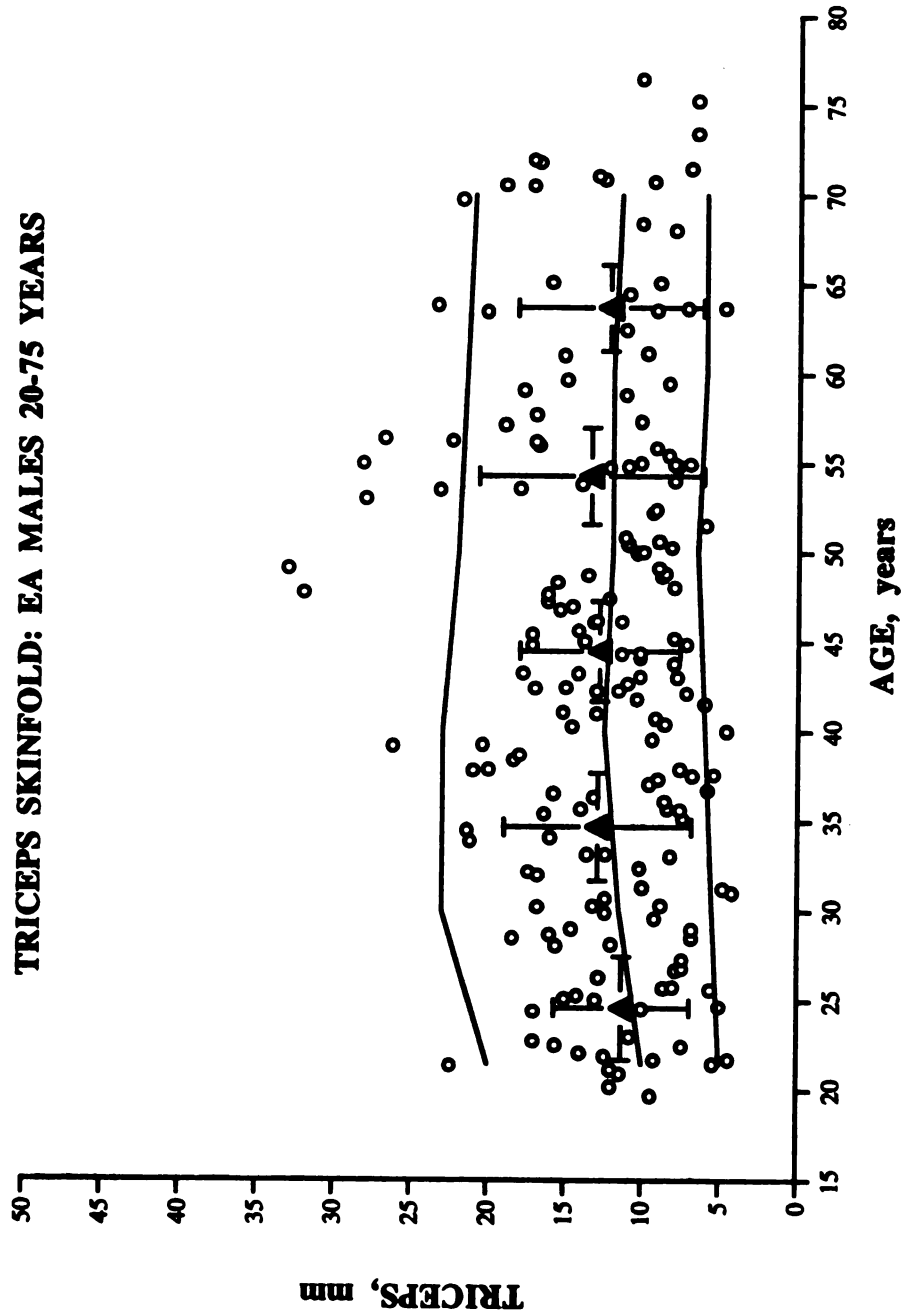


FIGURE 4.57 Triceps skinfold of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

TRICEPS SKINFOLD: FN MALES 20-75 YEARS

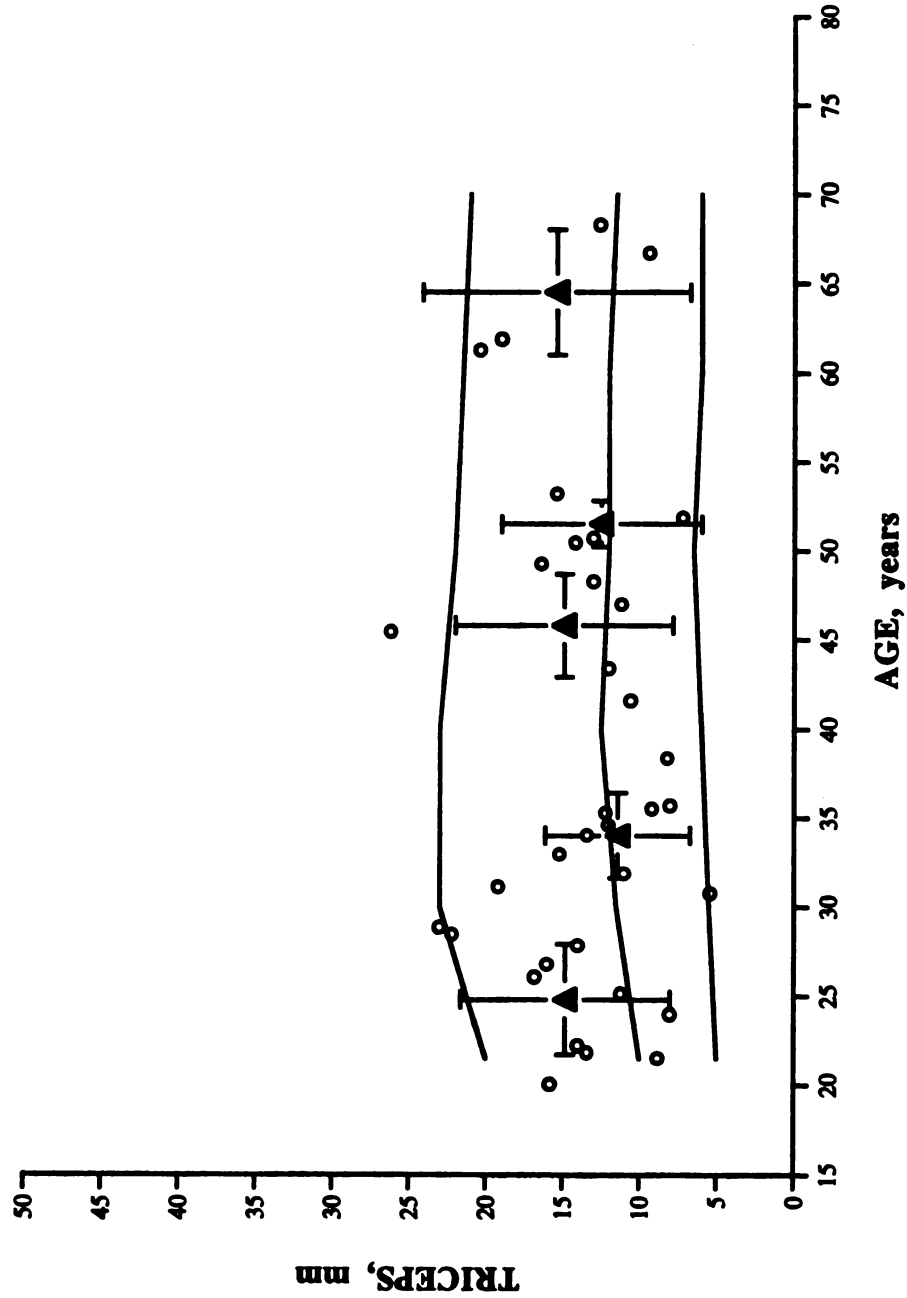


FIGURE 4.58 Triceps skinfold of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal lines represent 10th, 50th, and 90th percentiles.

TRICEPS SKINFOLD: EA FEMALES 20-75 YEARS

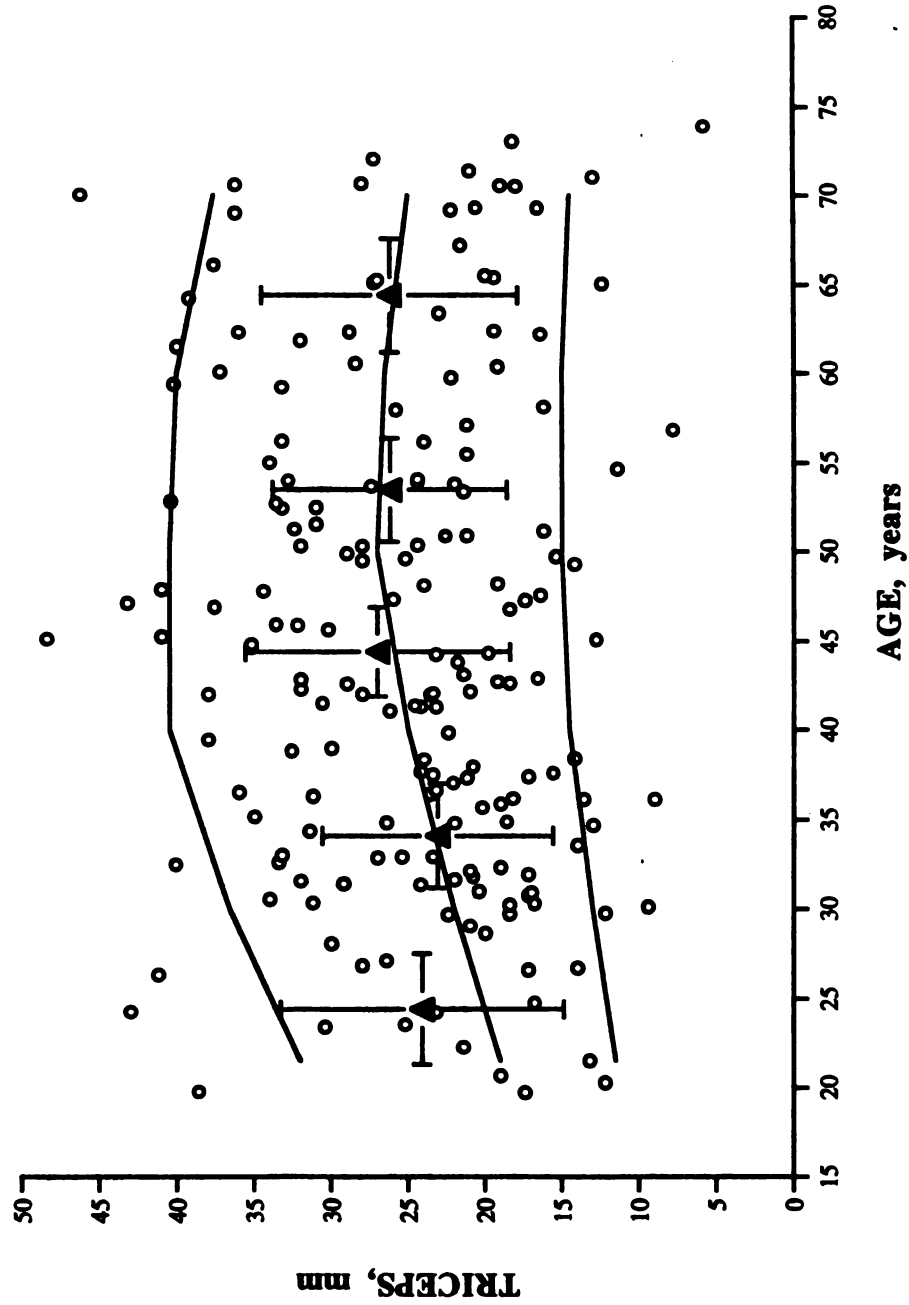


FIGURE 4.59 Triceps skinfold of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

TRICEPS SKINFOLD: FN FEMALES 20-75 YEARS

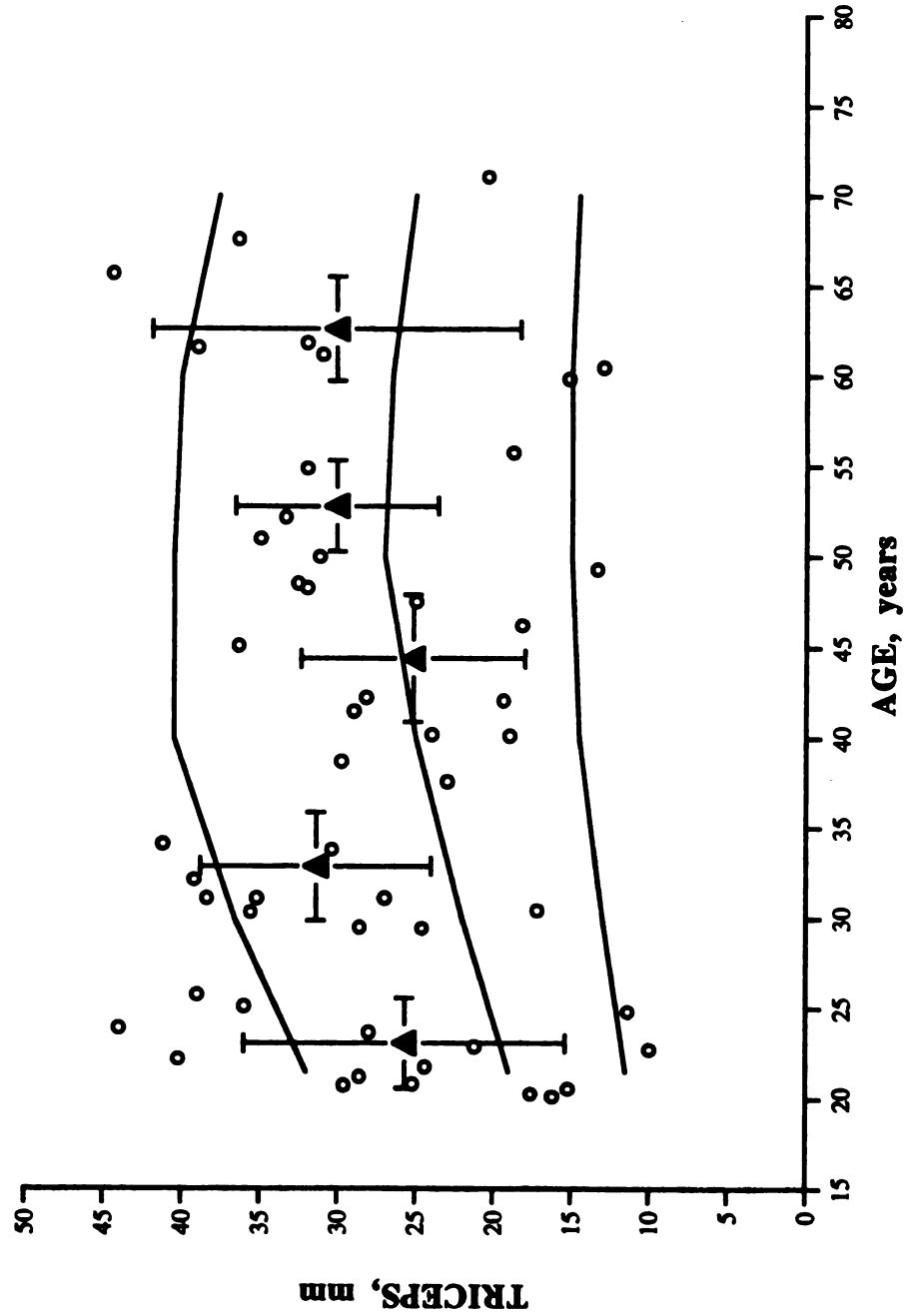


FIGURE 4.60 Triceps skinfold of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

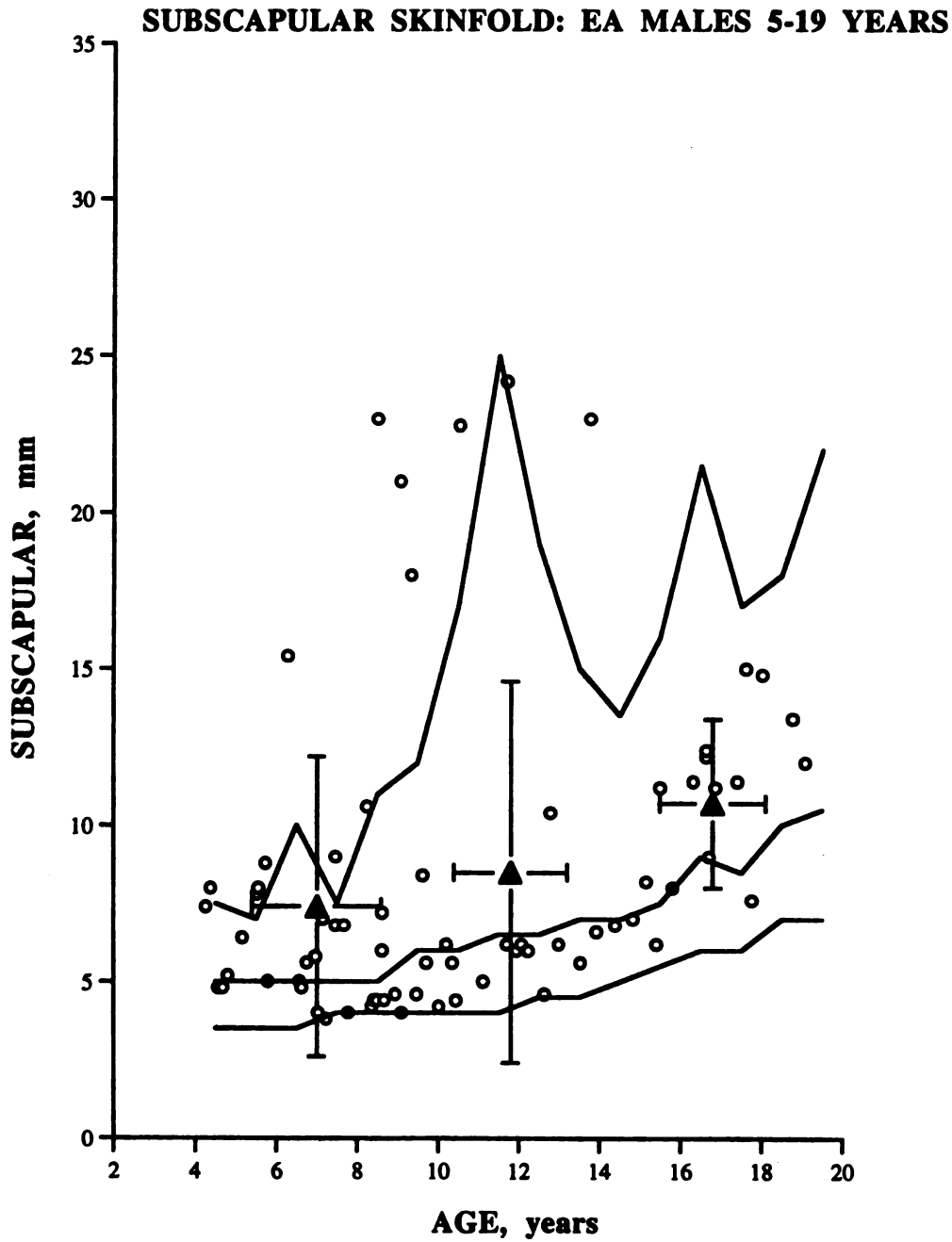


FIGURE 4.61 Subscapular skinfold of EA males (o) 5-19 years and five-year age group means (▲ $\pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

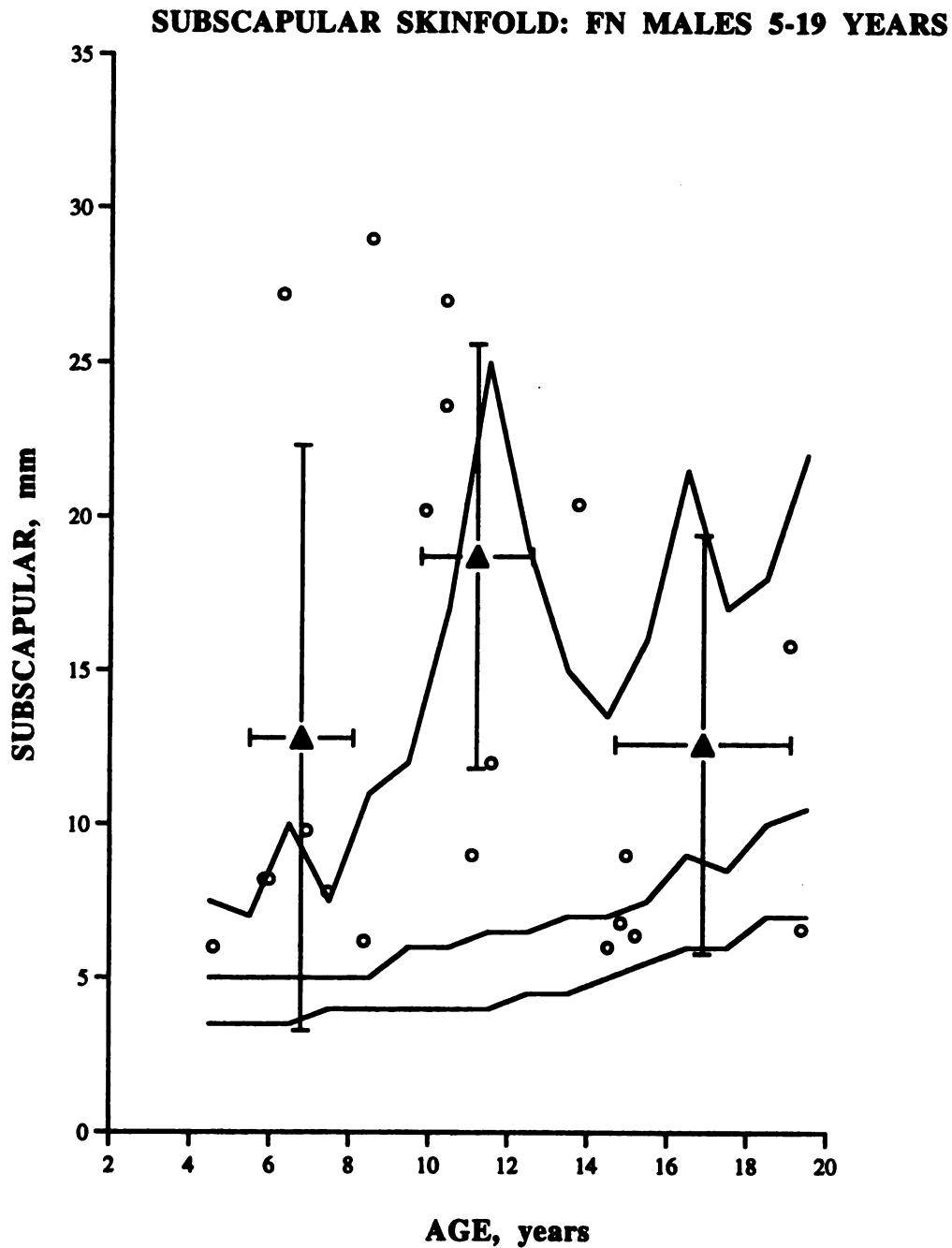


FIGURE 4.62 Subscapular skinfold of FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

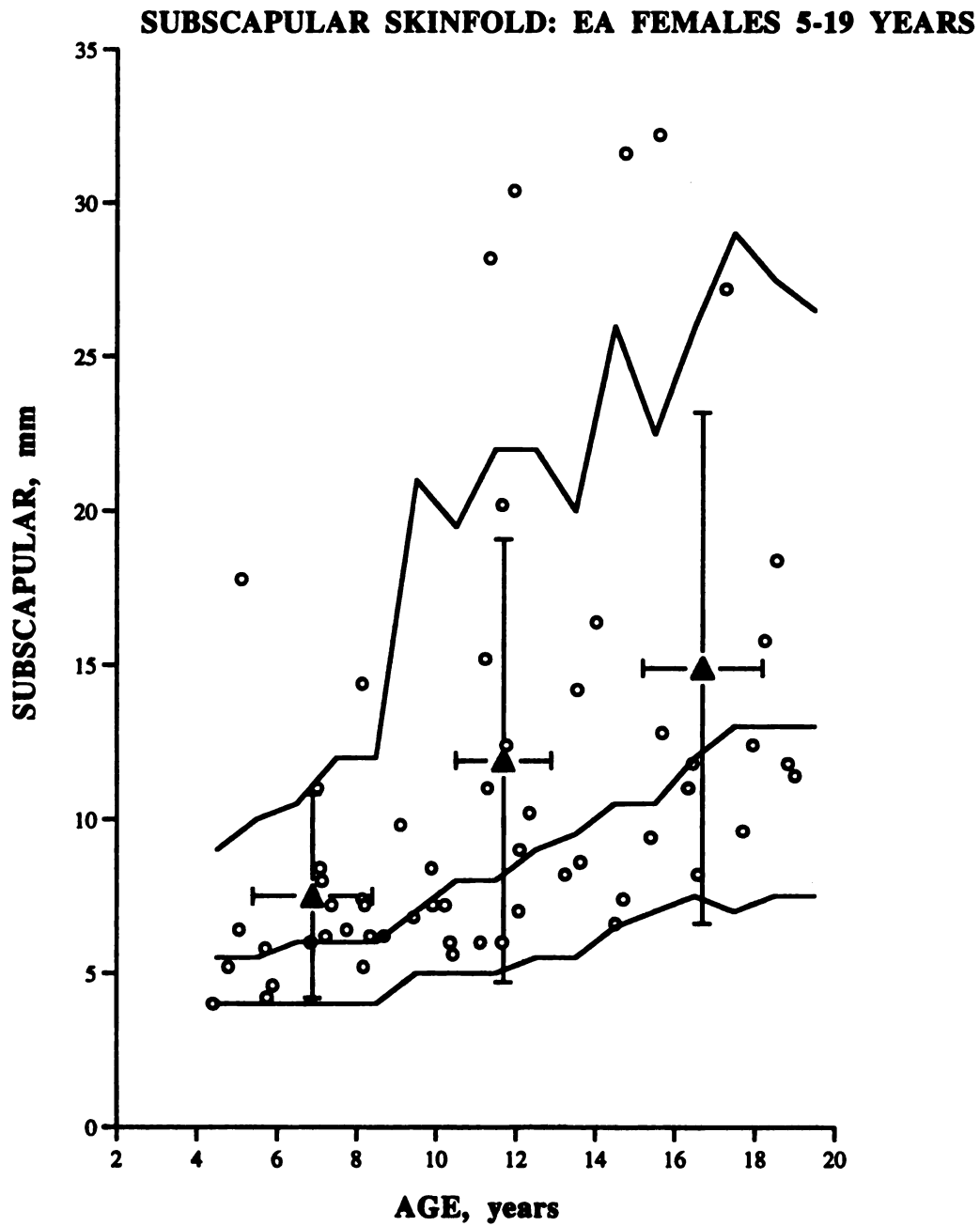


FIGURE 4.63 Subscapular skinfold of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBSCAPULAR SKINFOLD: FN FEMALES 5-19 YEARS

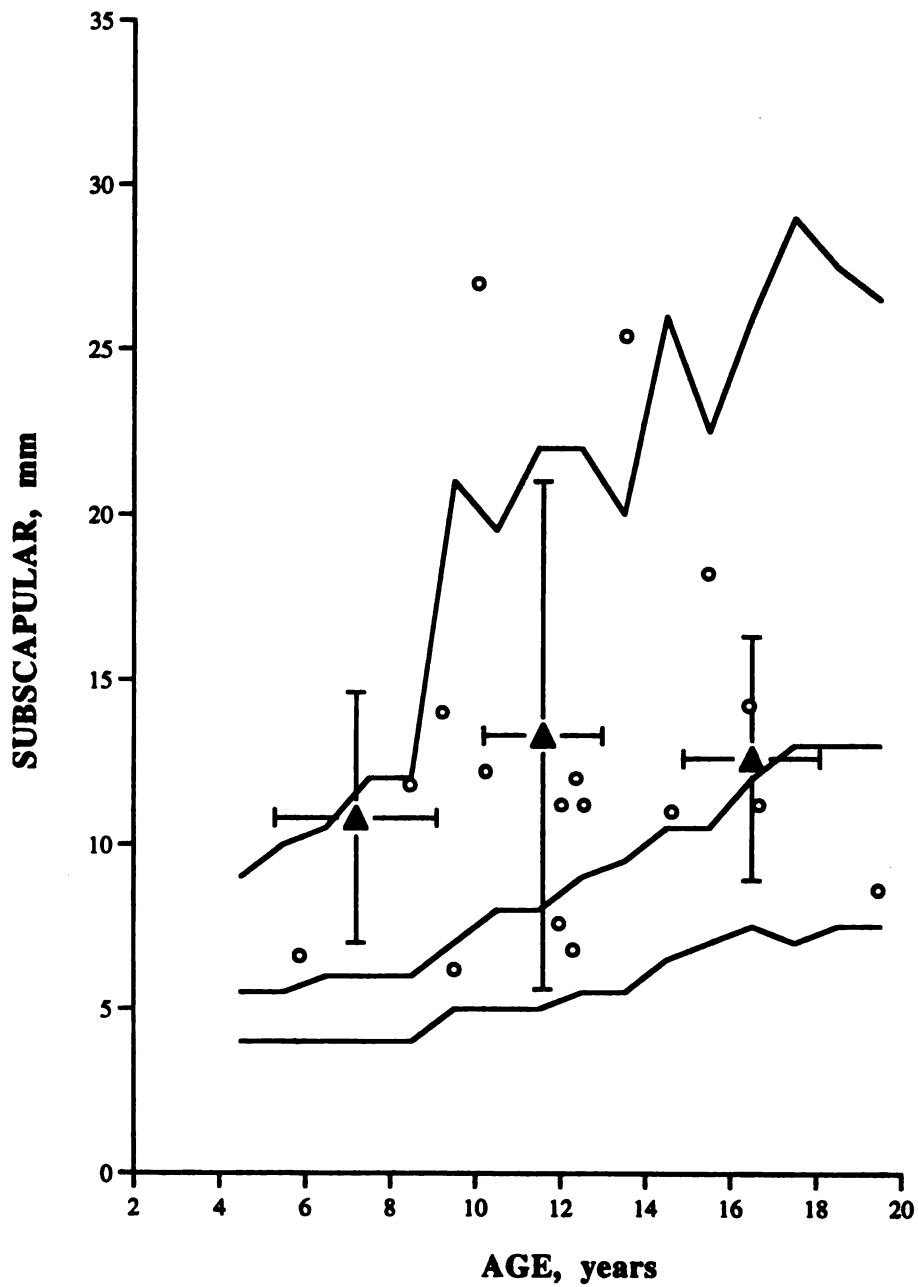


FIGURE 4.64 Subscapular skinfold of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBSCAPULAR SKINFOLD: EA MALES 20-75 YEARS

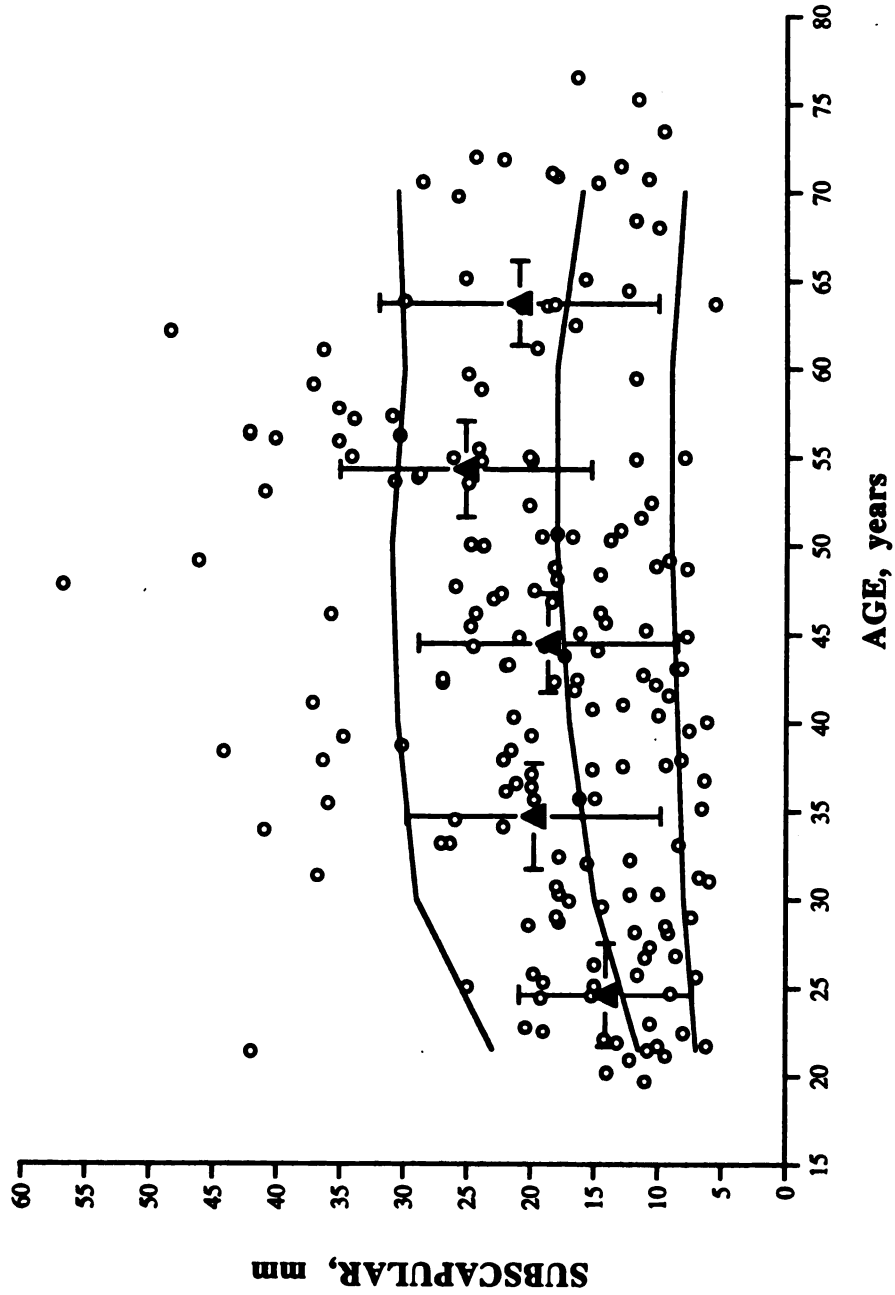


FIGURE 4.65 Subscapular skinfold of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBSCAPULAR SKINFOLD: FN MALES 20-75 YEARS

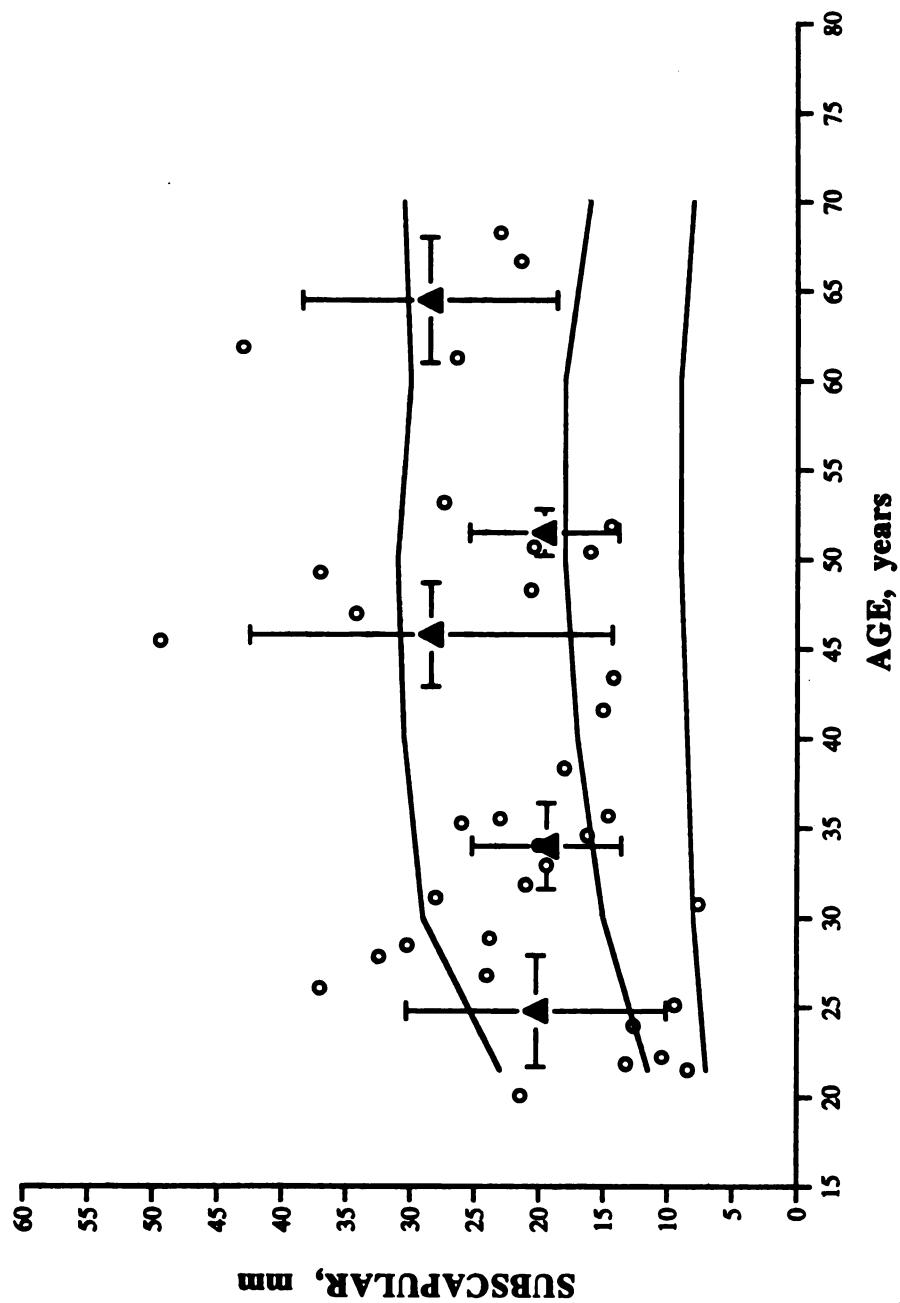


FIGURE 4.66 Subscapular skinfold of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

SUBSCAPULAR SKINFOLD: EA FEMALES 20-75 YEARS

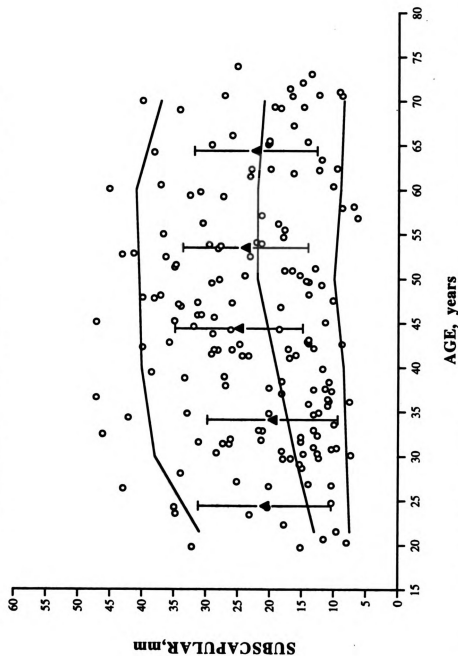


FIGURE 4.67 Subscapular skinfold of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars represent 10th, 50th, and 90th percentiles.

SUBSCAPULAR SKINFOLD: FN FEMALES 20-75 YEARS

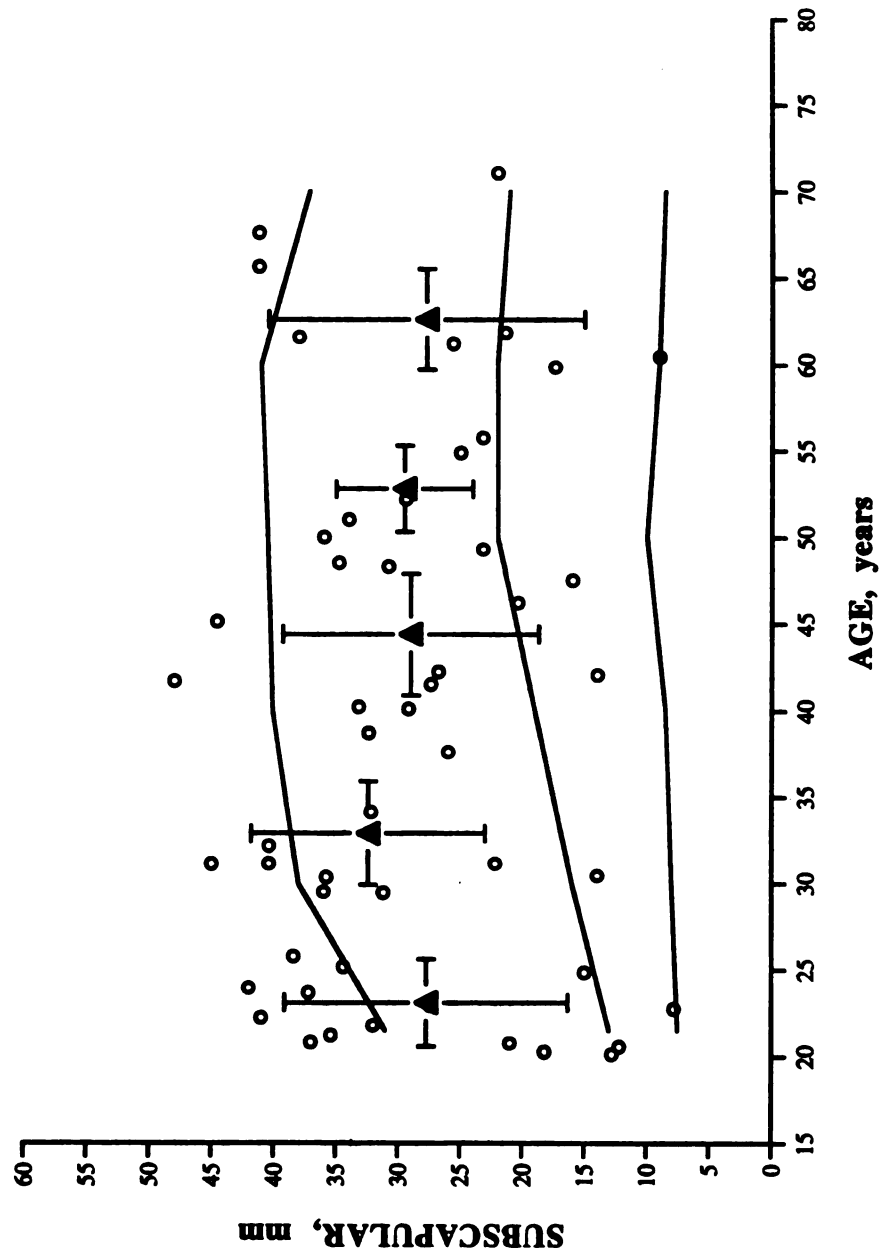


FIGURE 4.68 Subscapular skinfold of FN females (o) 20-75 years and ten-year age group means (▲ $\pm$ SD) plotted relative to U.S. reference data (Najjar and Rowland, 1987). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

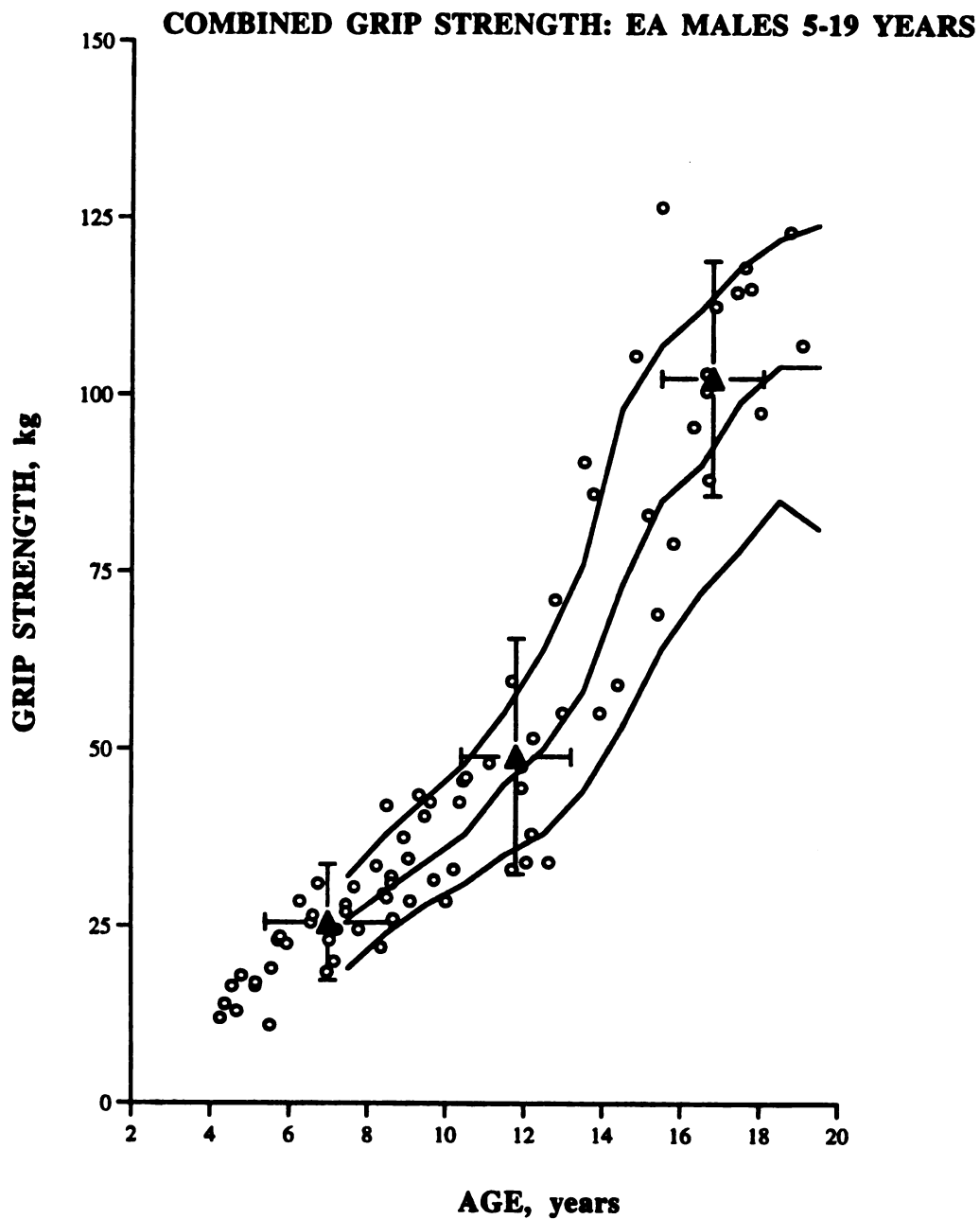


FIGURE 4.69 Combined grip strength (right + left) of EA males (o) 5-19 years and five-year age group means (▲ ± SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: FN MALES 5-19 YEARS

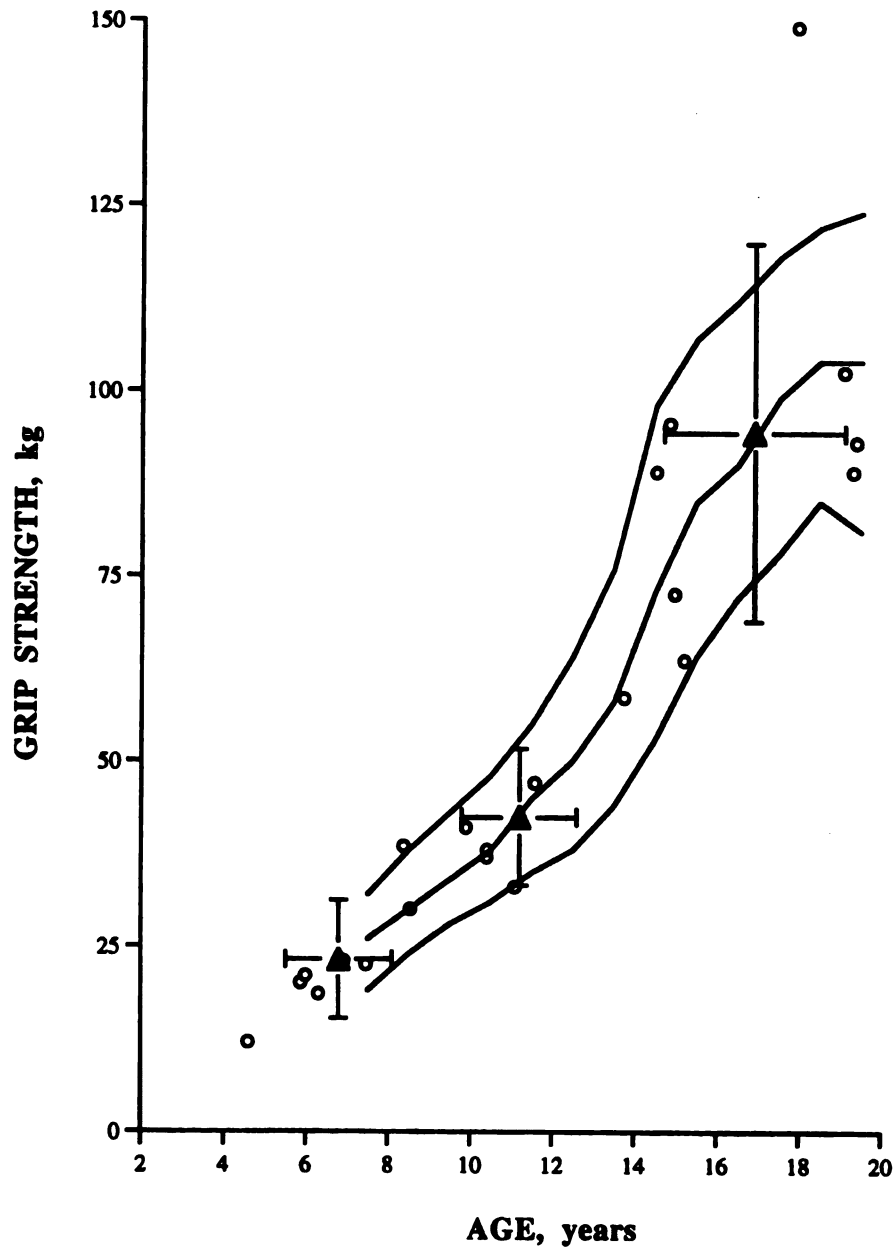


FIGURE 4.70 Combined grip strength (right + left) of FN males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: EA FEMALES 5-19 YEARS

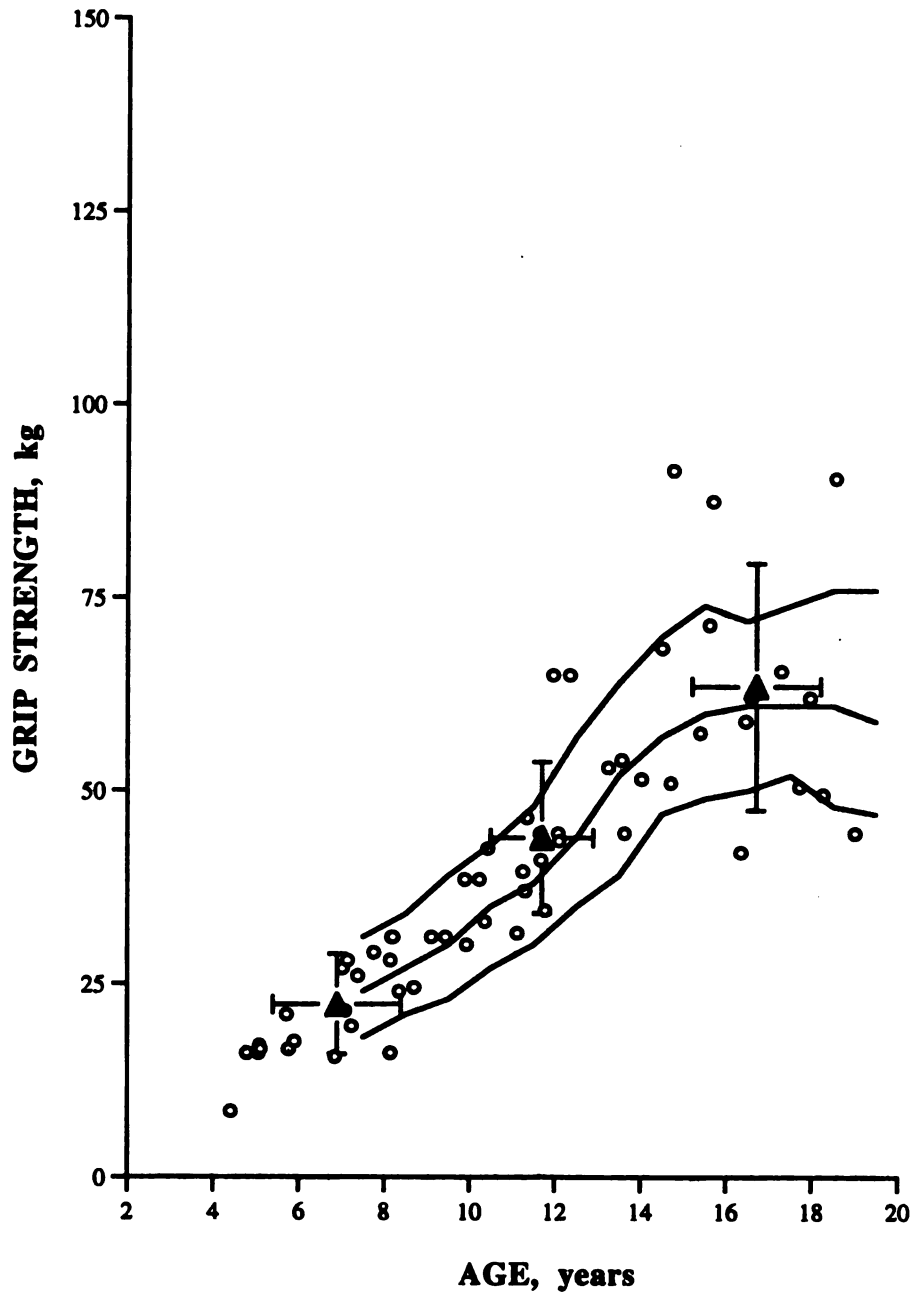


FIGURE 4.71 Combined grip strength (right + left) of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: FN FEMALES 5-19 YEARS

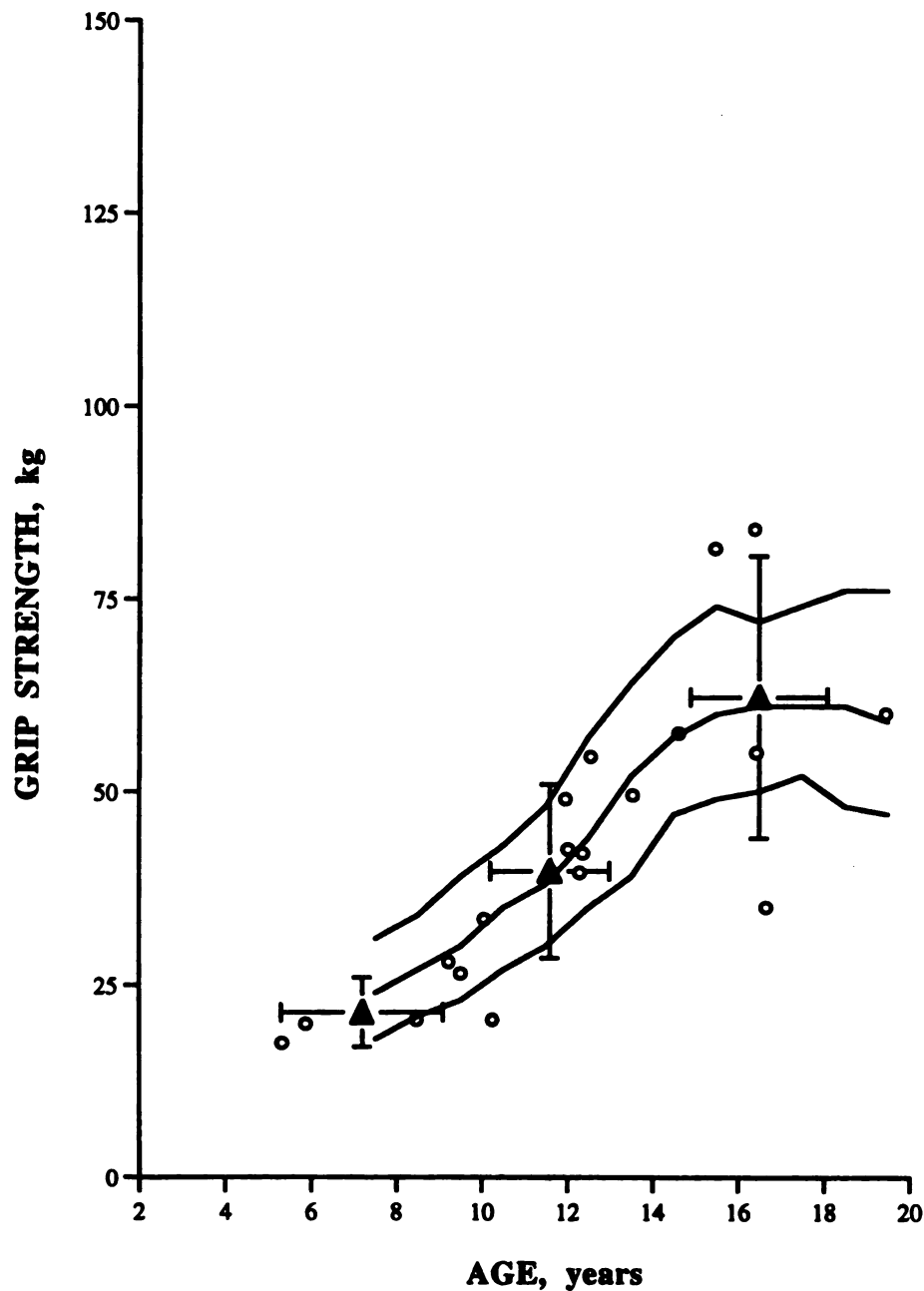


FIGURE 4.72 Combined grip strength (right + left) of FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: EA MALES 20-75 YEARS

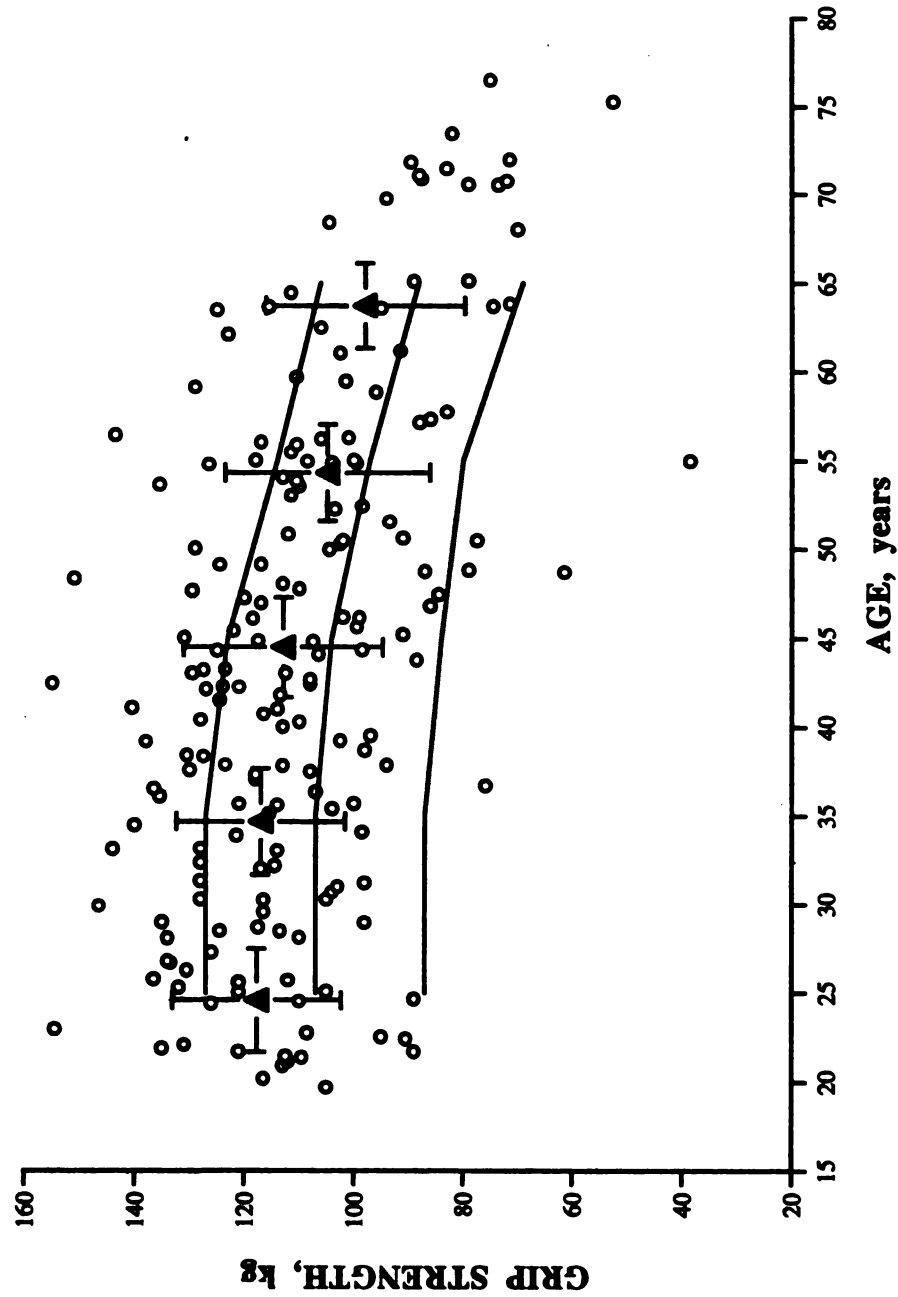


FIGURE 4.73 Combined grip strength (right + left) of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: FN MALES 20-75 YEARS

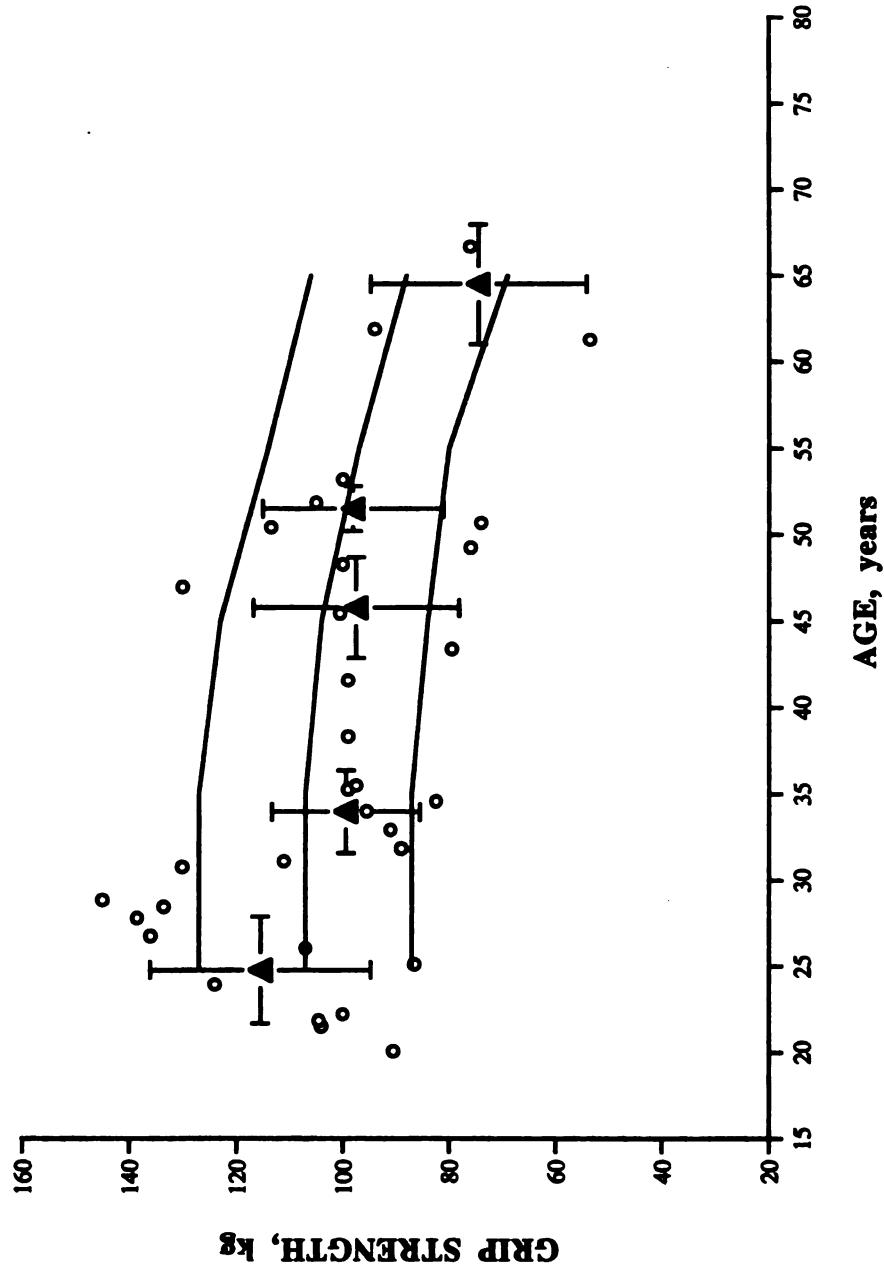


FIGURE 4.74 Combined grip strength (right + left) of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: EA FEMALES 20-75 YEARS

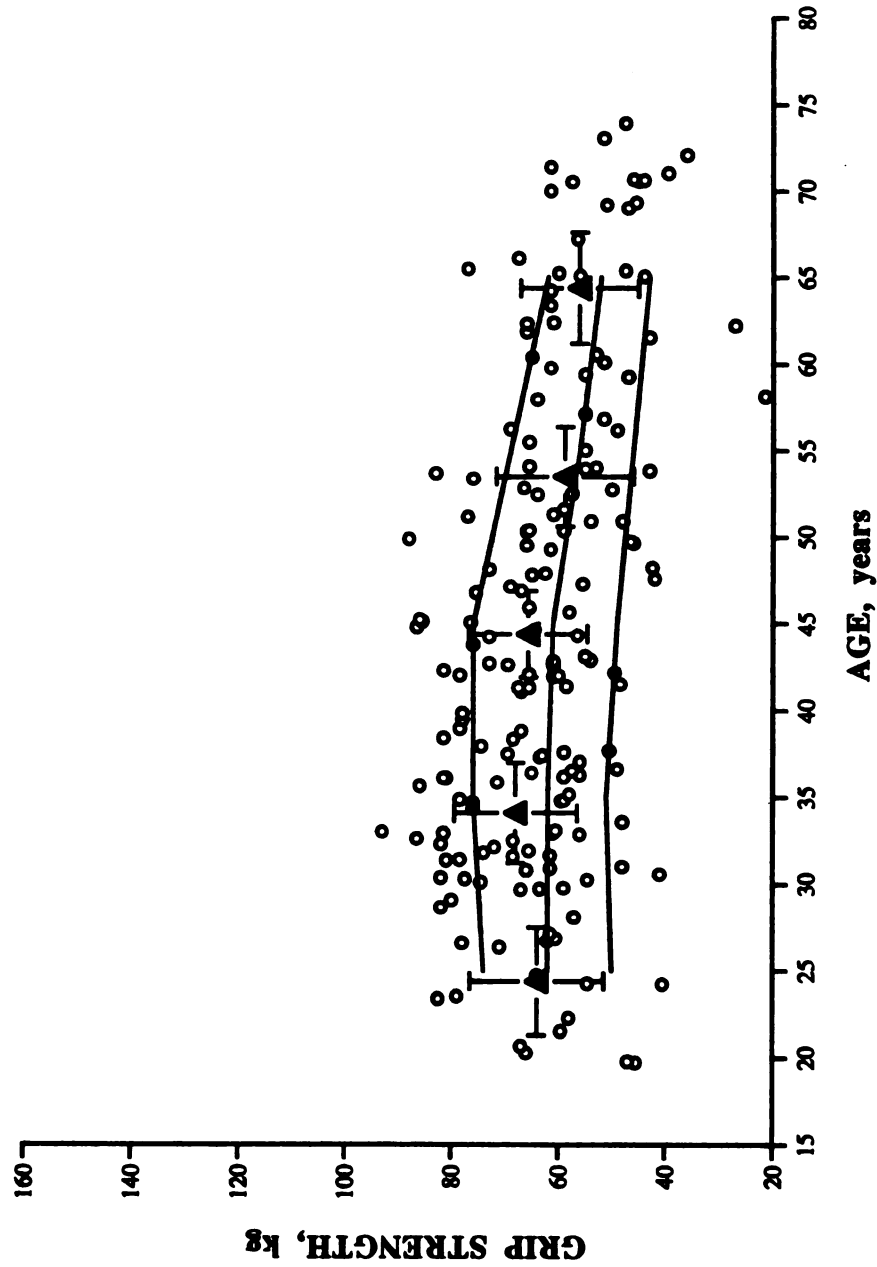


FIGURE 4.75 Combined grip strength (right + left) of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

COMBINED GRIP STRENGTH: FN FEMALES 20-75 YEARS

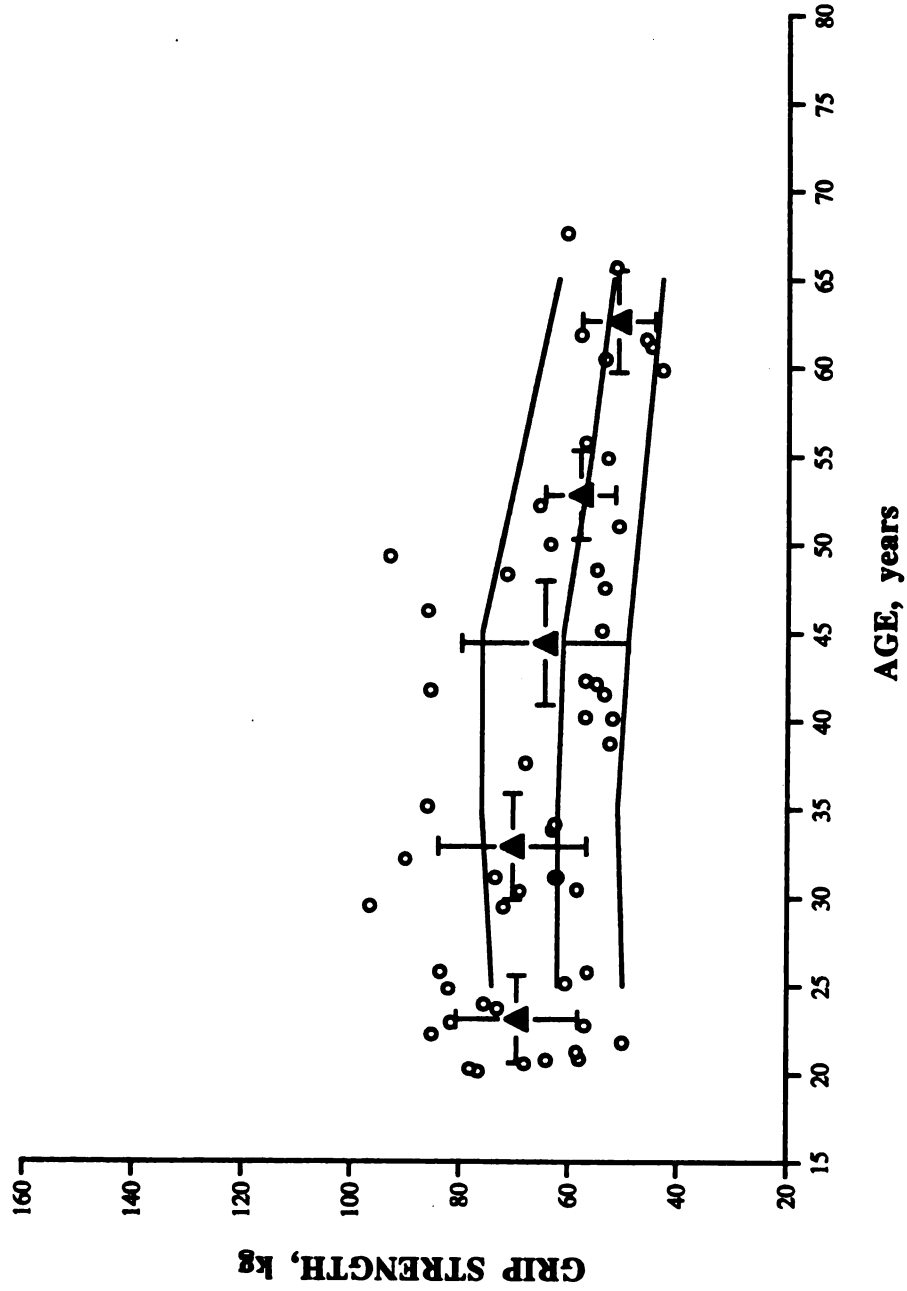


FIGURE 4.76 Combined grip strength (right + left) of FN females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

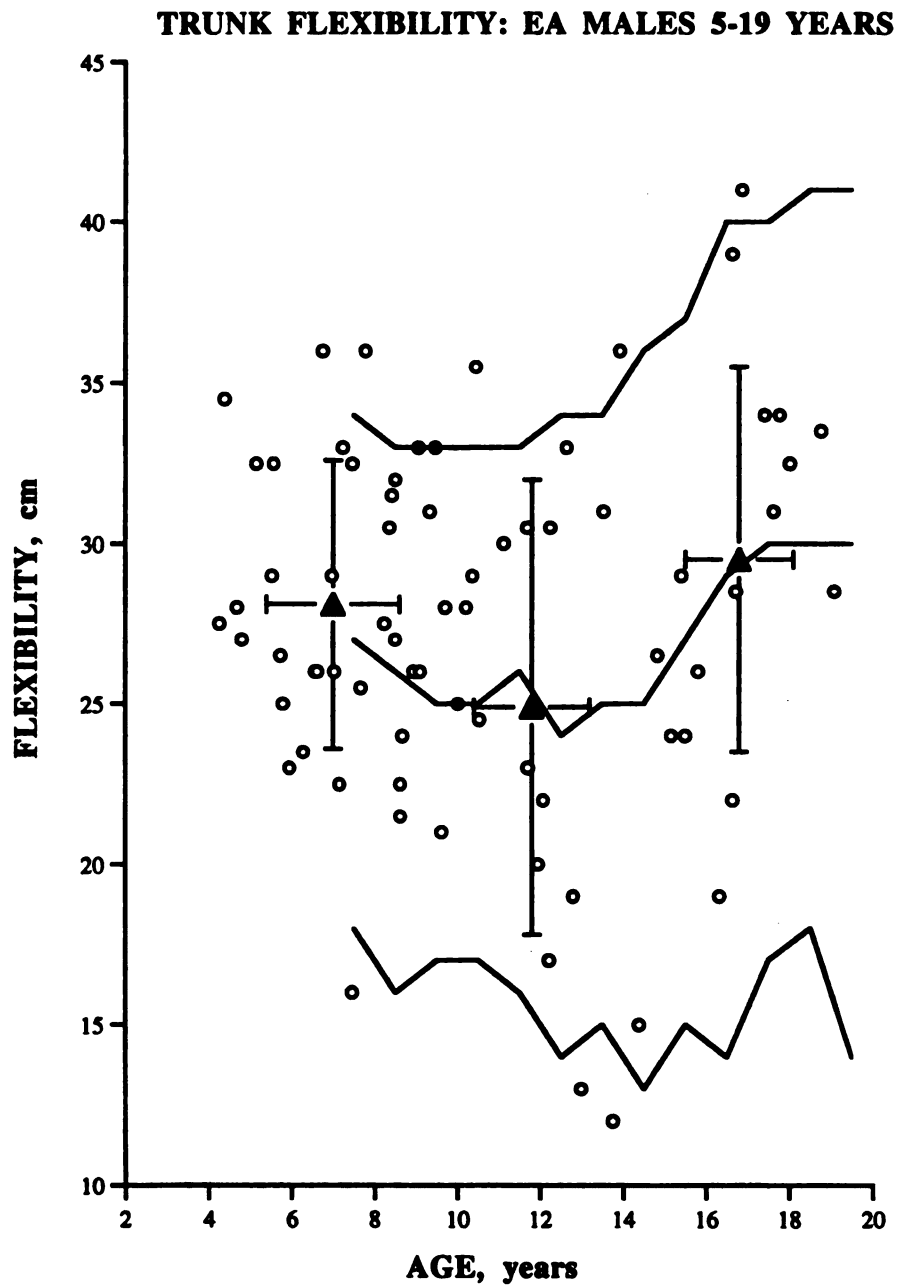


FIGURE 4.77 Trunk flexibility of EA males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

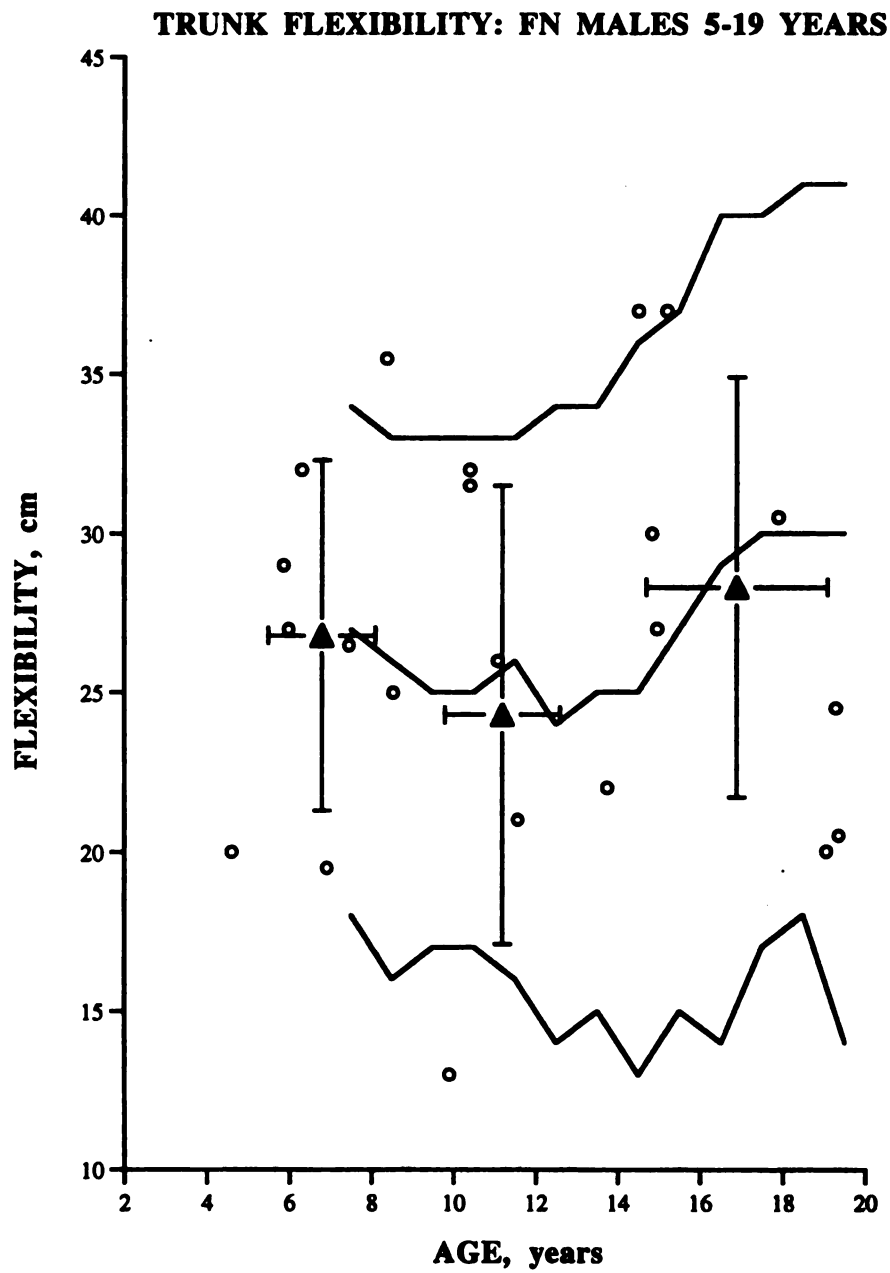


FIGURE 4.78 Trunk flexibility of FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

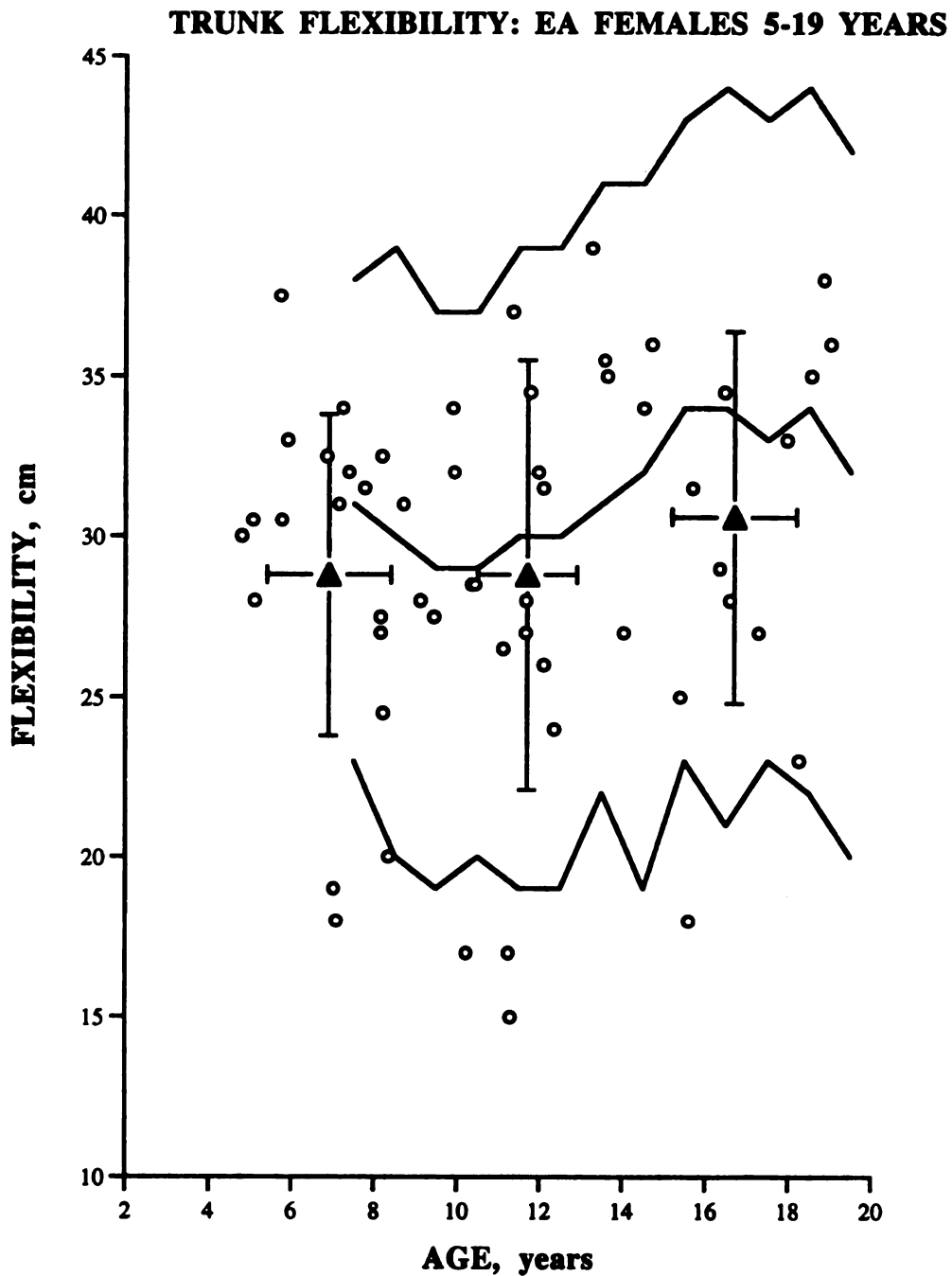
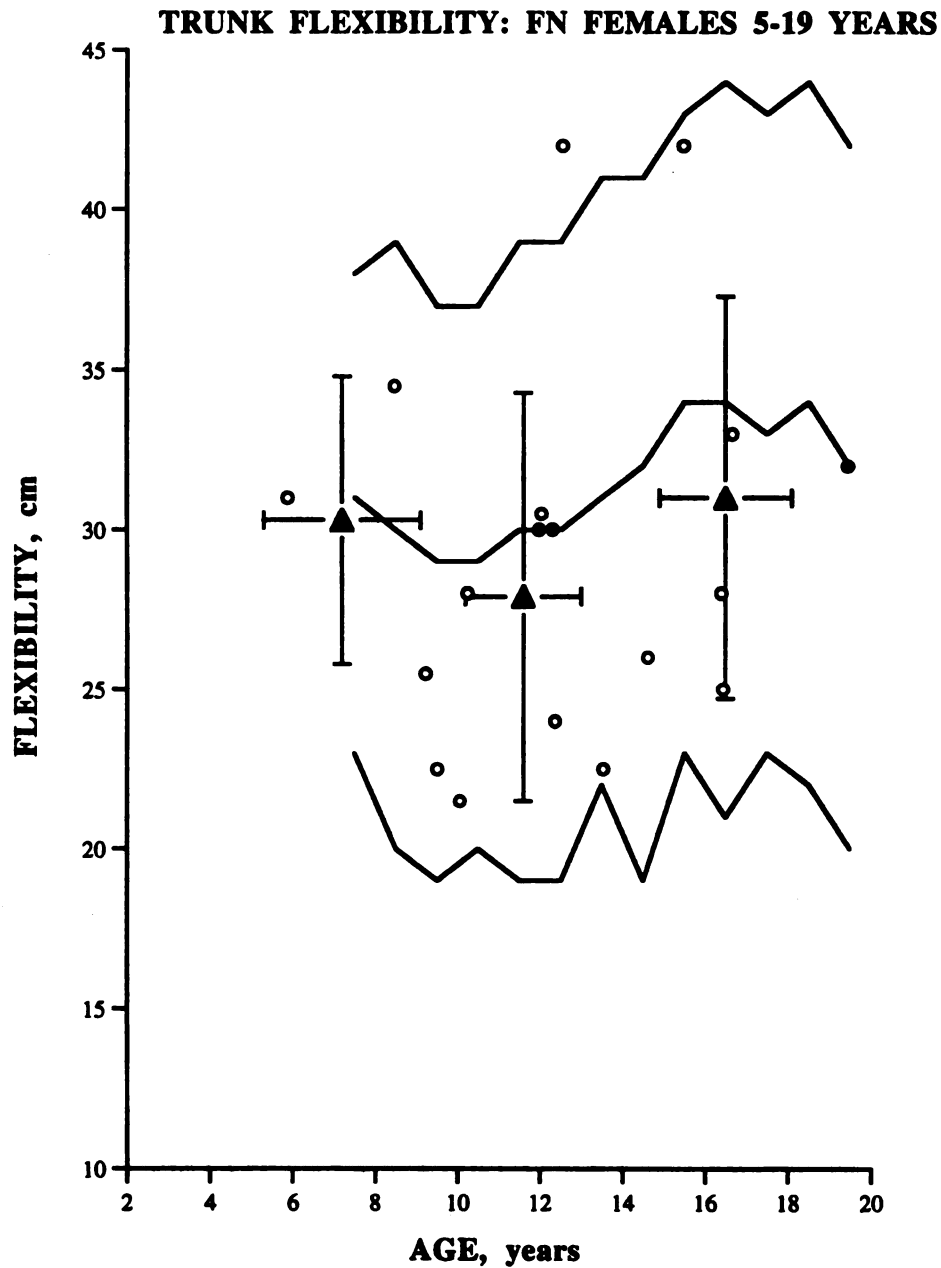


FIGURE 4.79 Trunk flexibility of EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.



TRUNK FLEXIBILITY: EA MALES 20-75 YEARS

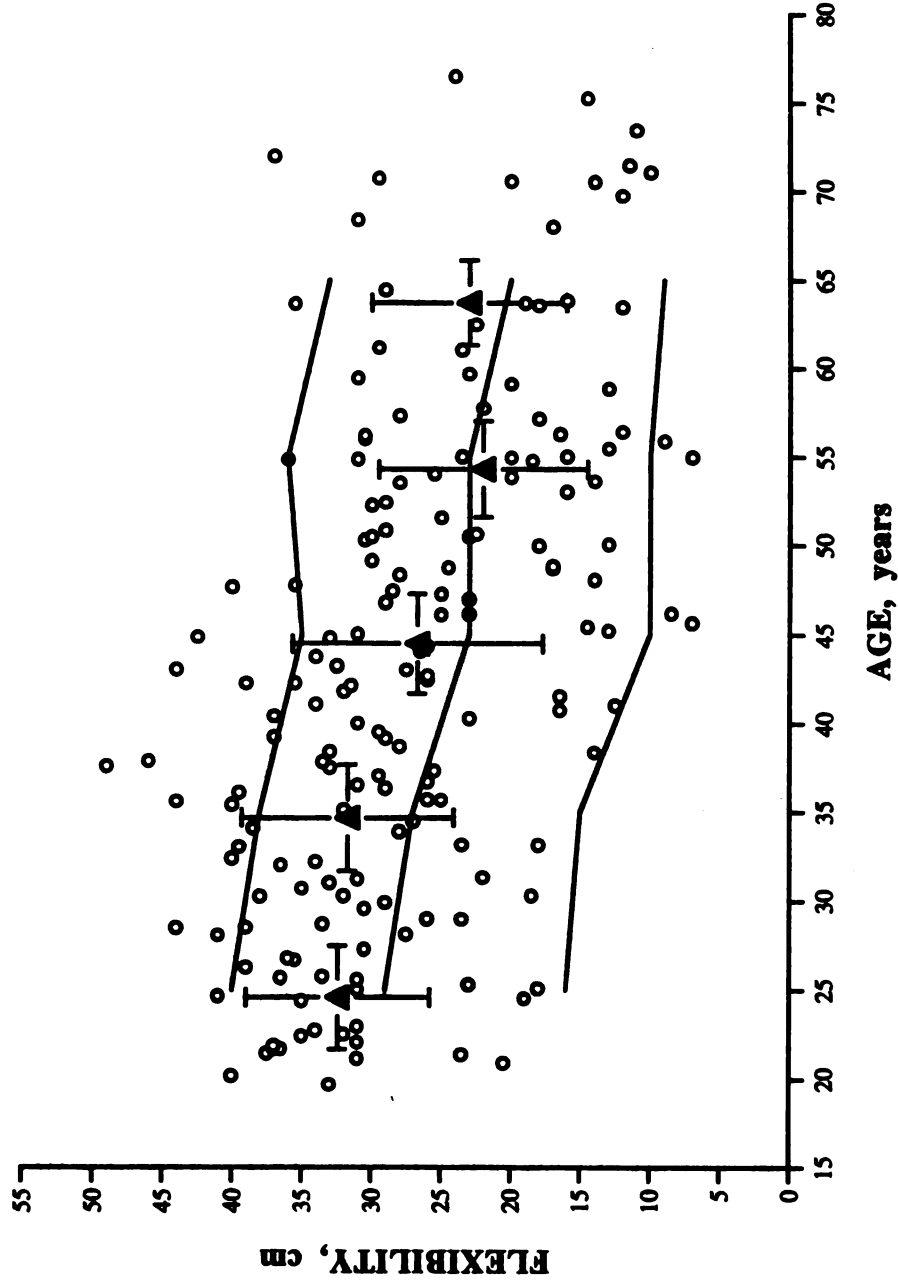


FIGURE 4.81 Trunk flexibility of EA males (o) 20-75 years and ten-year age group means ($\Delta \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

TRUNK FLEXIBILITY: FN MALES 20-75 YEARS

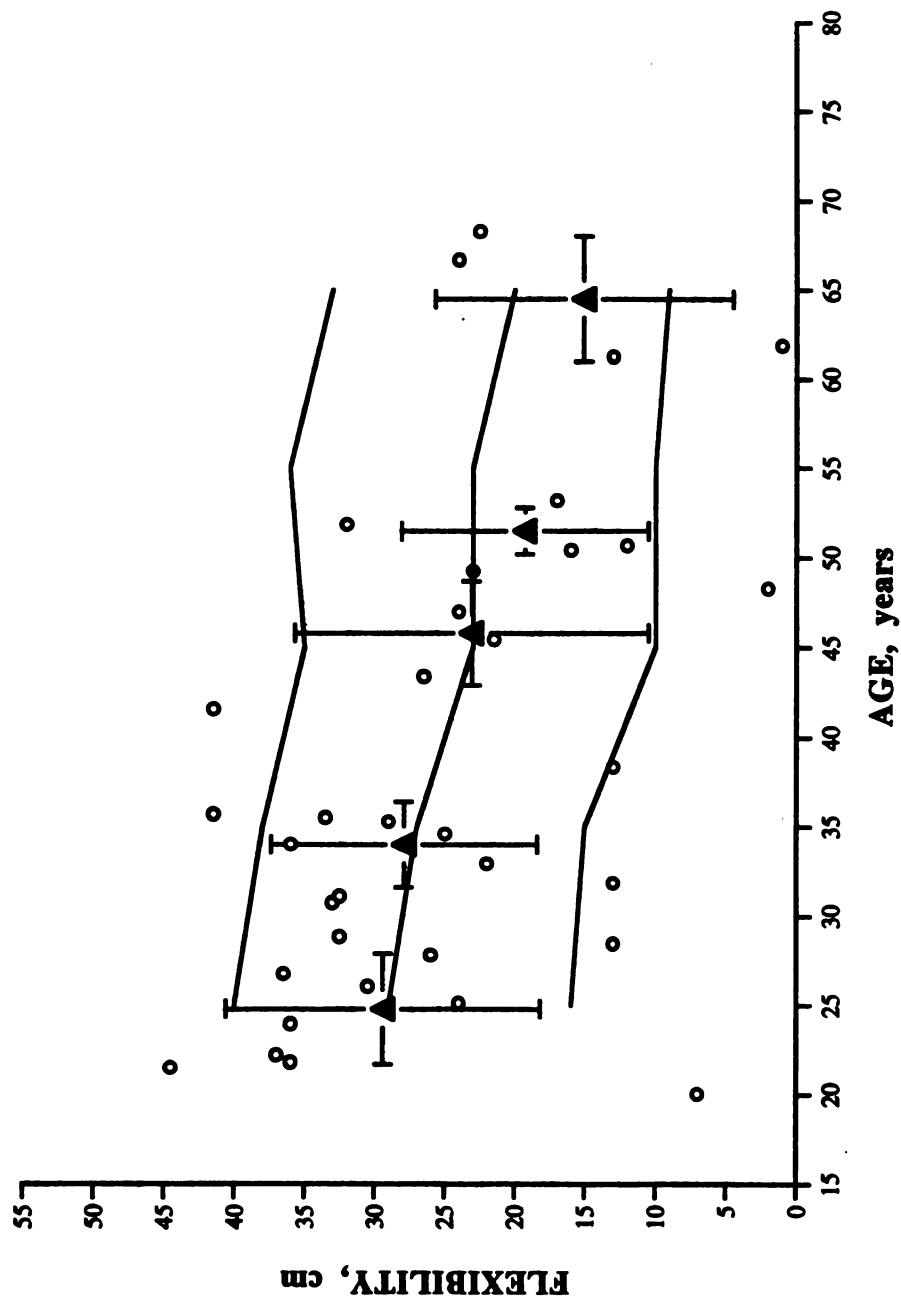


FIGURE 4.82 Trunk flexibility of FN males (o) 20-75 years and ten-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

TRUNK FLEXIBILITY: EA FEMALES 20-75 YEARS

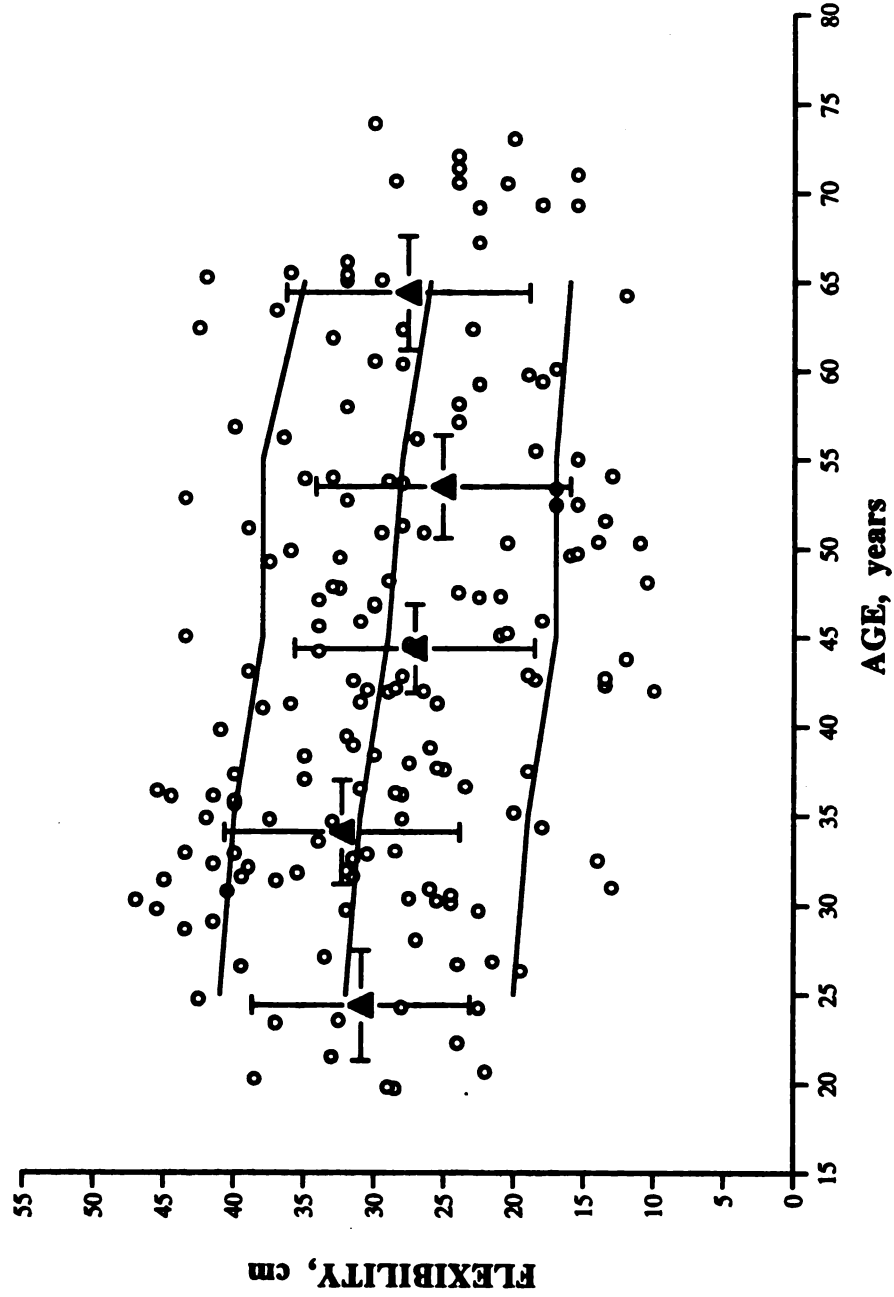


FIGURE 4.83 Trunk flexibility of EA females (o) 20-75 years and ten-year age group means ($\Delta \pm SD$) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

TRUNK FLEXIBILITY: FN FEMALES 20-75 YEARS

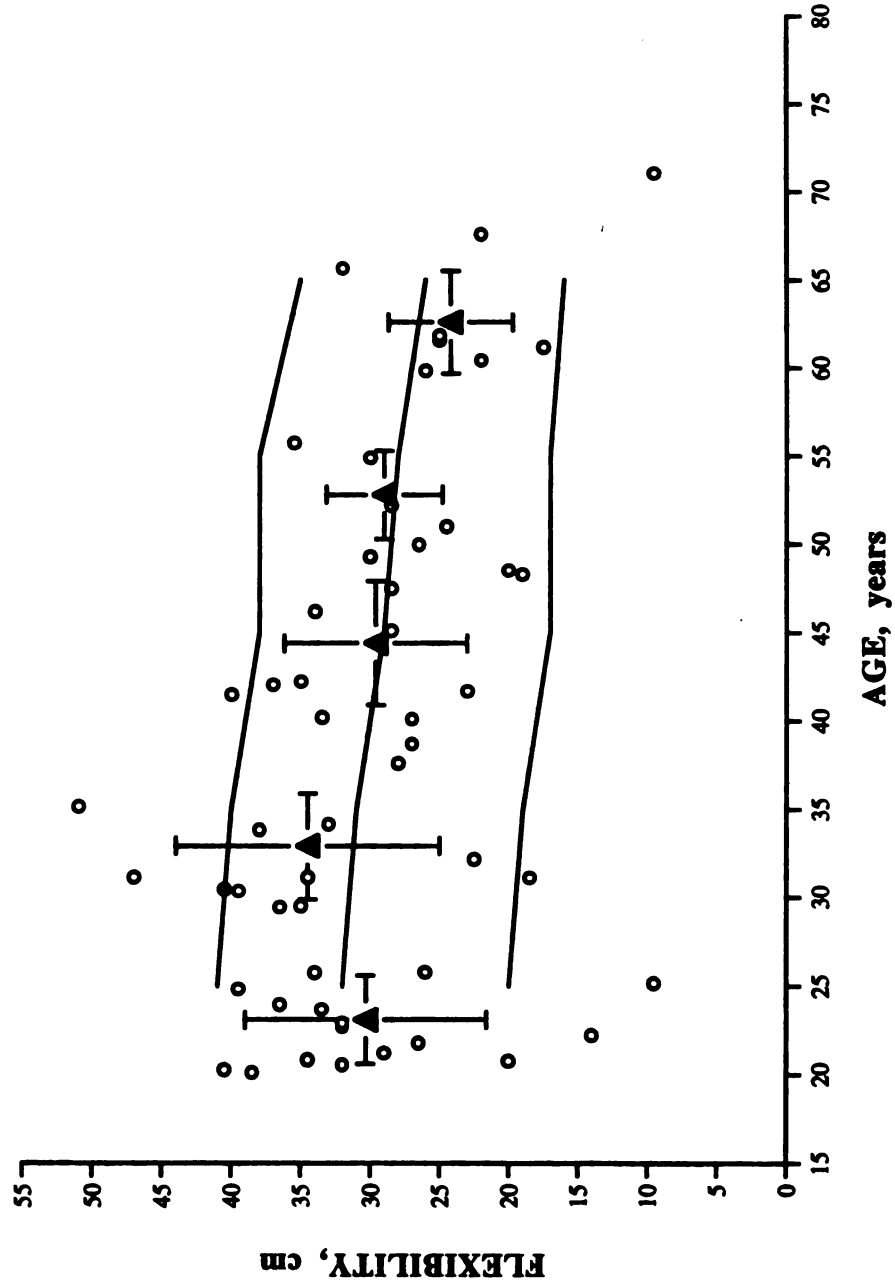


FIGURE 4.84 Trunk flexibility of EA males (o) 20-75 years and ten-year age group means (▲ ± SD) plotted relative to Canadian reference data (Fitness Canada, 1986). Horizontal bars are ± SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

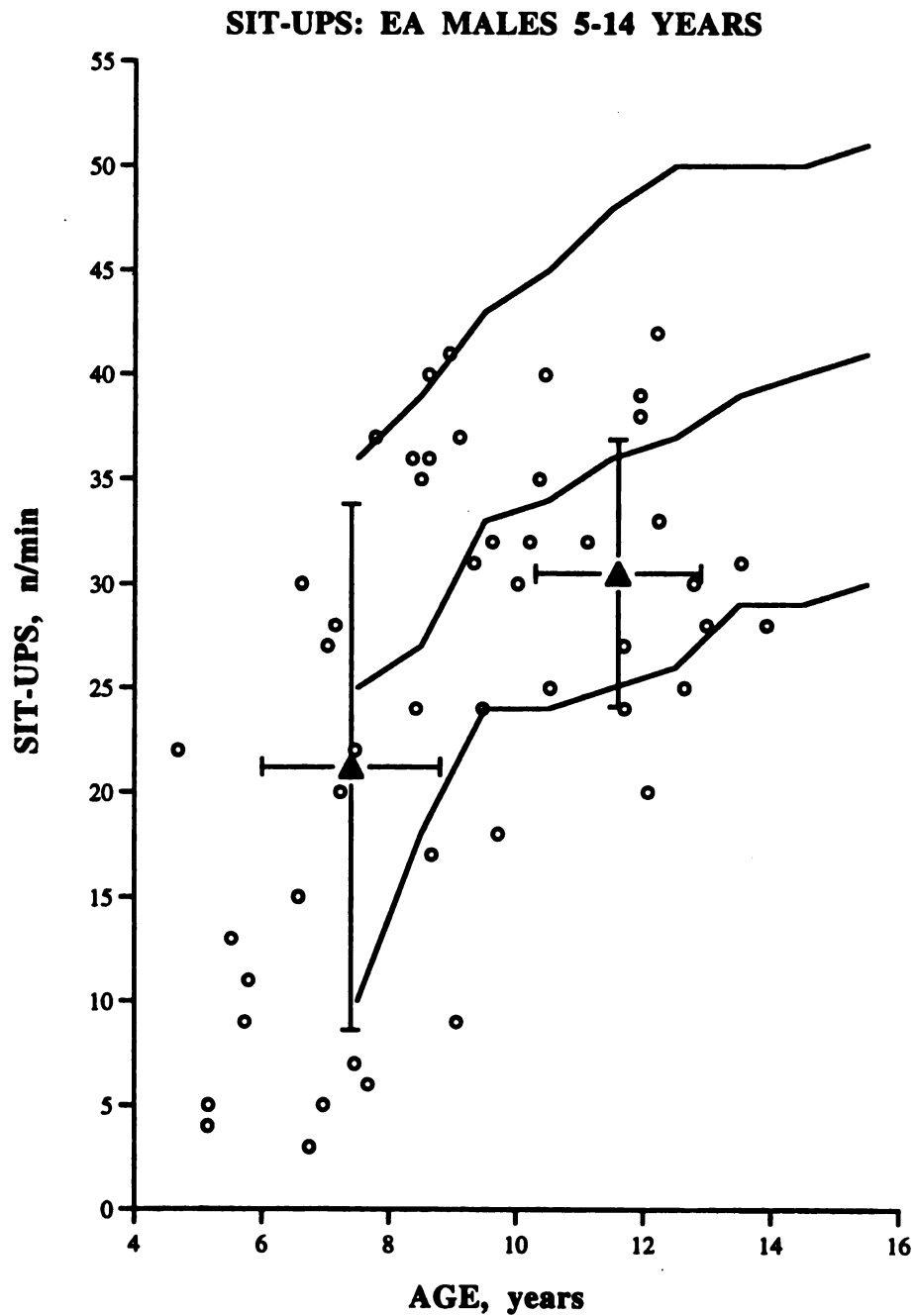


FIGURE 4.85 Sit-ups in EA males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

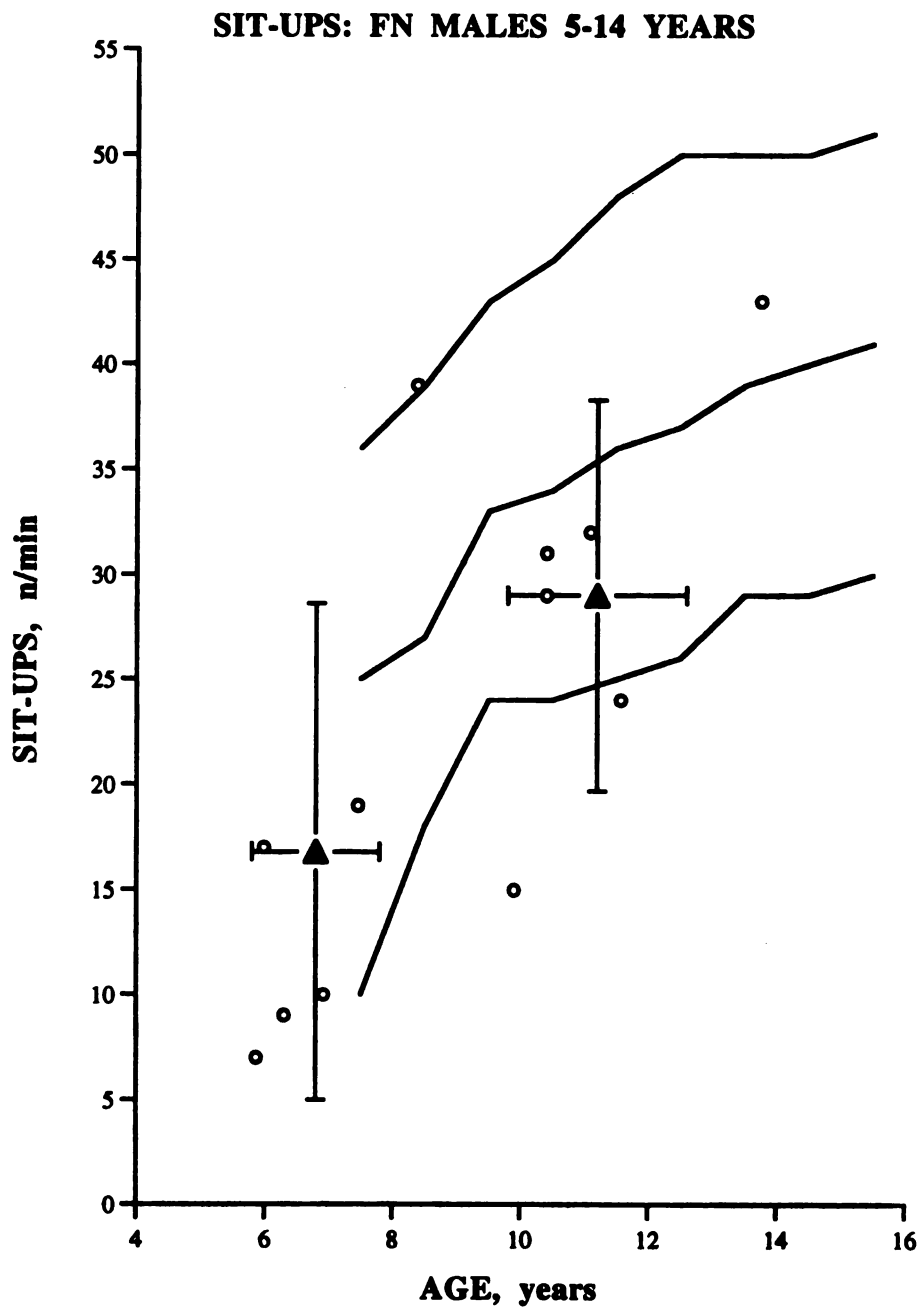


FIGURE 4.86 Sit-ups in FN males (o) 5-19 years and five-year age group means ($\blacktriangle \pm \text{SD}$) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

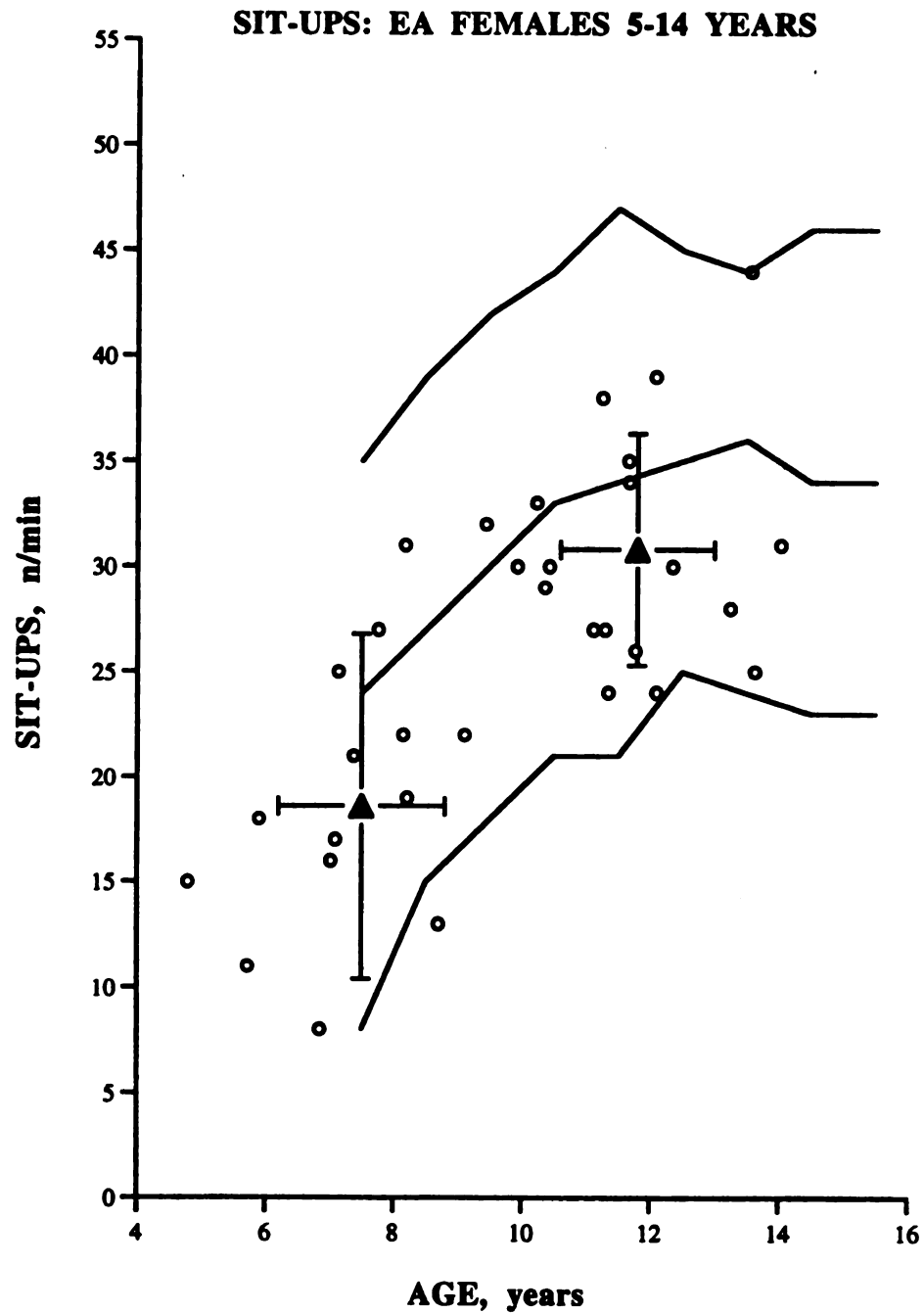


FIGURE 4.87 Sit-ups in EA females (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

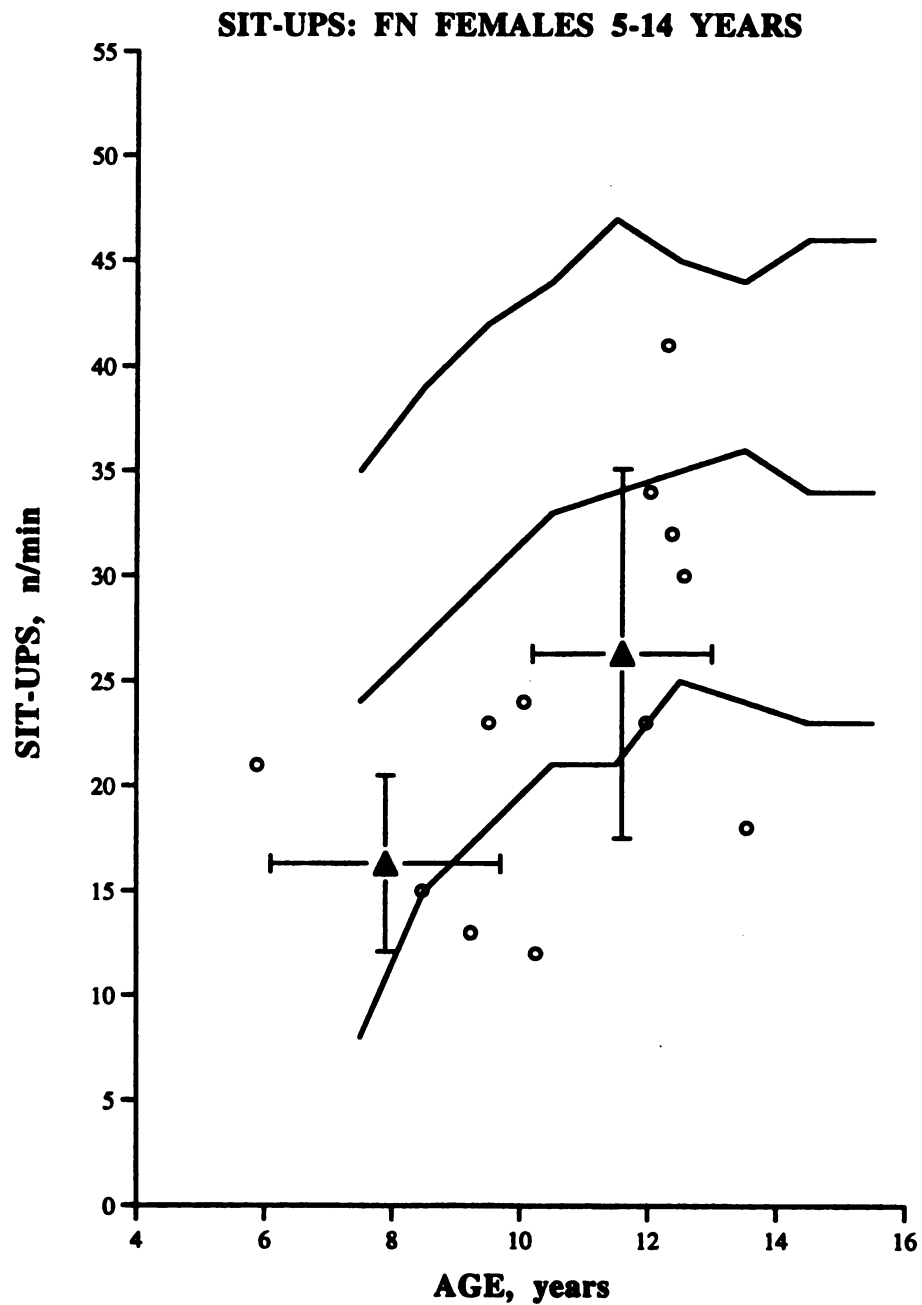


FIGURE 4.88 Sit-ups in FN females (o) 5-19 years and five-year age group means (▲ $\pm$ SD) plotted relative to Canadian reference data (Fitness Canada, 1985). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

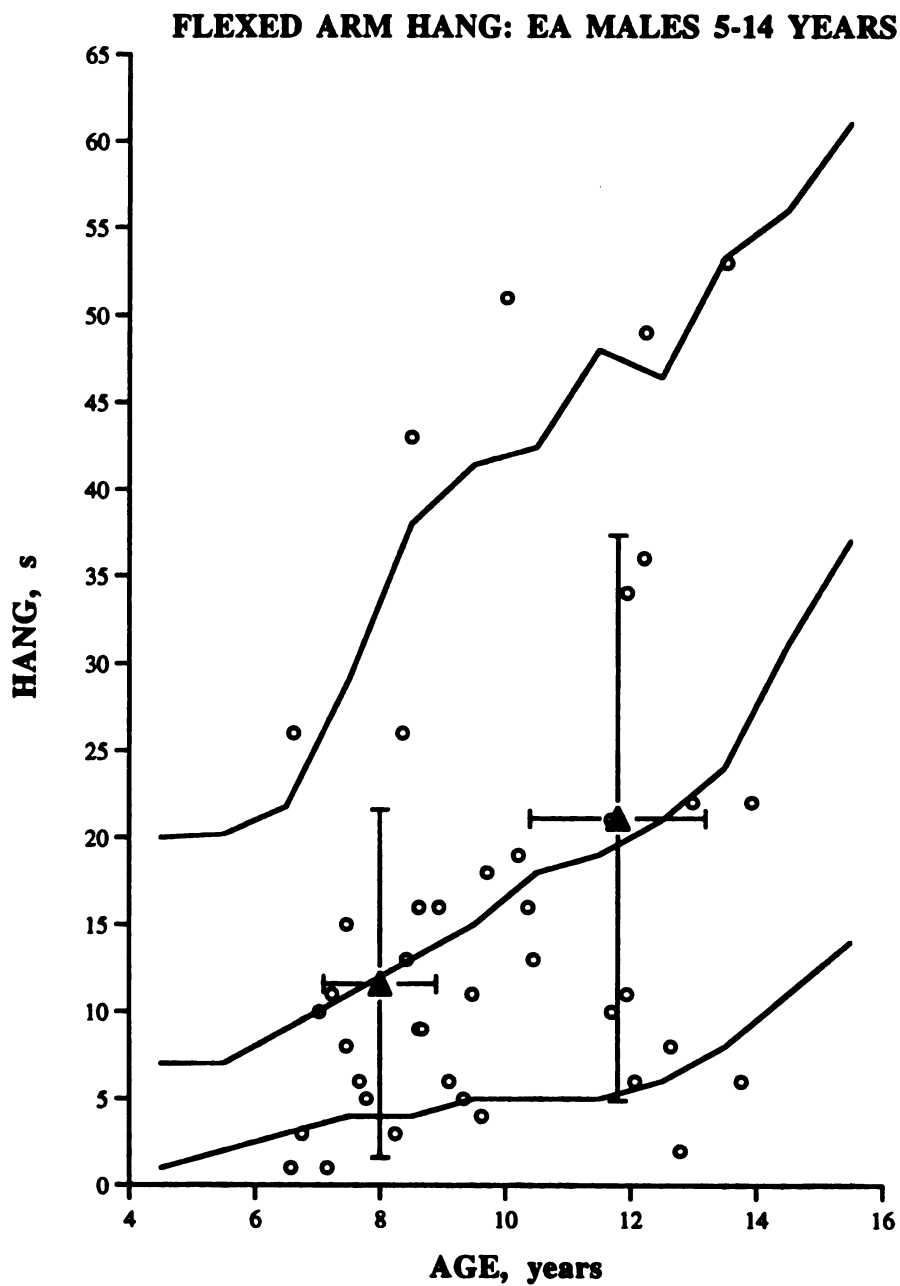


FIGURE 4.89 Flexed arm hang in EA males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

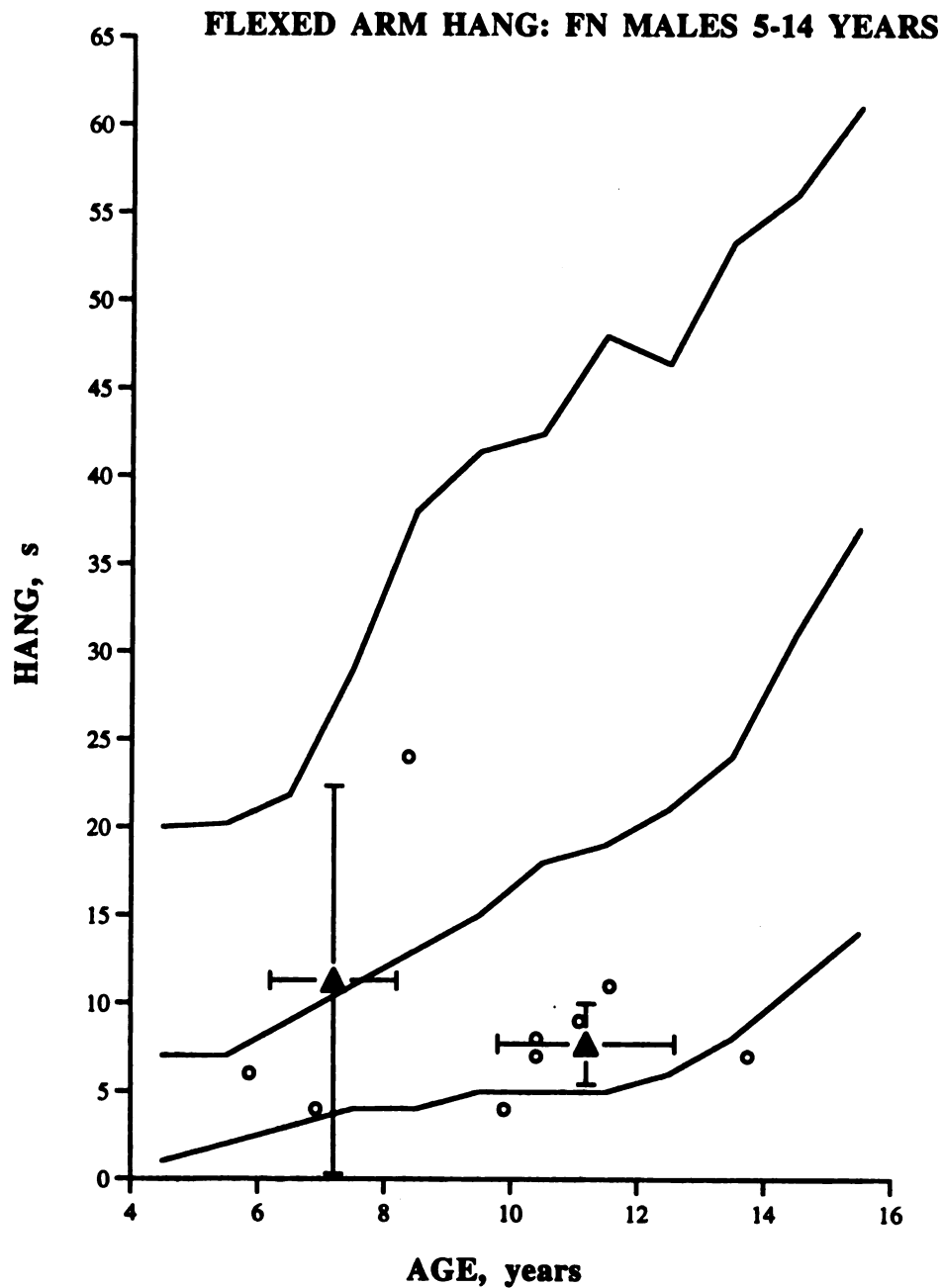


FIGURE 4.90 Flexed arm hang in FN males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

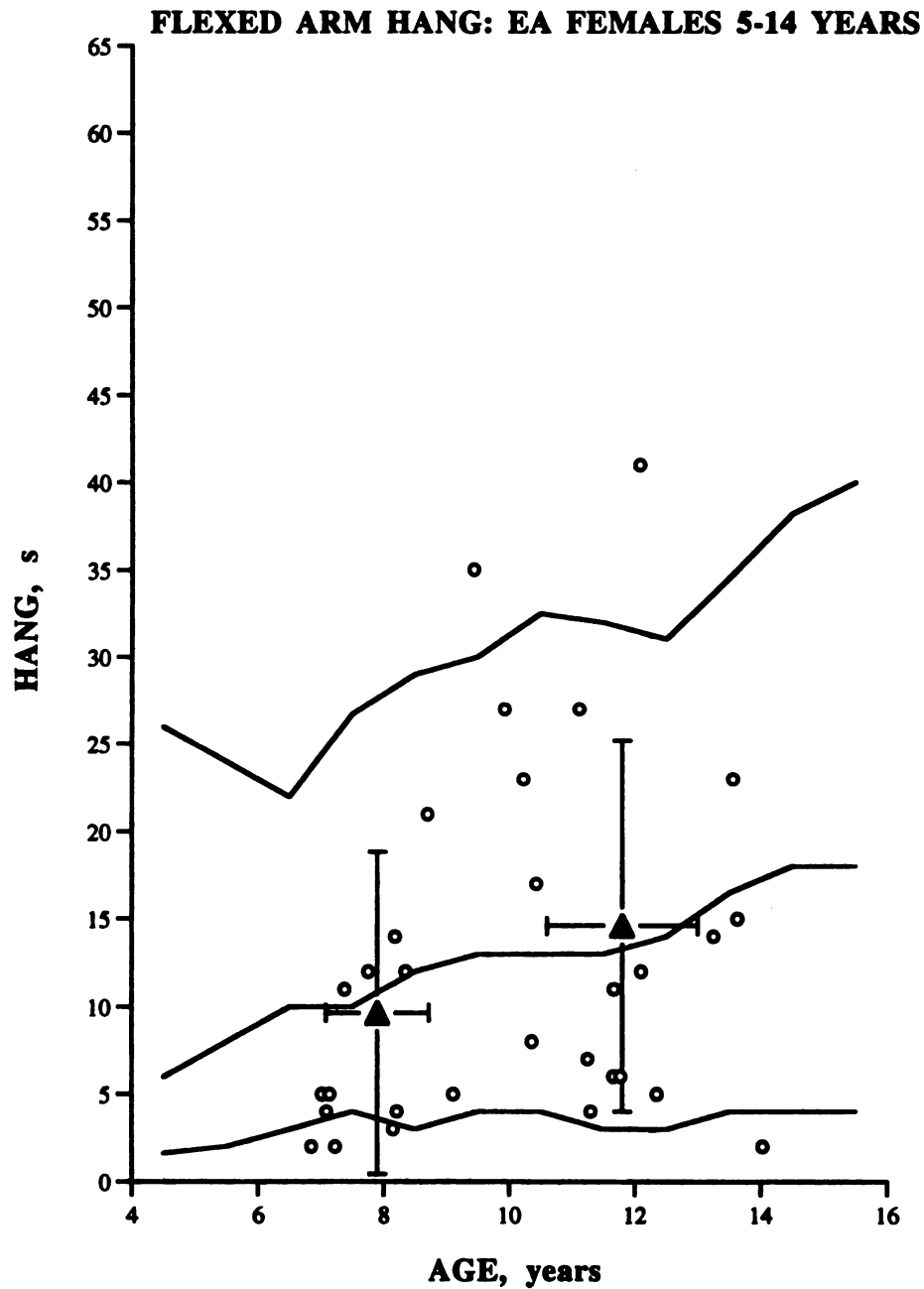


FIGURE 4.91 Flexed arm hang in EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

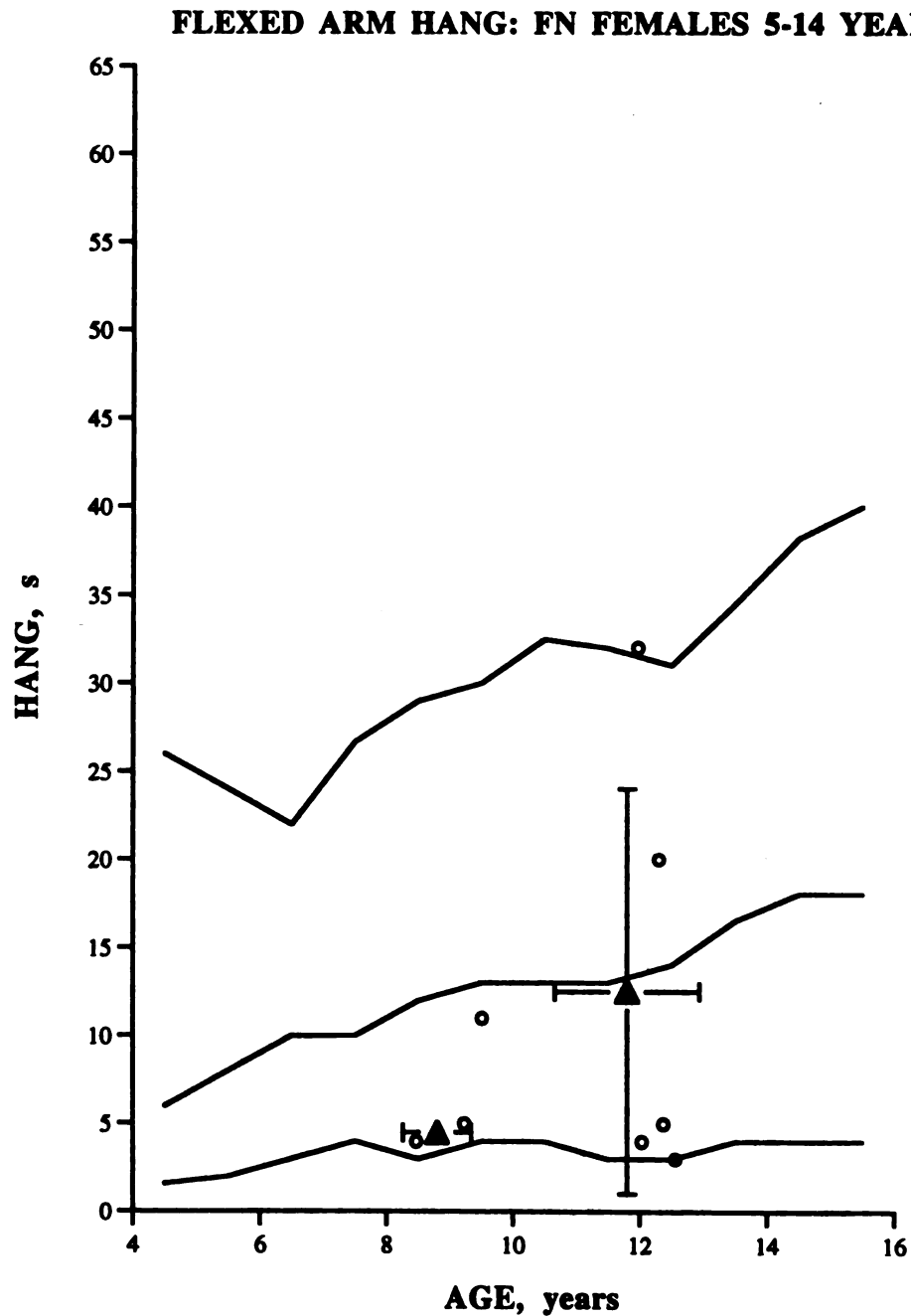


FIGURE 4.92 Flexed arm hang in FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

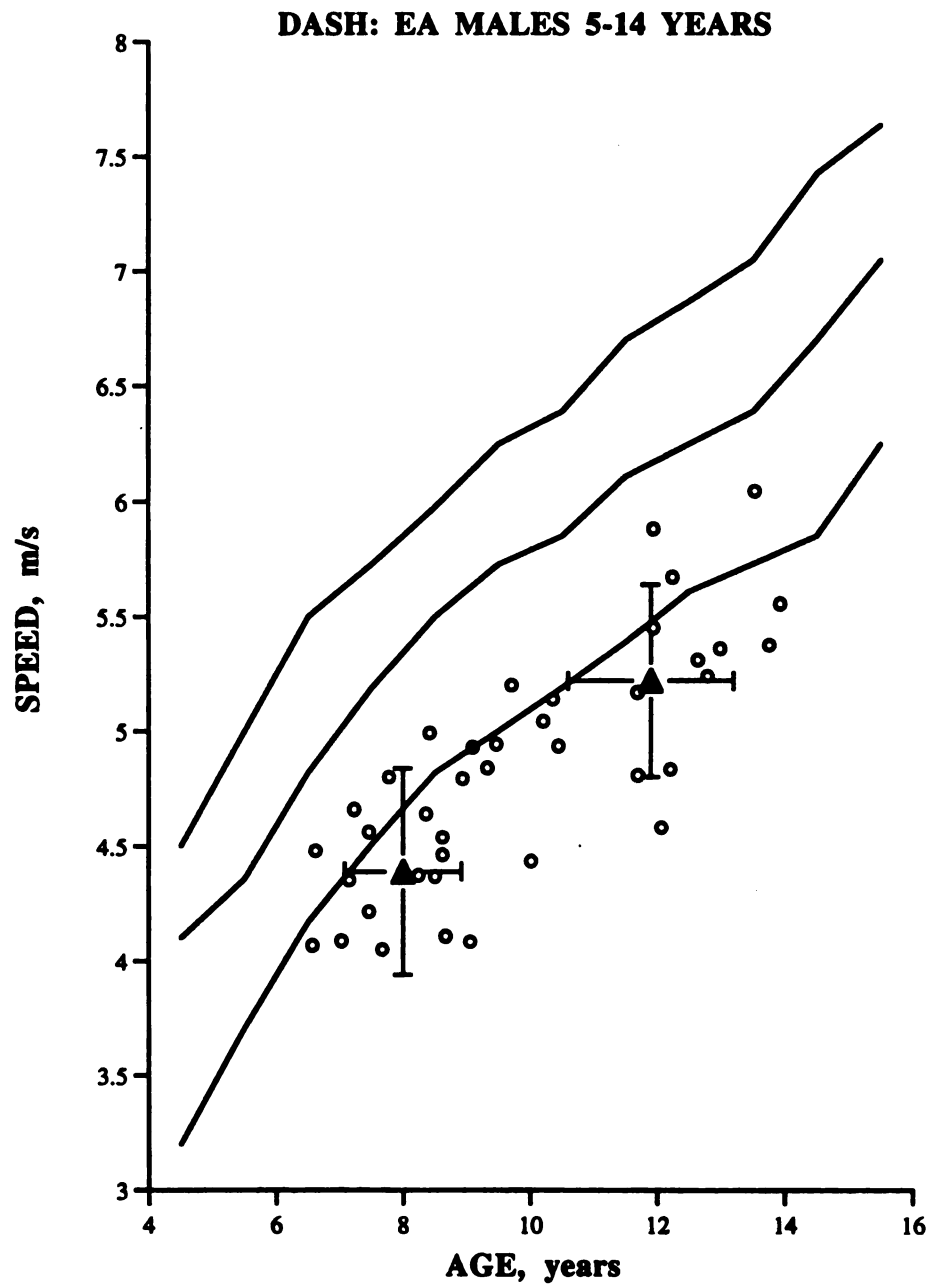


FIGURE 4.93 35-meter dash speed in EA males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

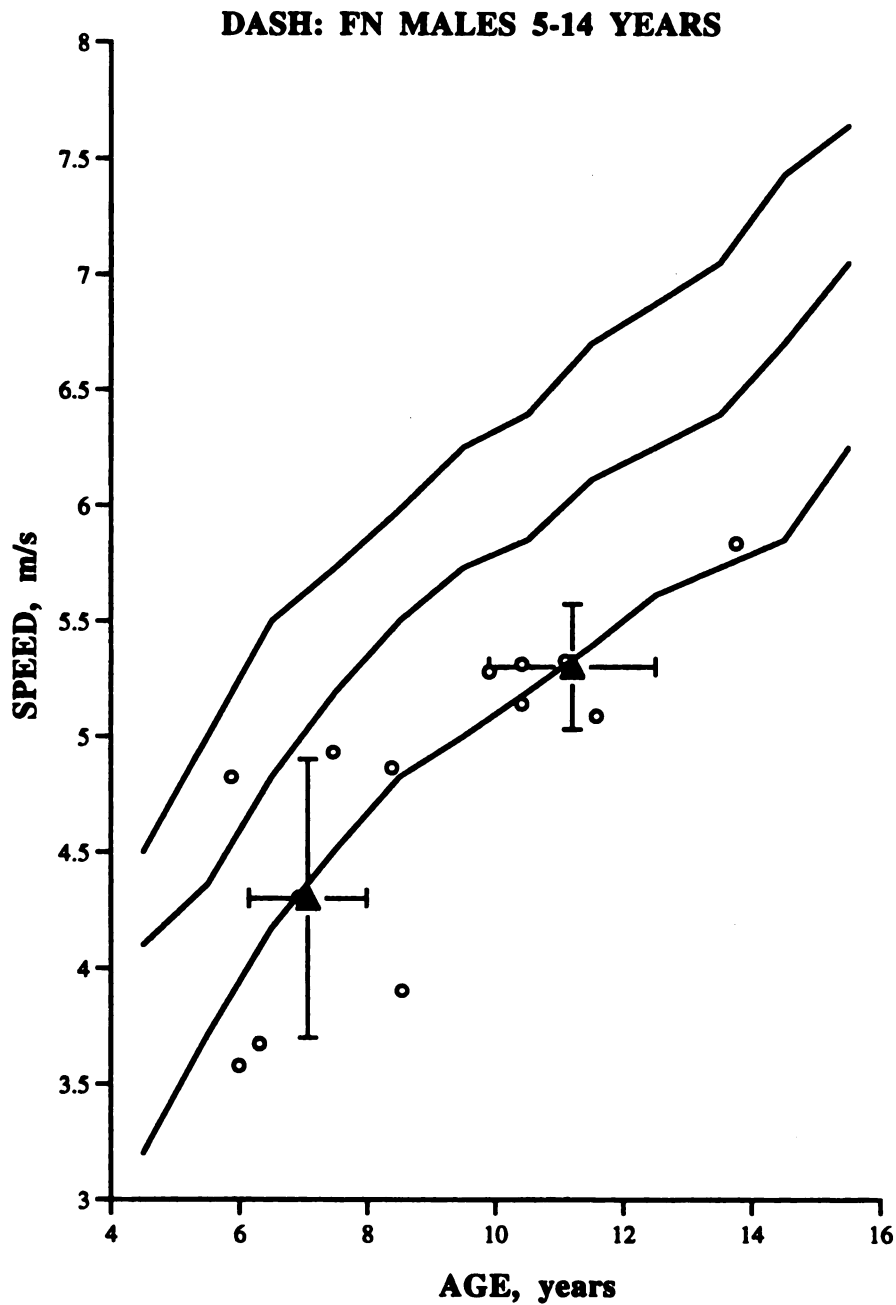


FIGURE 4.94 35-meter dash speed in FN males (o) 5-19 years and five-year age group means ($\Delta \pm SD$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm SD$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

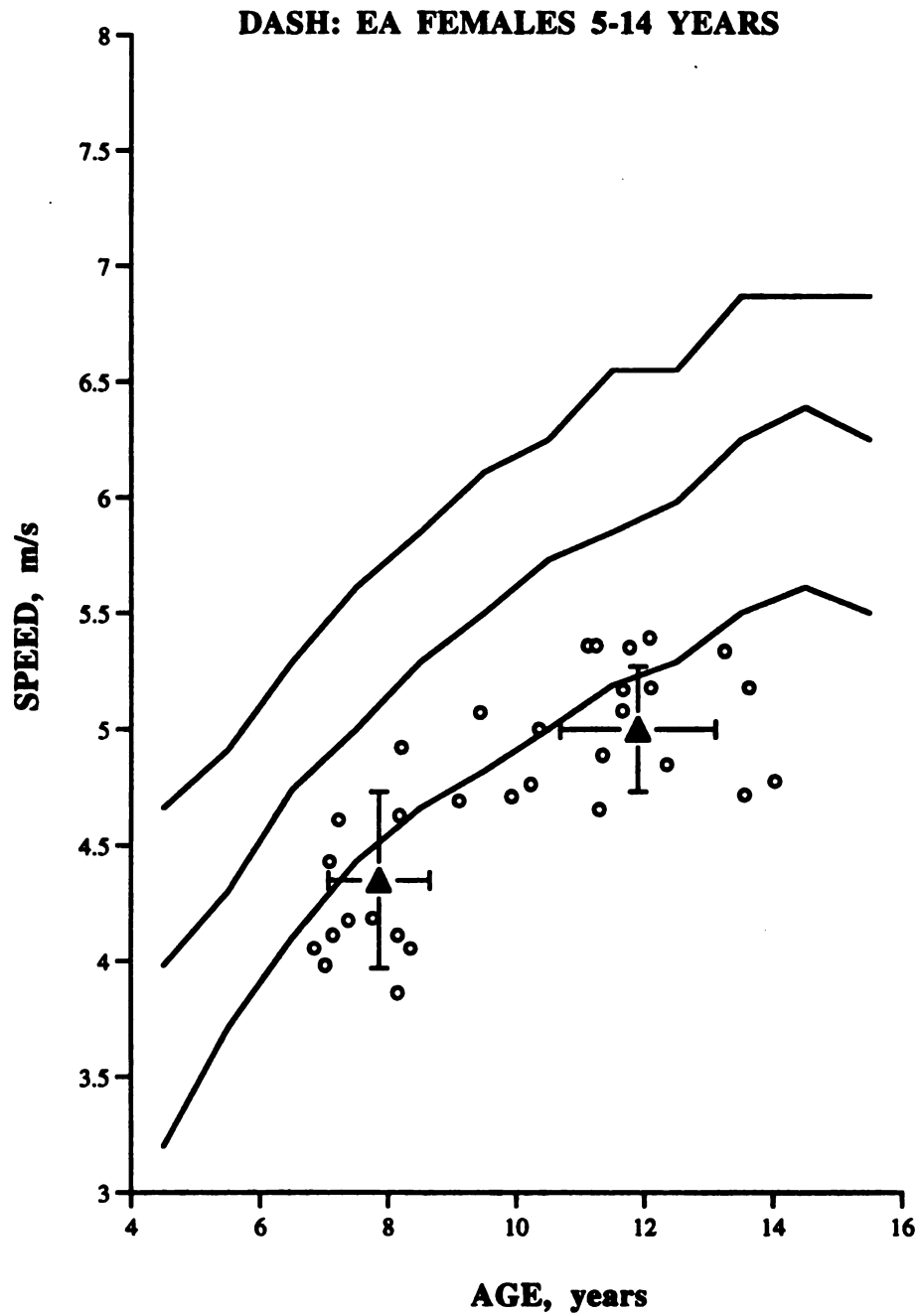


FIGURE 4.95 35-meter dash speed in EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

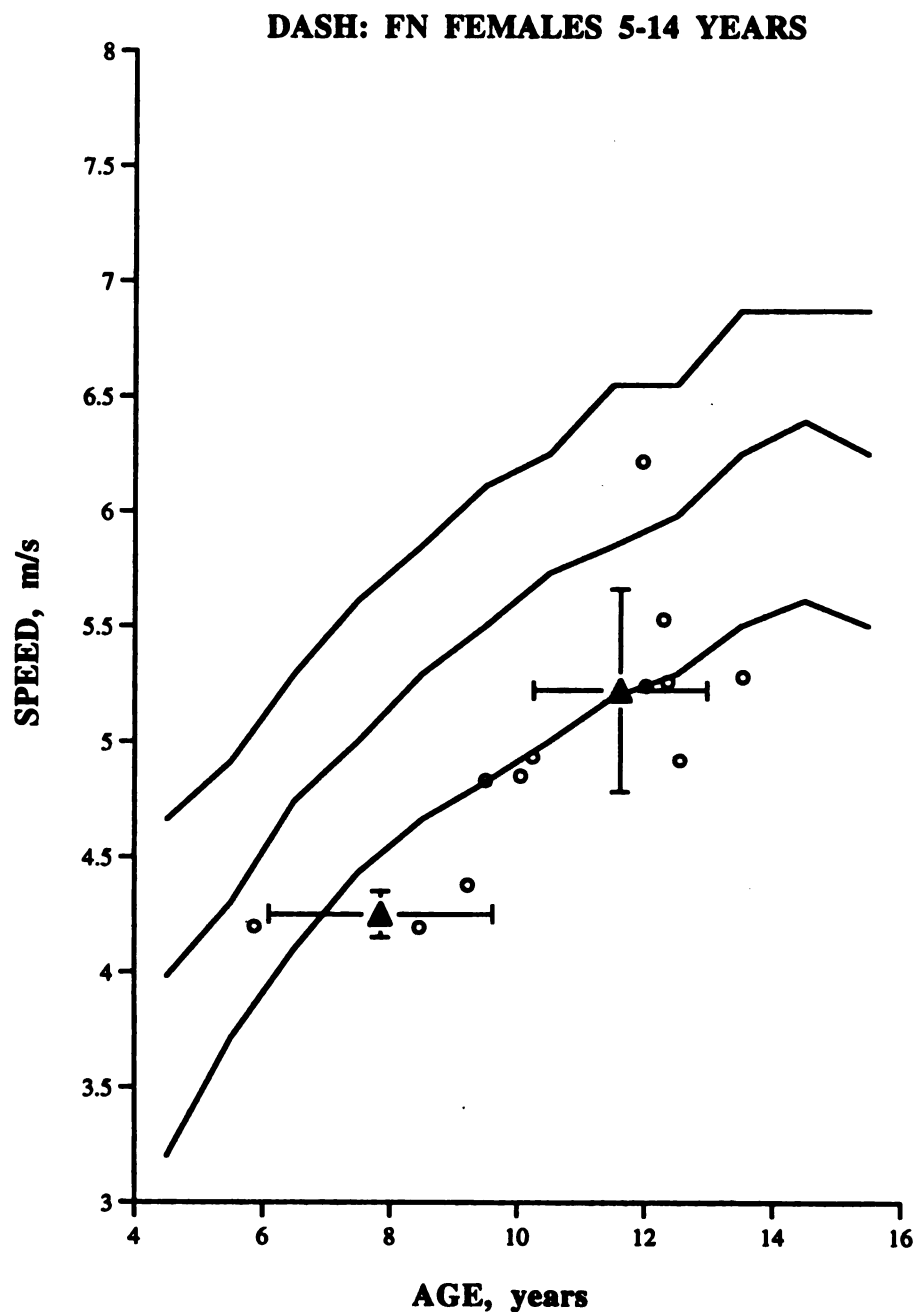


FIGURE 4.96 35-meter dash speed in FN females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

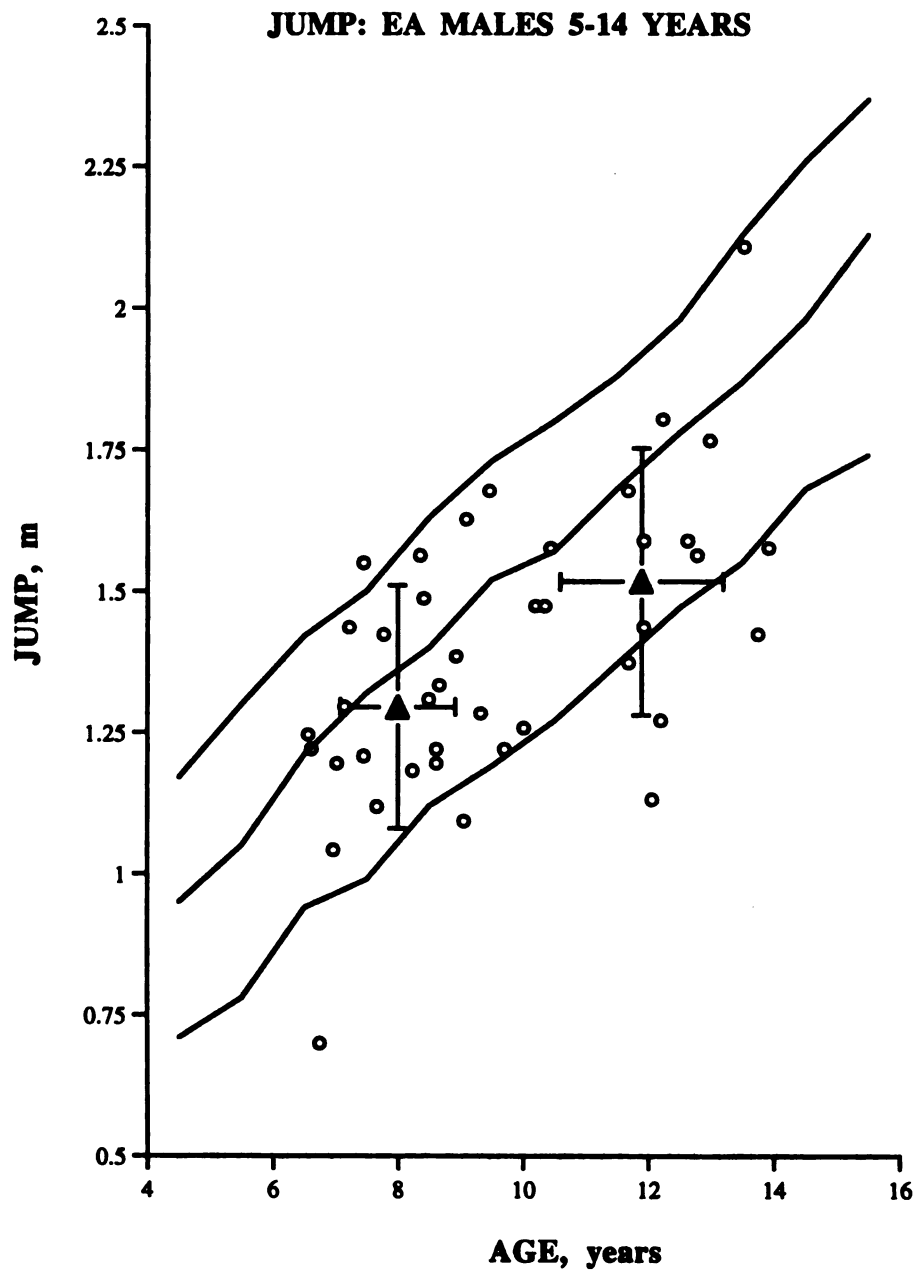


FIGURE 4.97 Standing long jump in EA males (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

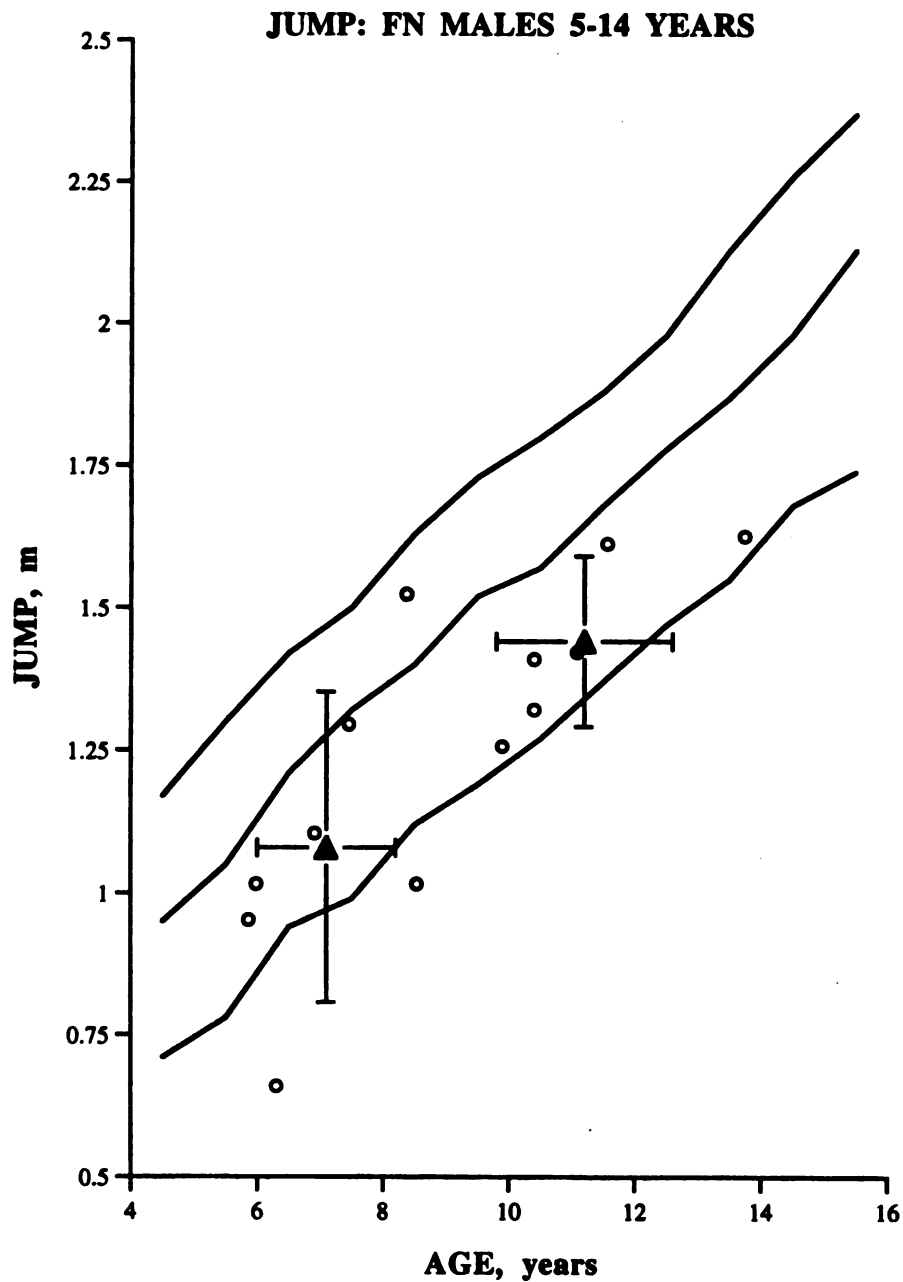


FIGURE 4.98 Standing long jump in FN males (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

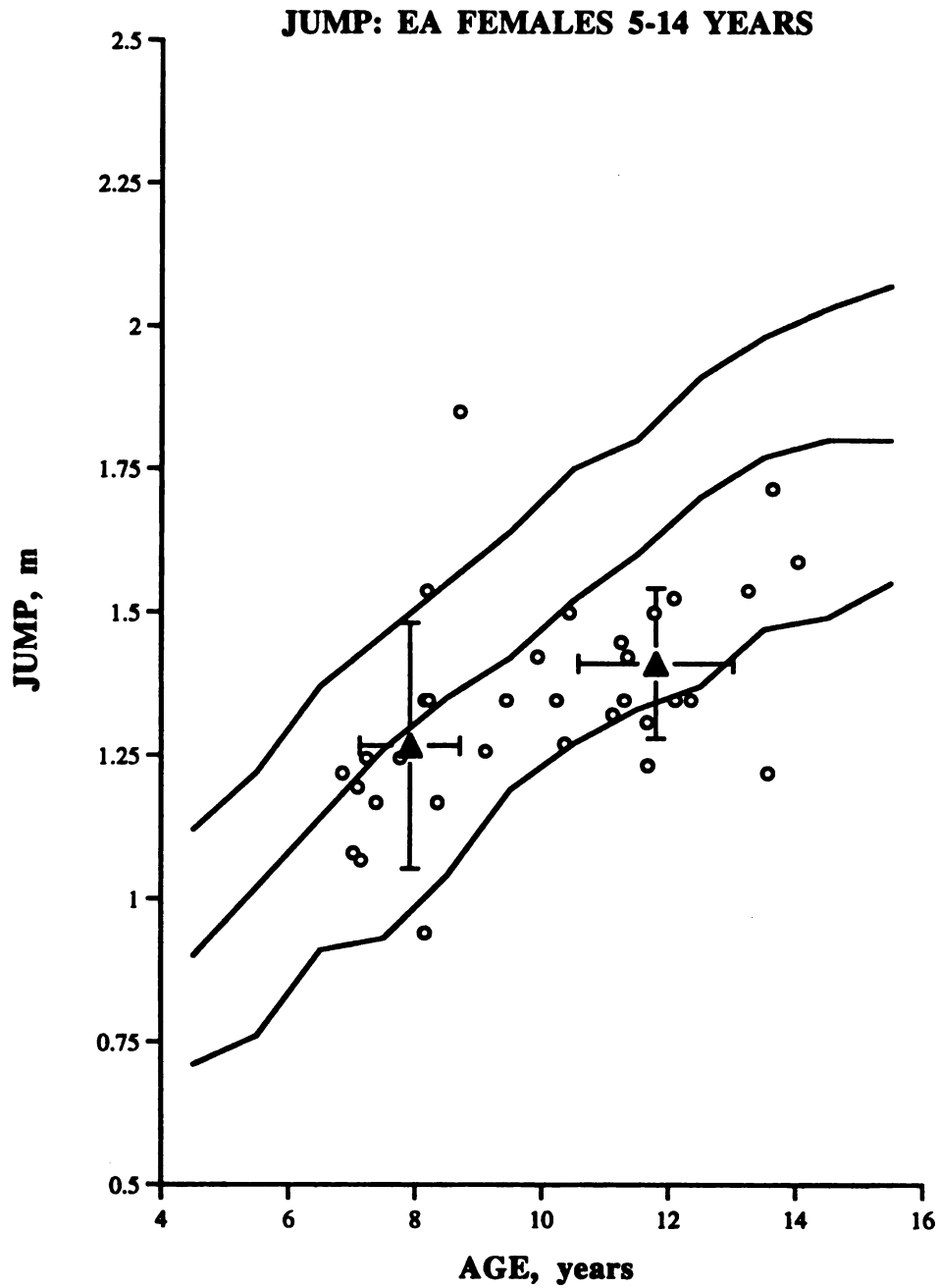


FIGURE 4.99 Standing long jump in EA females (o) 5-19 years and five-year age group means ($\Delta \pm \text{SD}$) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm \text{SD}$ for age. Solid lines represent 10th, 50th, and 90th percentiles.

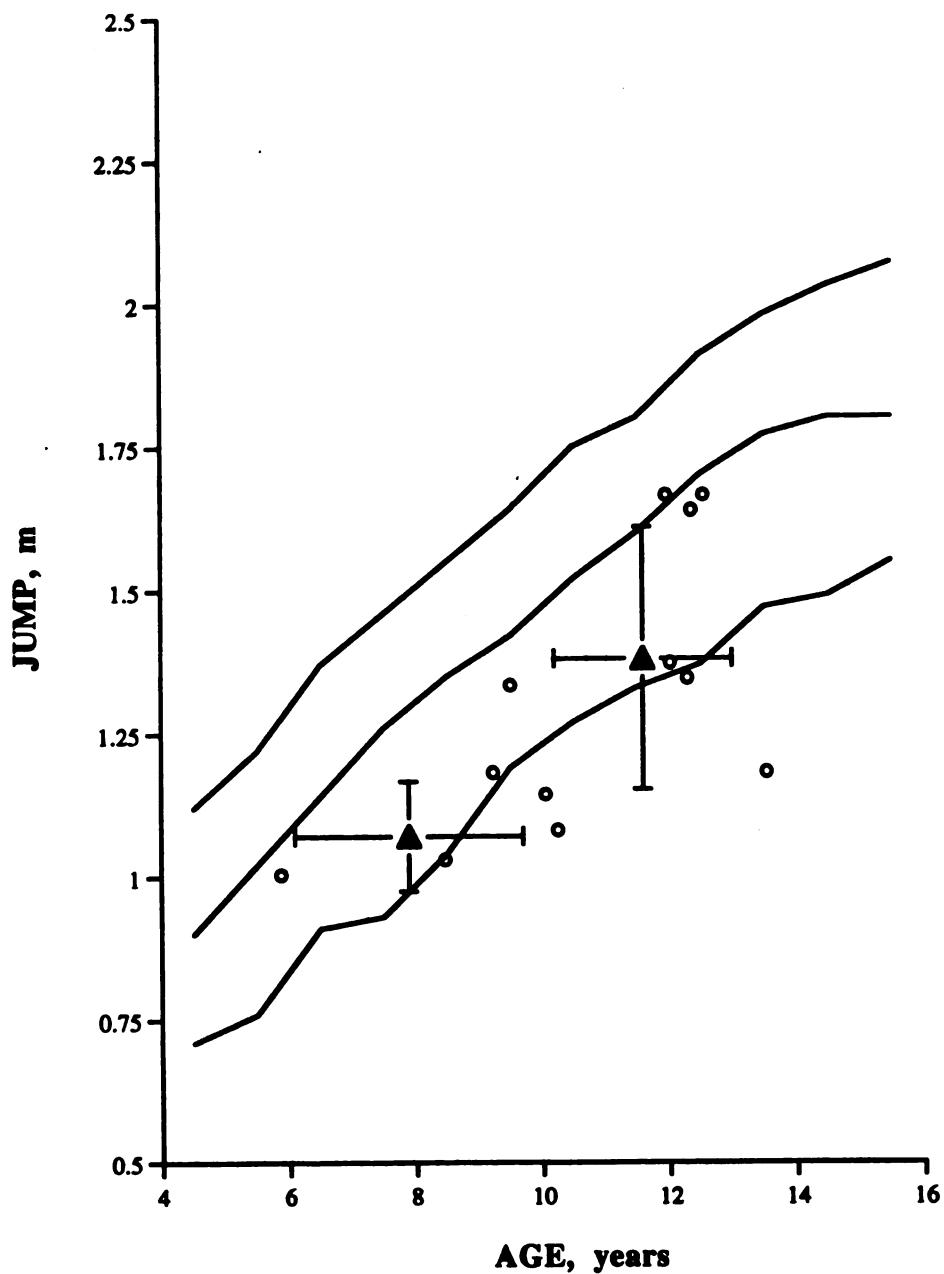
JUMP: FN FEMALES 5-14 YEARS

FIGURE 4.100 Standing long jump in FN females (o) 5-19 years and five-year age group means ($\Delta \pm$ SD) plotted relative to Michigan State University Motor Performance Study data (Haubenstricker et al., 1991). Horizontal bars are $\pm$ SD for age. Solid lines represent 10th, 50th, and 90th percentiles.

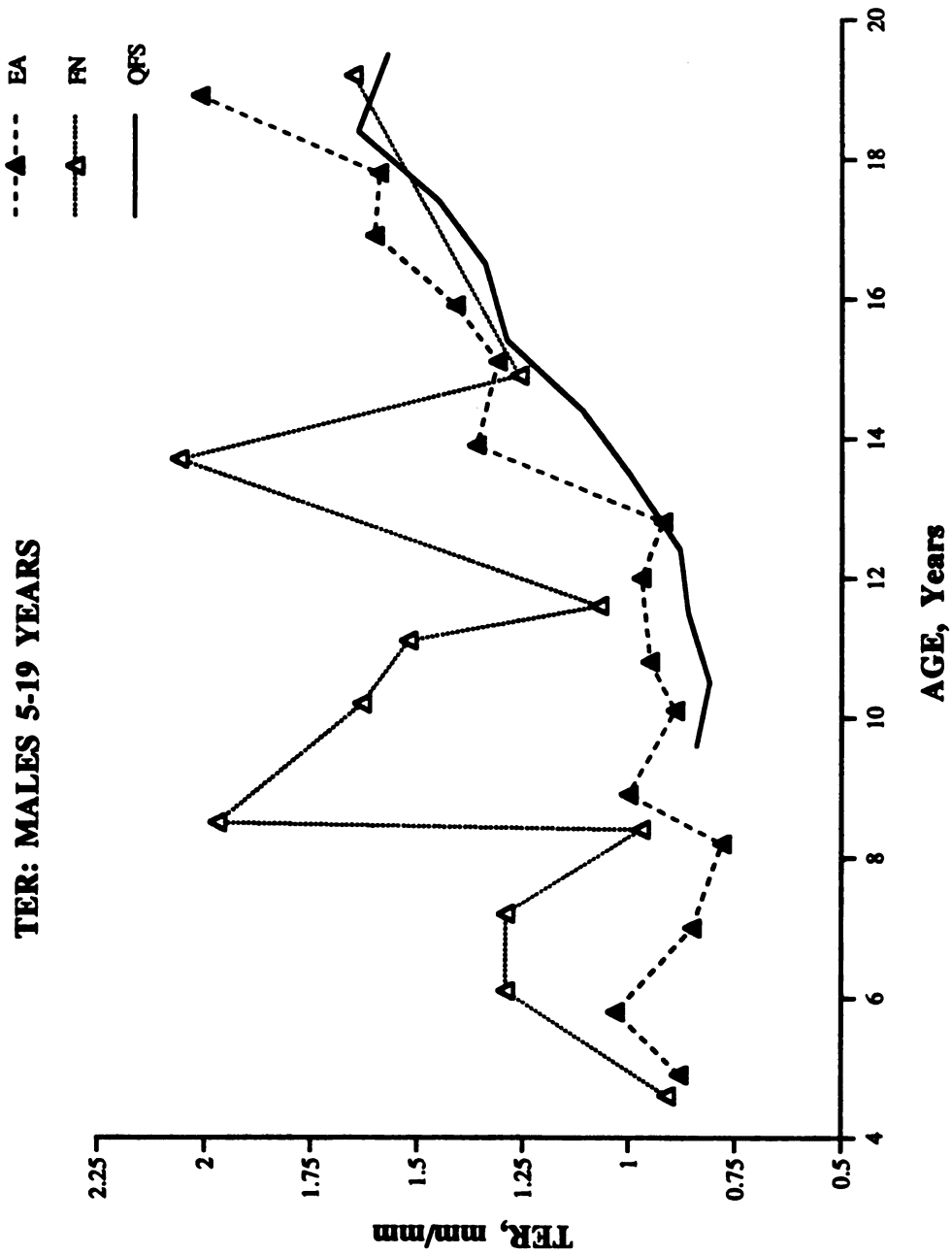


FIGURE 5.1 Age-specific TER means for males 5-19 years (▲ EA, △ FN) plotted relative to the median of the Québec Family Study.

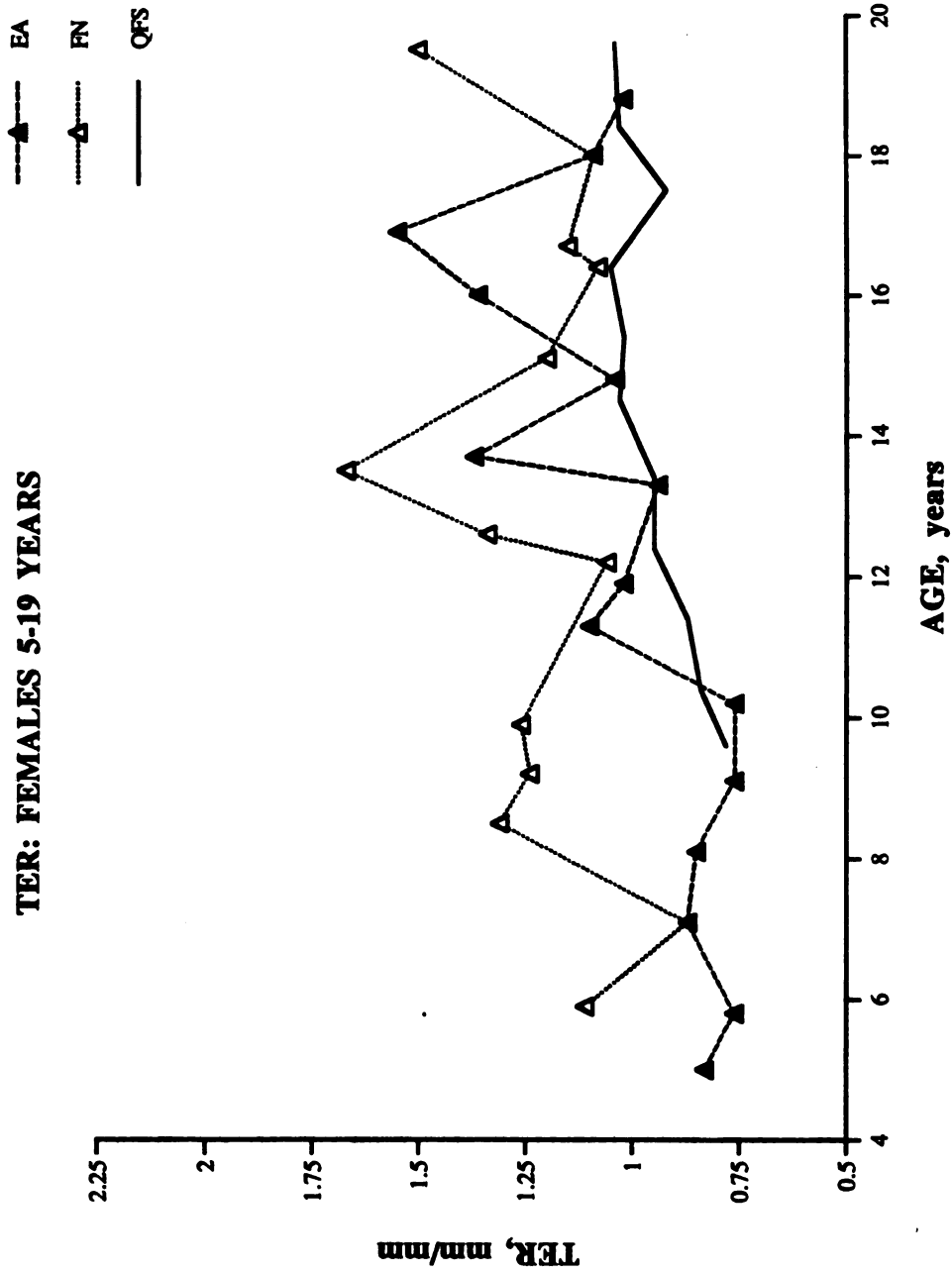


FIGURE 5.2 Age-specific TER means for females 5-19 years ($\blacktriangle$ EA, $\triangle$ FN) plotted relative to the median of the Québec Family Study.

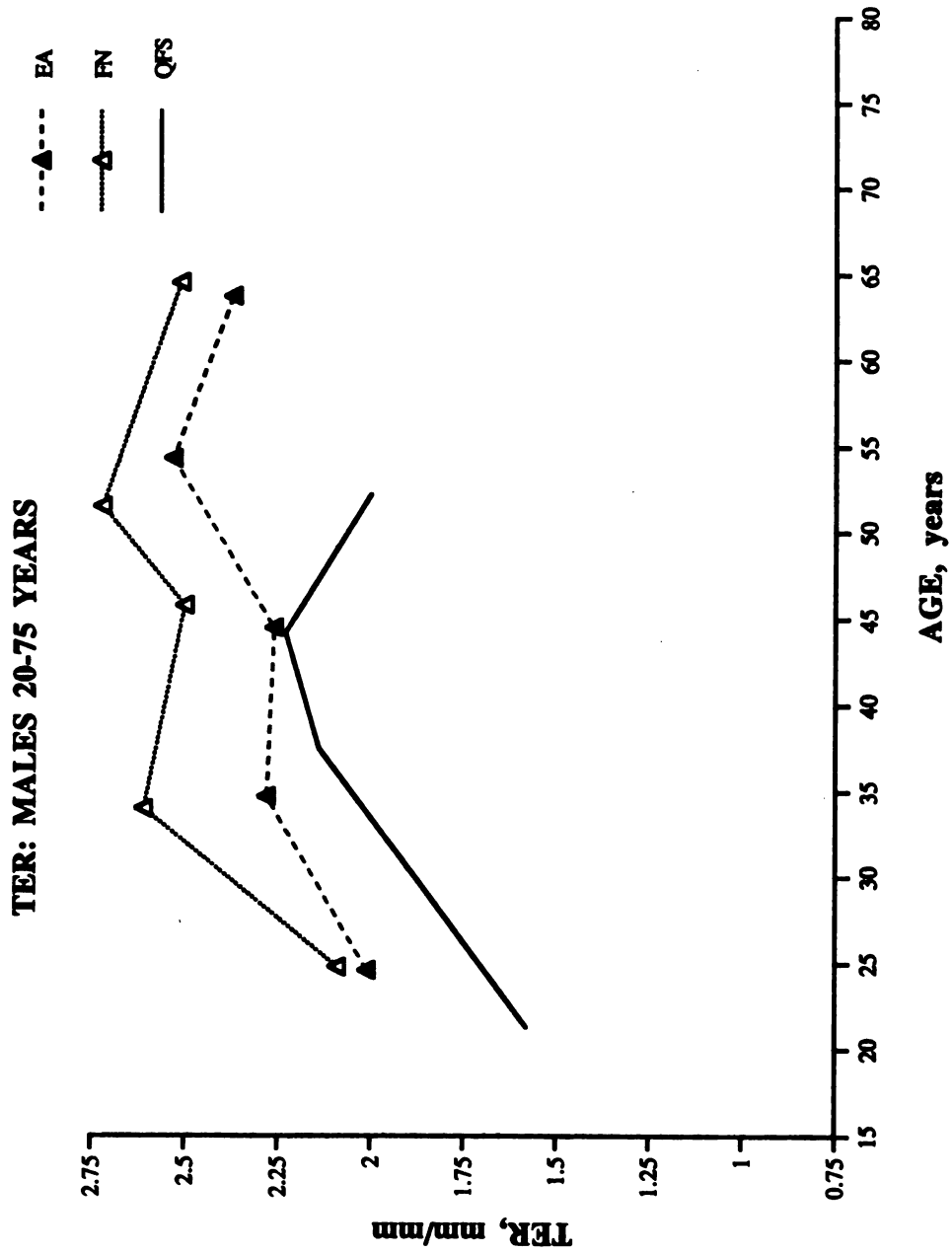


FIGURE 5.3 Ten-year age group TER means for males 20-75 years (▲ EA, △ FN) plotted relative to the median of the Québec Family Study.

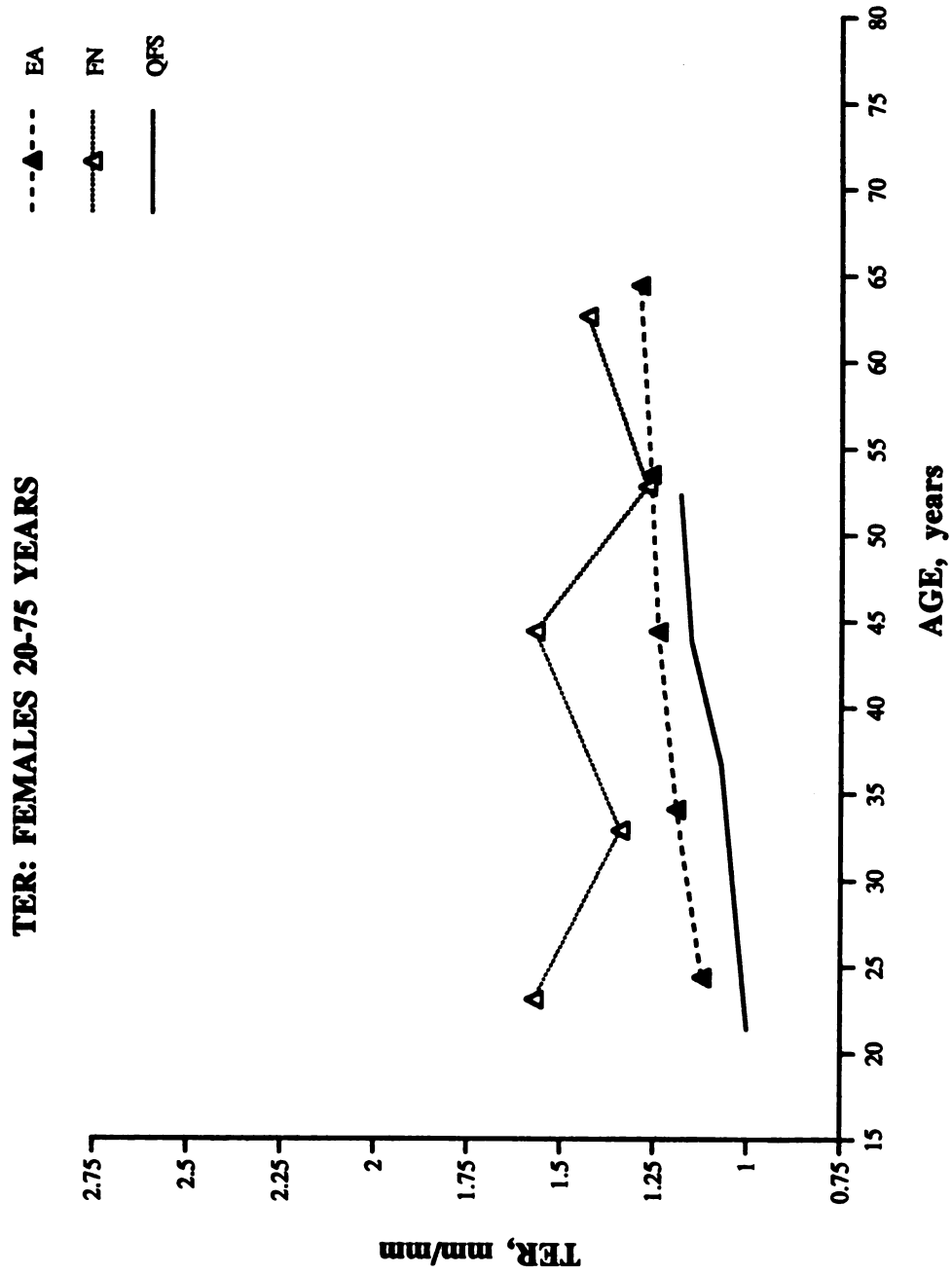


FIGURE 5.4 Ten-year age group TER means for females 20-75 years (Δ EA, Δ FN) plotted relative to the median of the Québec Family Study.

WHR: MALES 20-75 YEARS

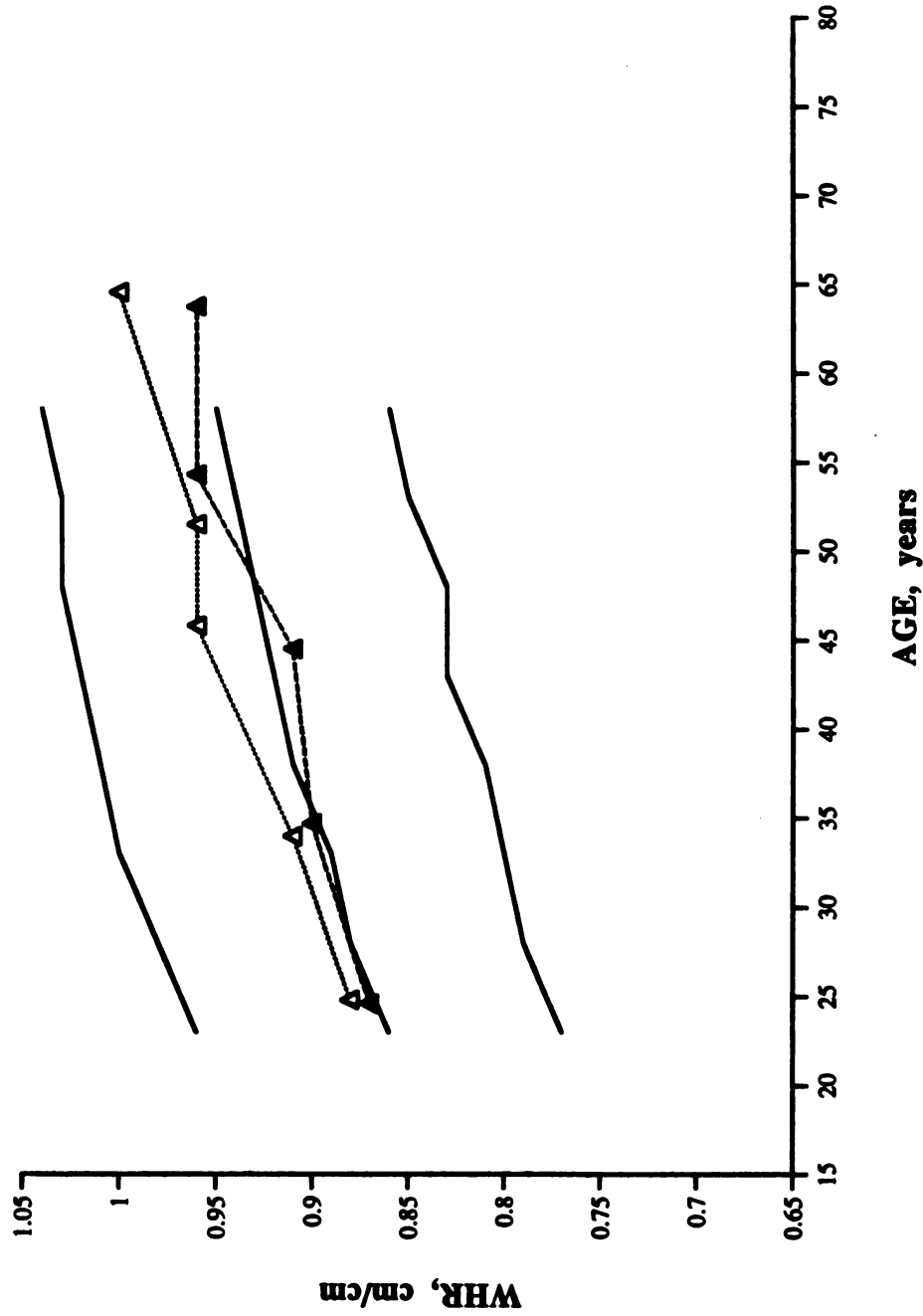


FIGURE 5.5 Ten-year age group WHR means for males (▲ EA, Δ FN) plotted relative to French data (Tichet et al., 1993). Solid lines represent 5th, 50th and 95th percentiles.

WHR: FEMALES 20-75 YEARS

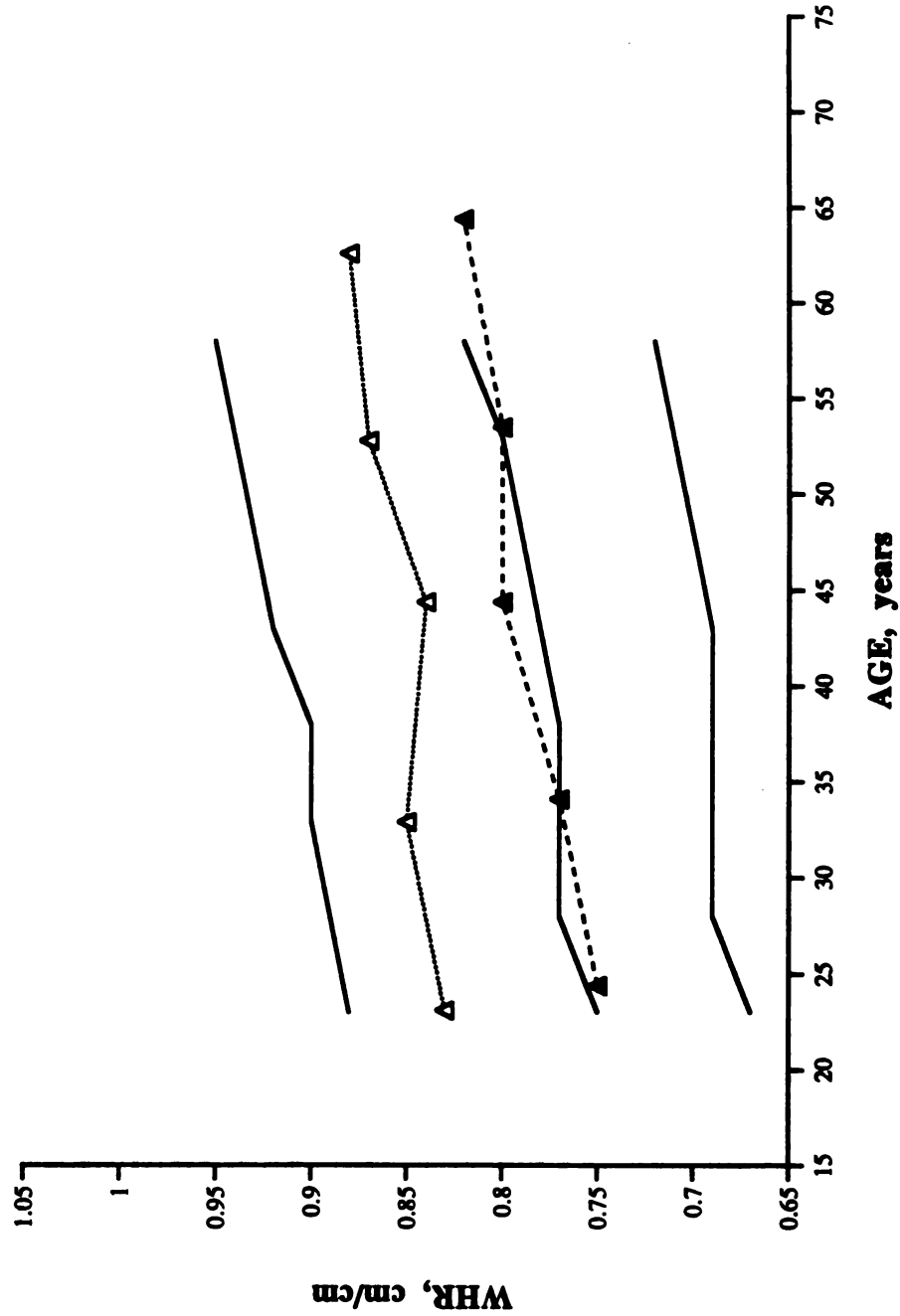


FIGURE 5.6 Ten-year age group WHR means for females (Δ EA, Δ FN) plotted relative to French data (Tichet et al., 1993). Solid lines represent 5th, 50th and 95th percentiles.

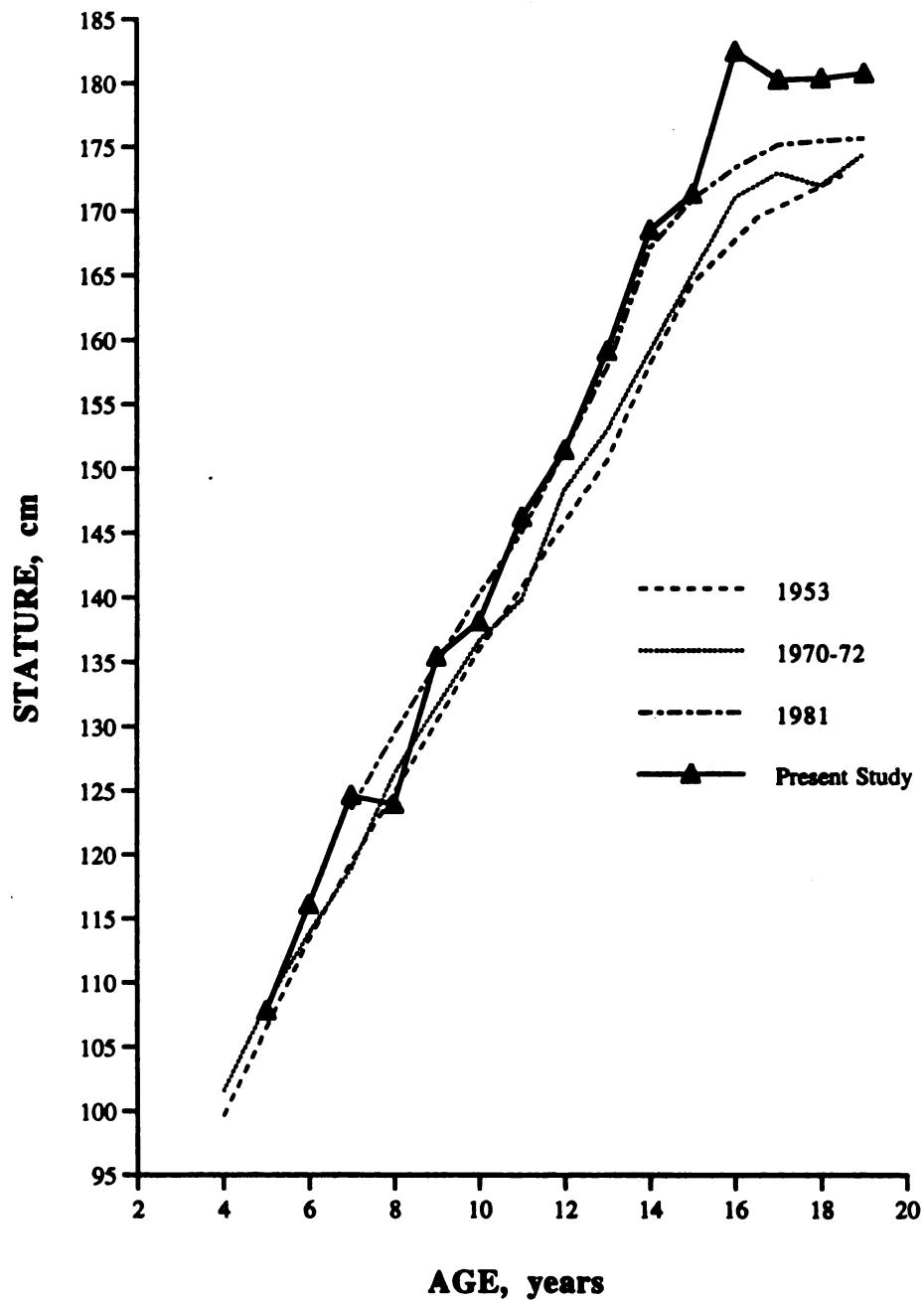
STATURE: MALES 5-19 YEARS

FIGURE 5.7 Stature in EA Canadian males 5-19 years from studies ranging from 1953 to 1996.

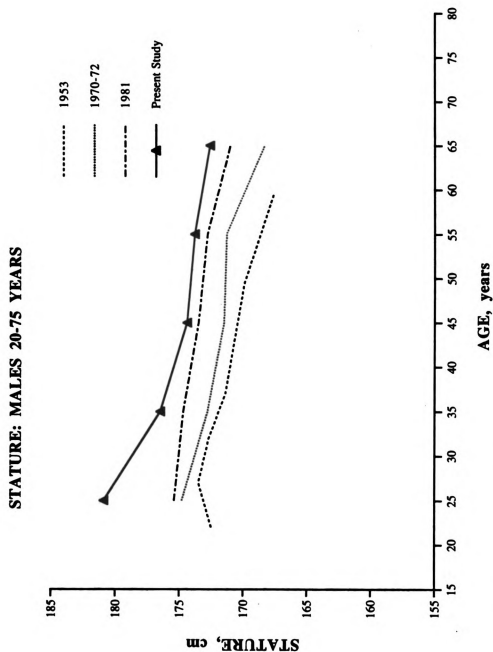


FIGURE 5.8 Stature in EA Canadian males 20-75 years from studies ranging from 1953 to 1996.

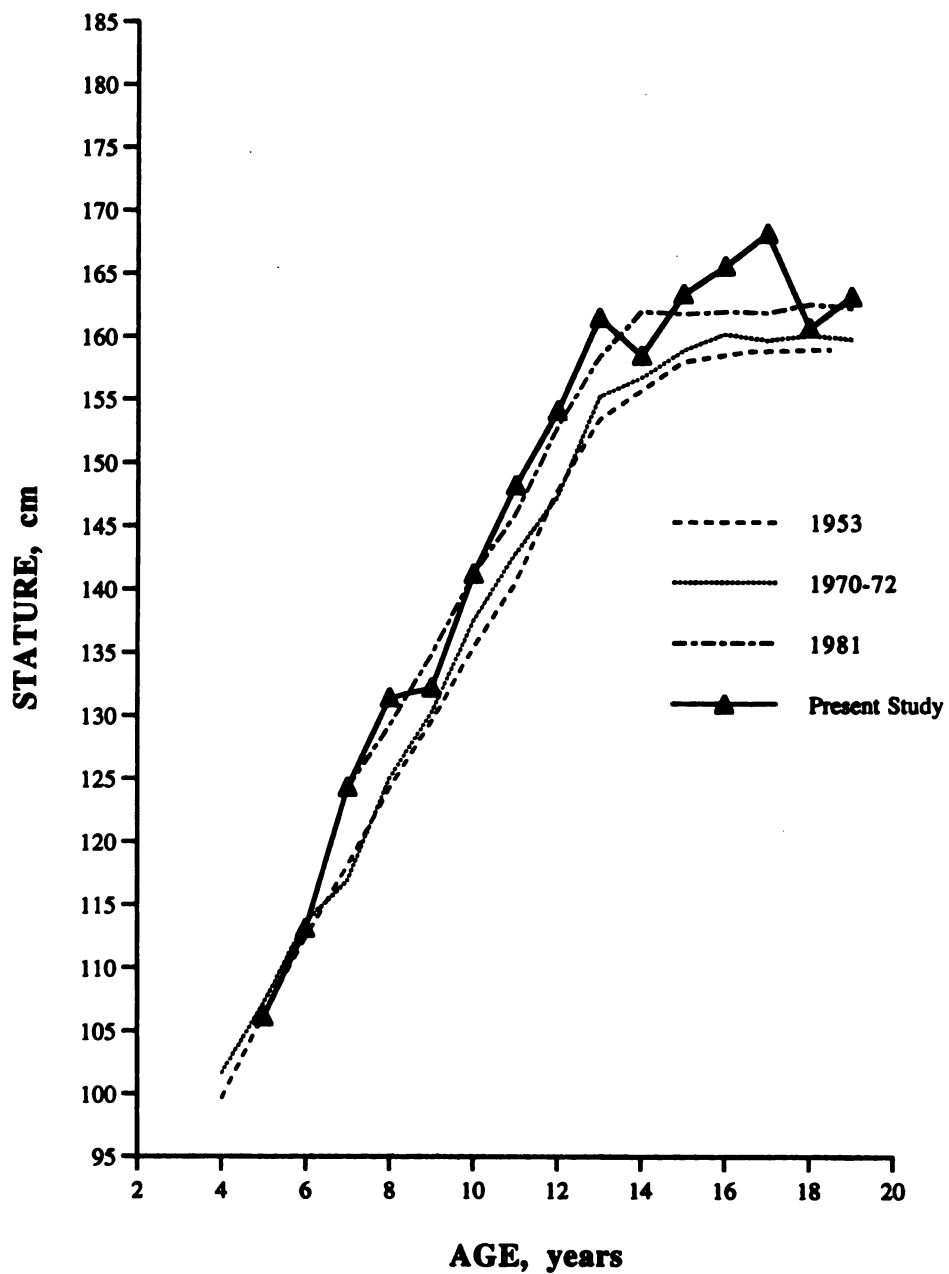
STATURE: FEMALES 5-19 YEARS

FIGURE 5.9 Stature in EA Canadian females 5-19 years from studies ranging from 1953 to 1996.

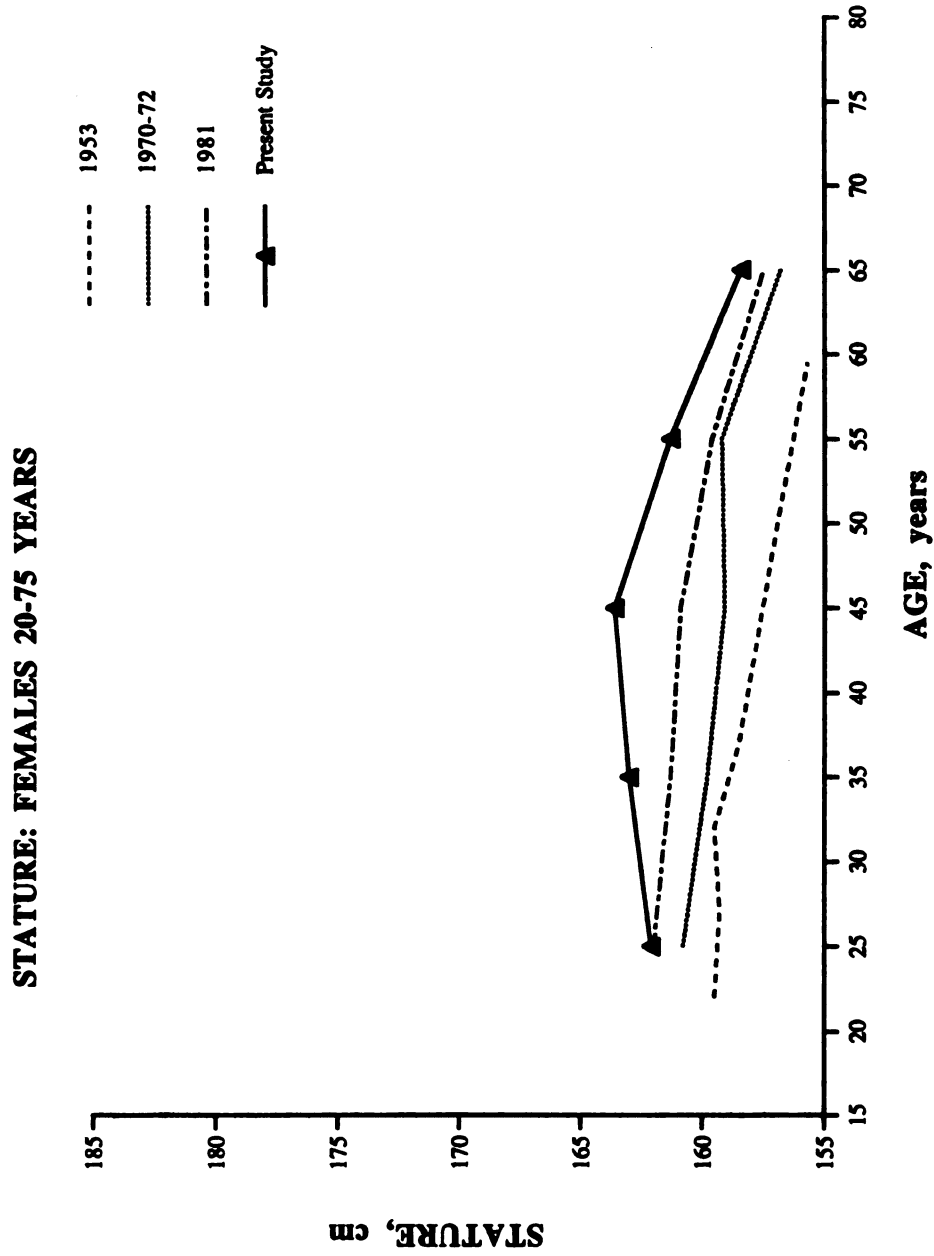


FIGURE 5.10 Stature in EA Canadian females 20-75 years from studies ranging from 1953 to 1996.

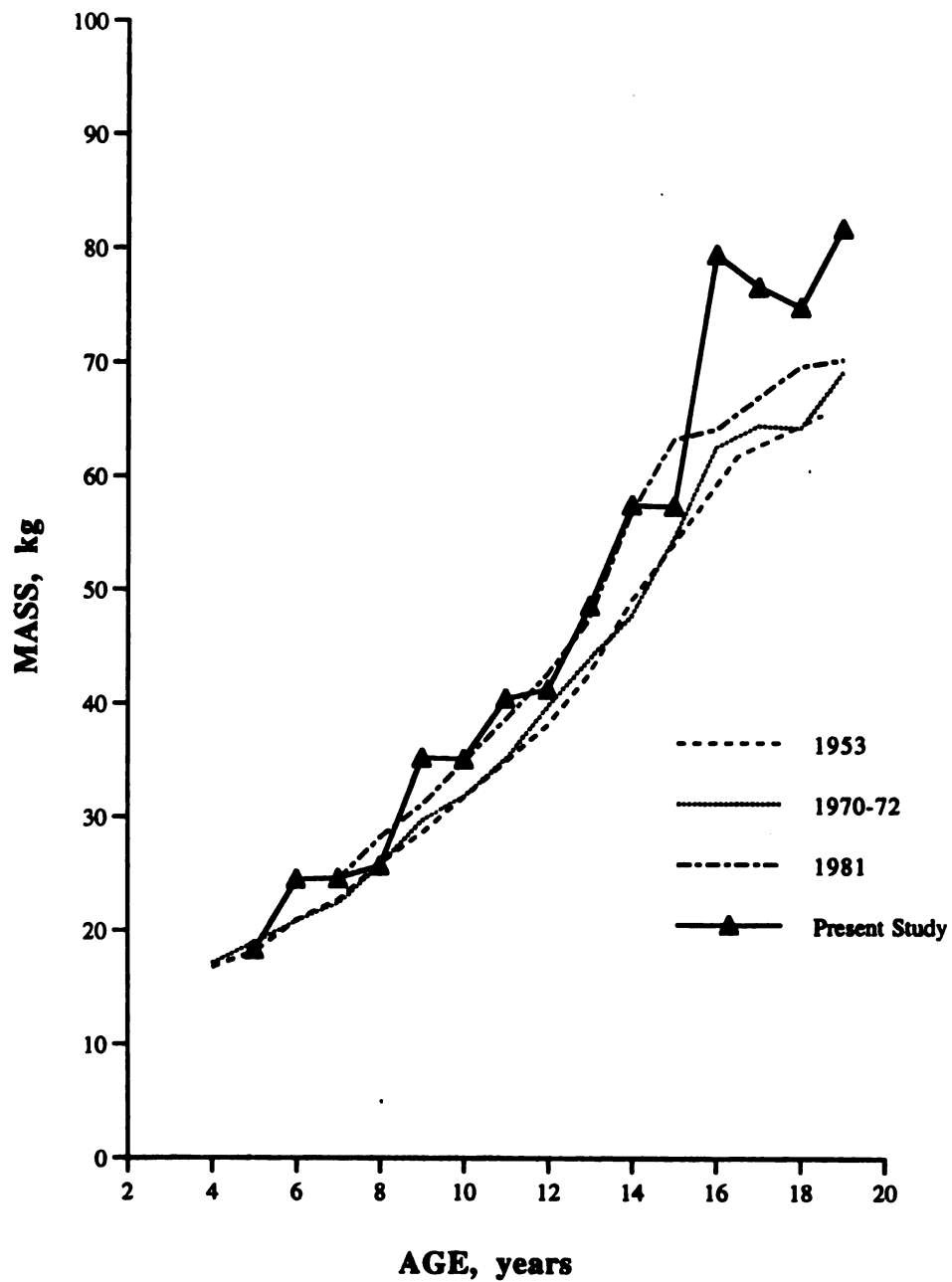
MASS: MALES 5-19 YEARS

FIGURE 5.11 Body mass in EA Canadian males 5-19 years from studies ranging from 1953 to 1996.

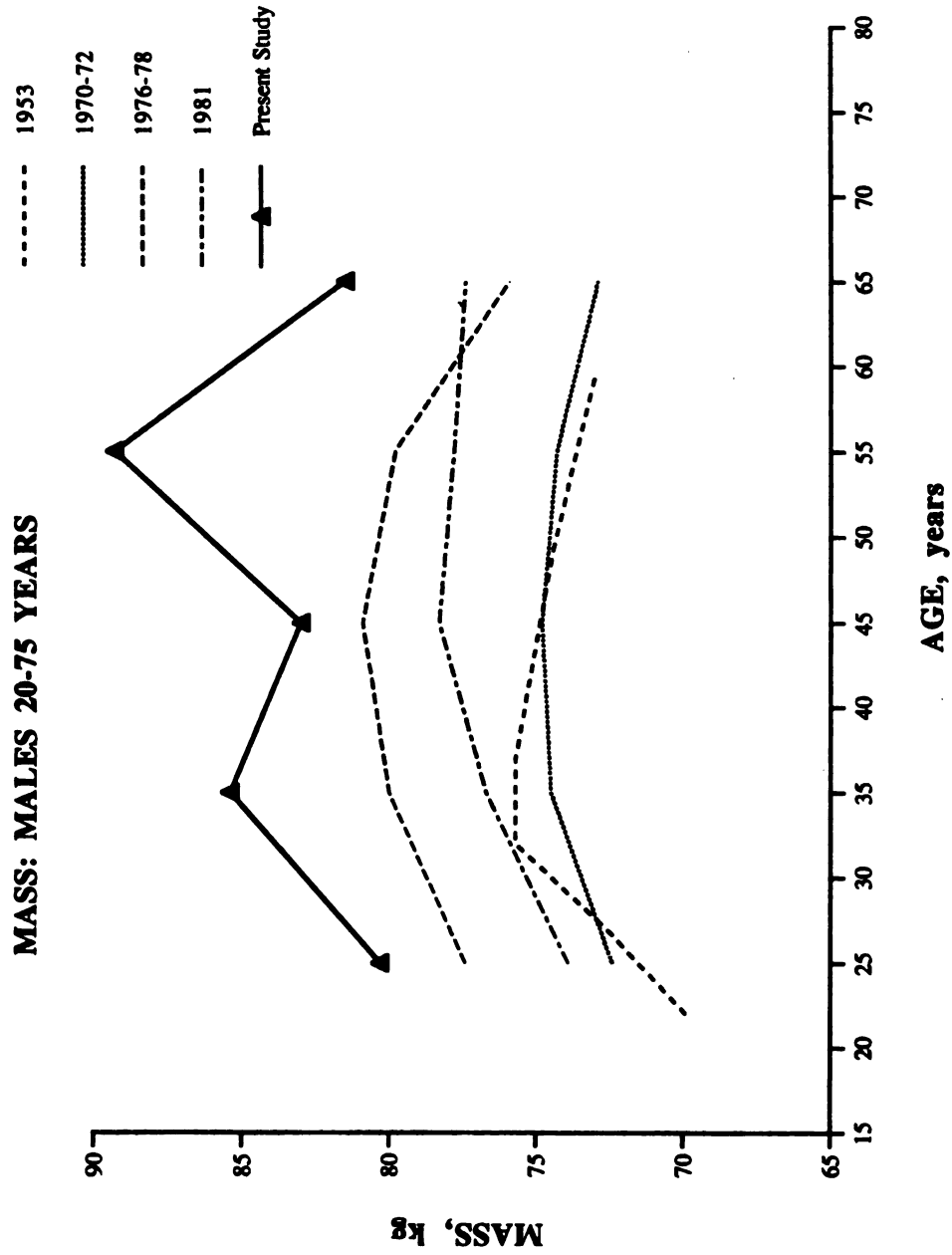


FIGURE 5.12 Body mass in EA Canadian males 20-75 years from studies ranging from 1953 to 1996.

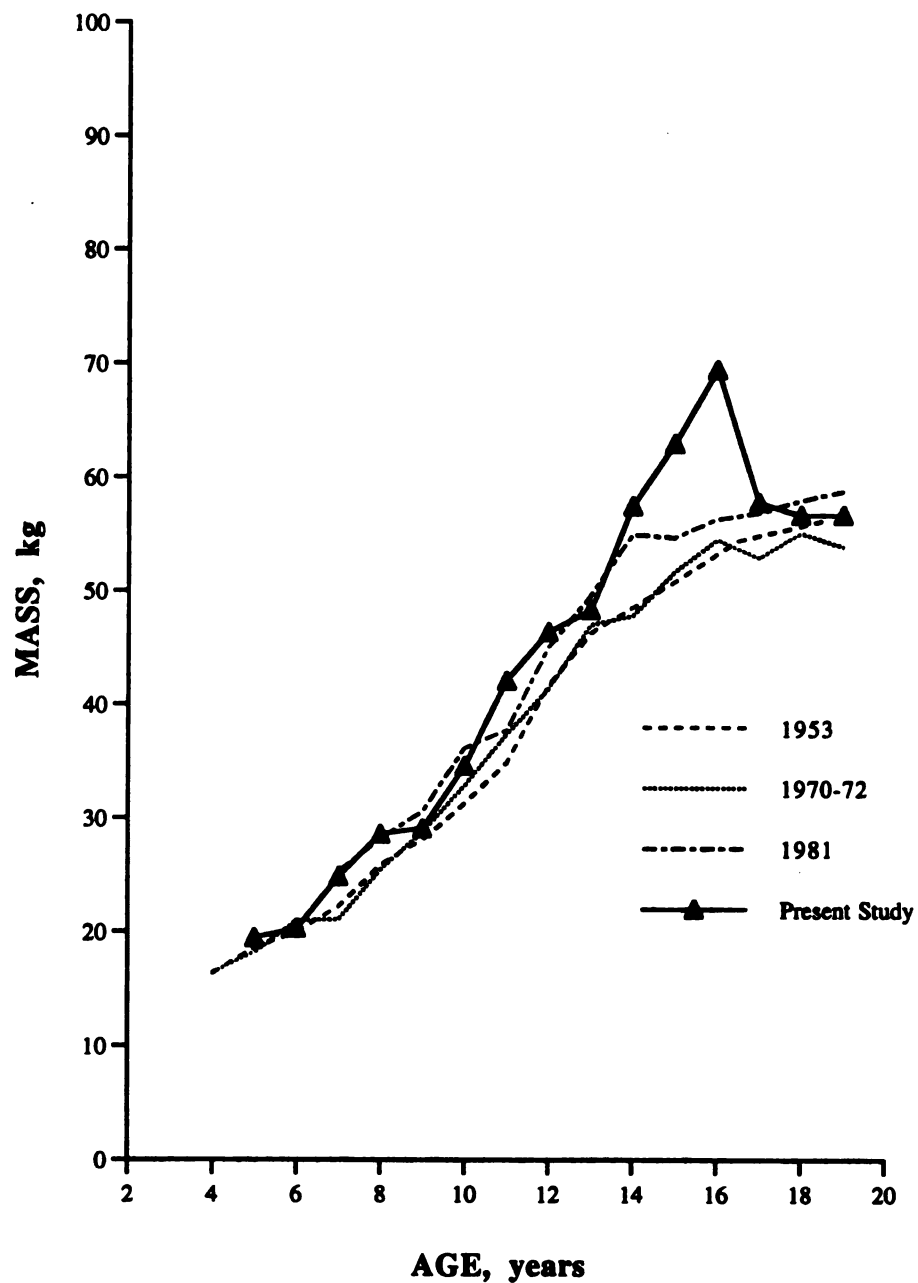
MASS: FEMALES 5-19 YEARS

FIGURE 5.13 Body mass in EA Canadian females 5-19 years from studies ranging from 1953 to 1996.

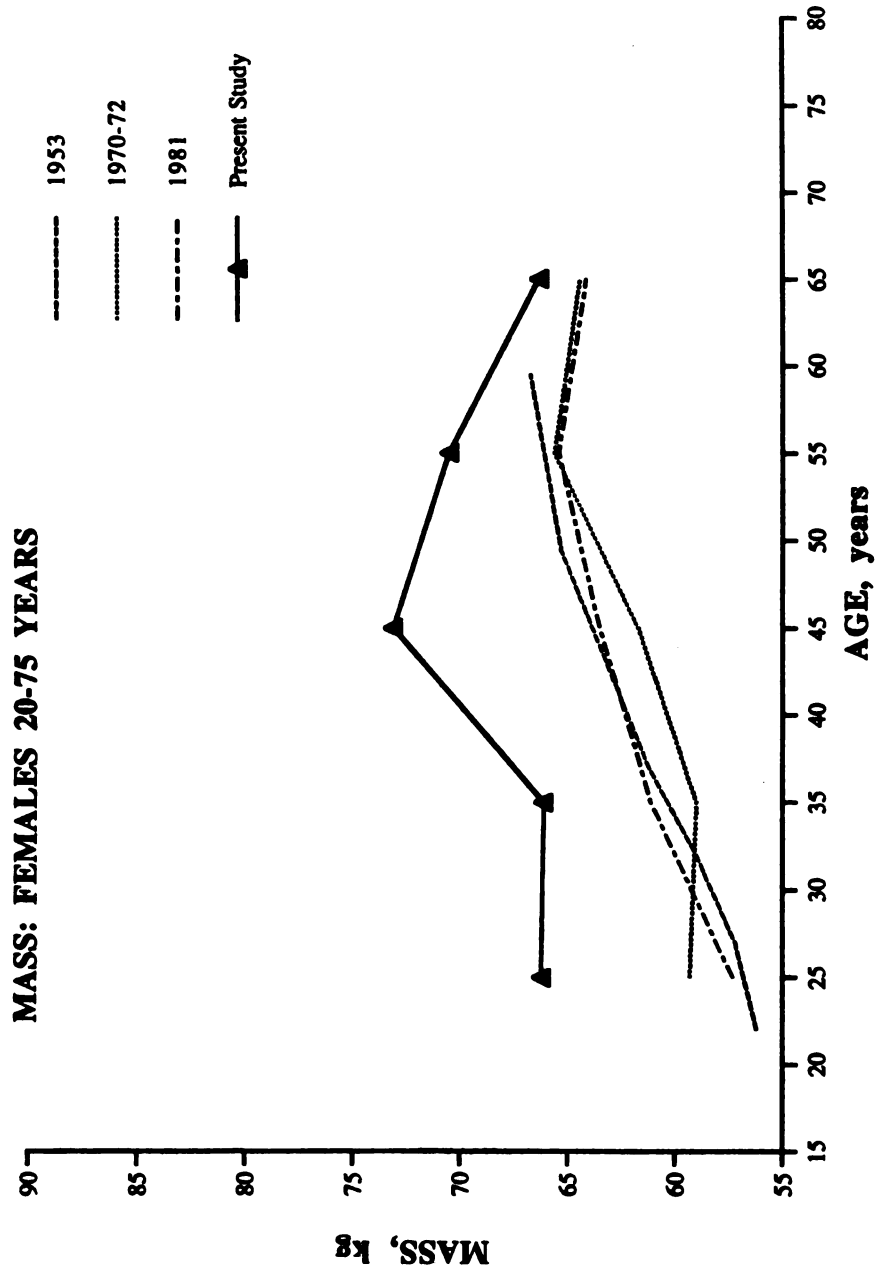


FIGURE 5.14 Body mass in EA Canadian females 20-75 years from studies ranging from 1953 to 1996.

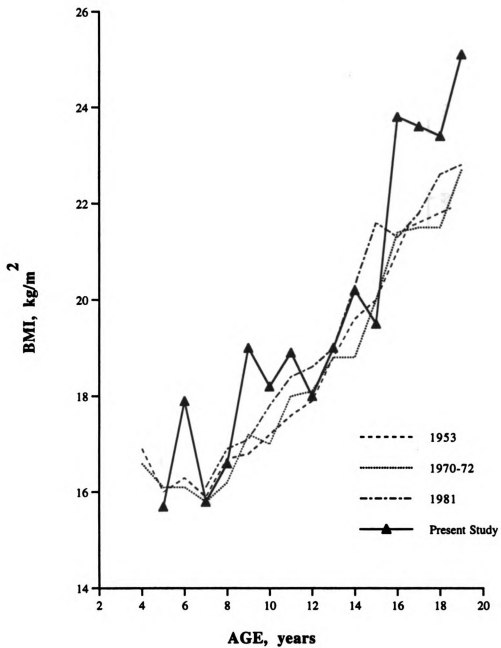
BMI: MALES 5-19 YEARS

FIGURE 5.15 BMI in EA Canadian males 5-19 years from studies ranging from 1953 to 1996.

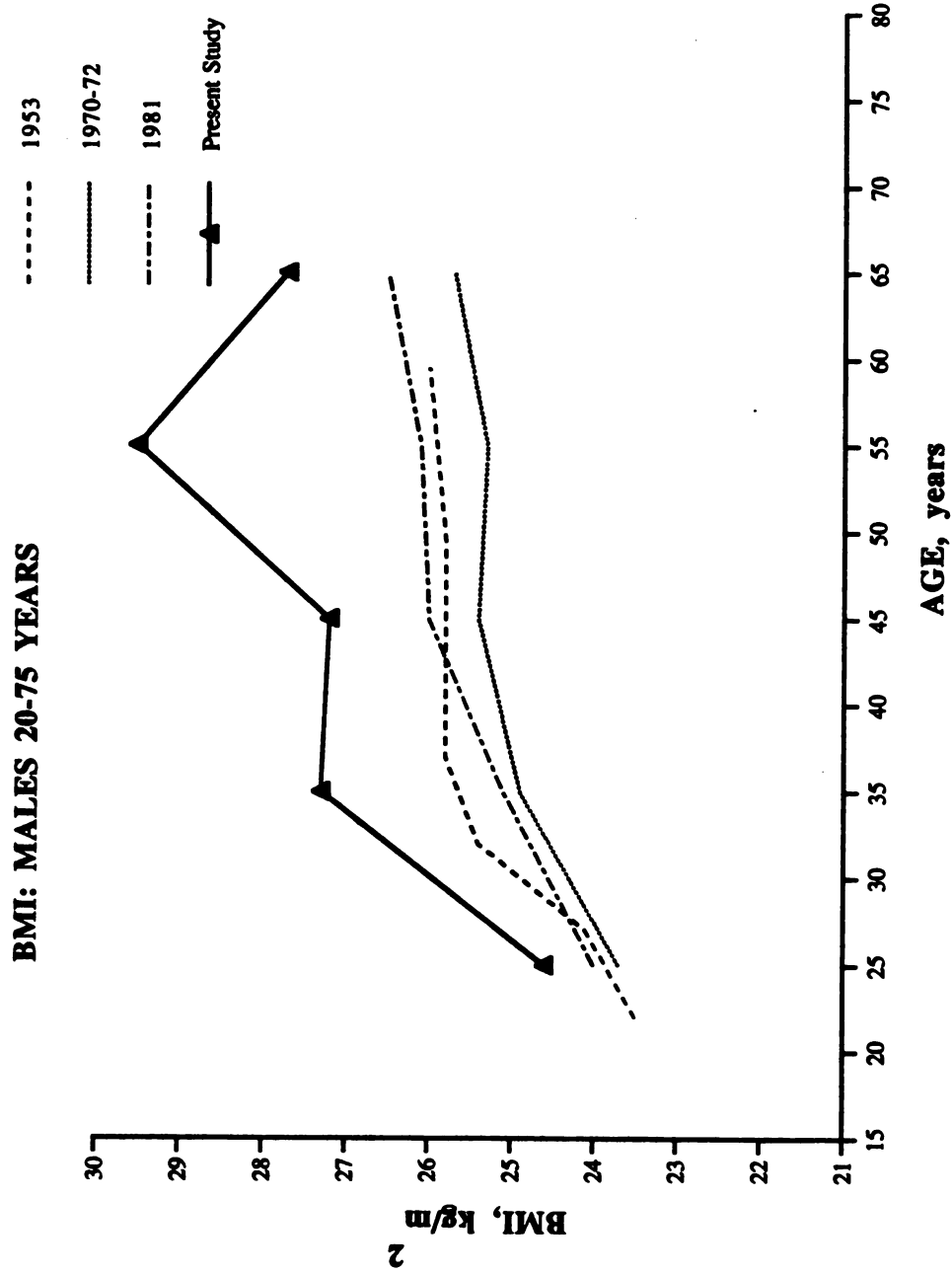


FIGURE 5.16 BMI in EA Canadian males 20-75 years from studies ranging from 1953 to 1996.

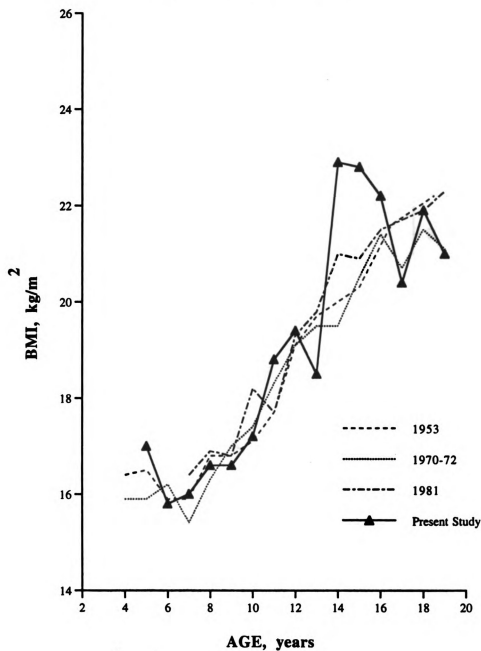
BMI: FEMALES 5-19 YEARS

FIGURE 5.17 BMI in EA Canadian females 5-19 years from studies ranging from 1953 to 1996.

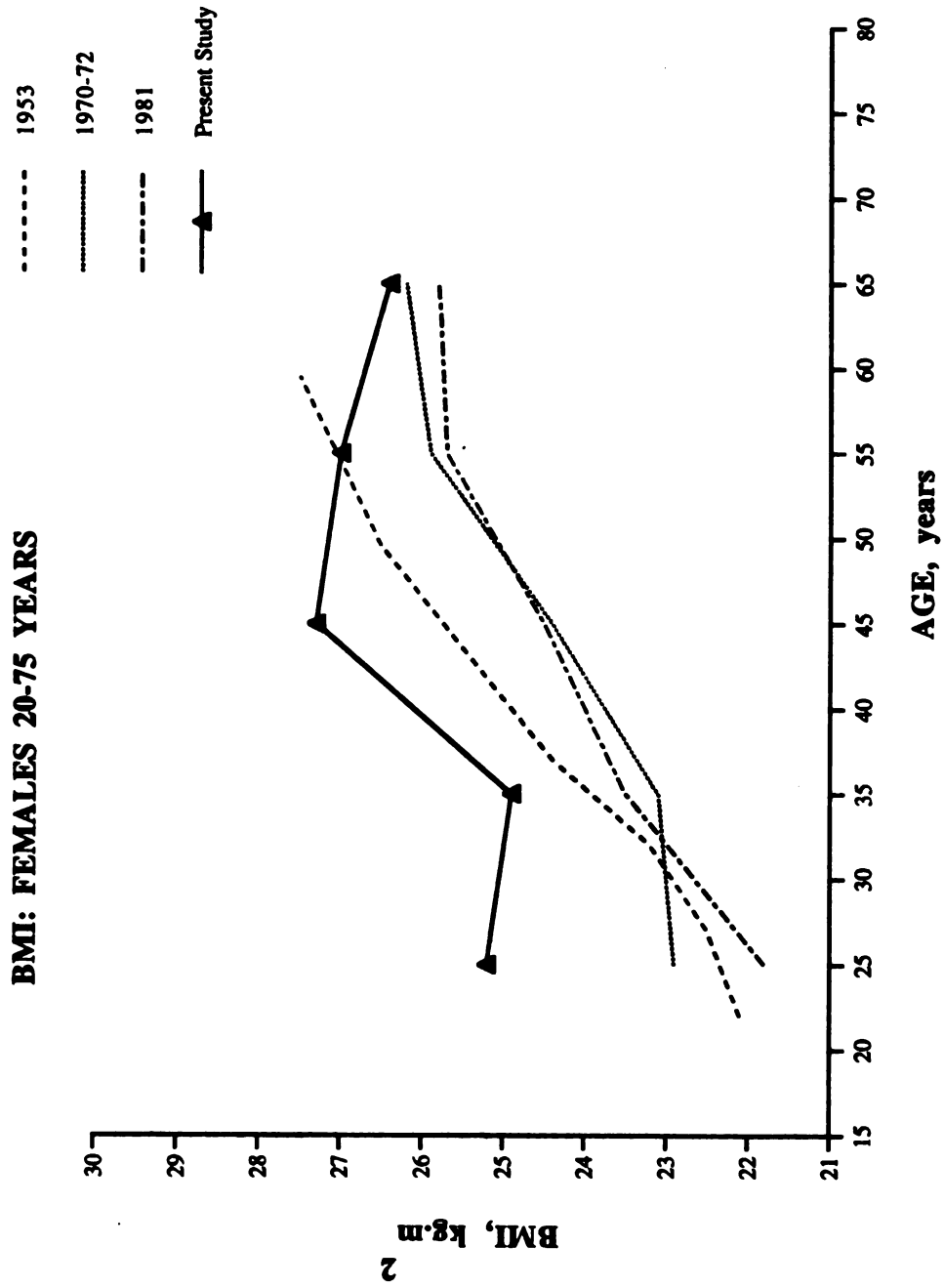


FIGURE 5.18 BMI in EA Canadian females 20-75 years from studies ranging from 1953 to 1996.

APPENDIX A



TEMAGAMI FIRST NATION

BEAR ISLAND
LAKE TEMAGAMI, ONTARIO P0H 1C0

TEL: (705) 237-8943 or (705) 237-8944

FAX: (705) 237-8959

NNADAP: (705) 237-8974 CHILDCARE: (705) 237-8961

CLINIC: (705) 237-8900



January 11, 1996

VIA FACSIMILE: (517)353-5363

ATTN: DR. MALINA

*Peter Katzmarzyk
Institute for the Study of Youth Sports
211 IM Sports Circle
Michigan State University
East Lansing, MI
48824*

Dear Peter:

RE: TEMAGAMI FAMILY STUDY OF HEALTH RELATED FITNESS

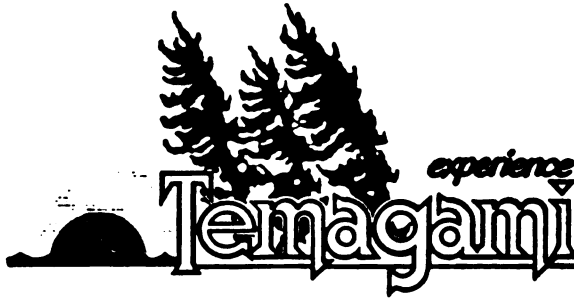
The Temagami First Nation has reviewed your proposal on December 4, 1995. I am pleased to advise you that we are in support of your study and look forward to participating in the study.

Thanking you in advance for considering the Temagami First Nation as a potential study group. I would like to wish you success in your study.

Sincerely,

*Chief Holly Charyna
Temagami First Nation*

C:\Cnp\katzmtr.sdy



The Corporation of the
Township of Temagami
P.O. Box 220
Temagami, Ontario P0H 2H0
(705) 569-3421
FAX: (705) 569-2834

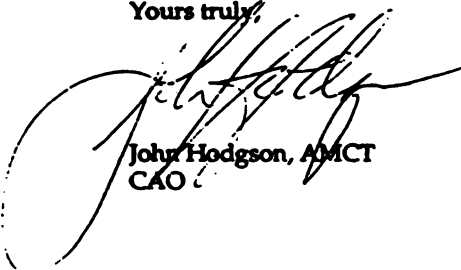
January 11, 1996

Peter Ketzmarzyk
4465 Januice Lee
Apt. F-103
Okemos, Michigan
48864

Dear Peter:

Further to our conversation of December 29, 1995, I wish to confirm that the municipal council of the Township of Temagami reviewed your request with regard to your study. Council is very supportive and wishes you the best of luck in your endeavor.

Yours truly,



John Hodgson, AMCT
CAO



The Timiskaming Board of Education

River Road, P.O. Box 40, NEW LISKEARD, ONTARIO, P0J 1P0. (705) 647-7394 -FAX (705) 647-9212

T.F. McGrory, B.Sc., M.Ed.,
Director of Education

R.W. Purdy, B.A., M.Ed.,
Superintendent of Schools

C.F. Shepherdson, C.G.A., A.C.I.S., P. ADM.,
Superintendent of Business

March 12, 1996

**Peter Katzmarzyk,
Institute for The Study of Youth Sports,
211 1M Sports Circle,
Michigan State University,
East Lansing, MI 48824**

Dear Peter Katzmarzyk,

**The Timiskaming Board of Education, at its regular meeting held on
Monday, March 11, 1996, approved the following motion:**

**THAT, The Timiskaming Board of Education grant permission
to Peter Katzmarzyk to conduct a study of the children at
Temagami Public School and Laura McKenzie Learning Centre
as outlined in the attached proposal.**

**The Education Committee will be looking forward to your presentation
of data at one of their meetings in the Spring of 1997.**

Good luck with your research in Temagami.

Yours truly,

**R. W. Purdy,
Superintendent of Schools.**

RWP:eh

**p.c. D. Bolger, Principal
Chief Holly Charyna
Wayne Adair, Reeve**

FAKED
MAR 13/96

"Together for Better Education"

LIST OF REFERENCES

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- AAHPERD (1988) Physical Best: A Physical Fitness Education and Assessment Program. Reston, VA: AAHPERD.**
- Antonella E.-D. P., Luca S., Emilia D.F., Rosario P.M., Annarita C., Giuseppe C., Franco C., Giuliana V., Adriana F., Salvatore D.M., Armido R. (1994) Familial and environmental influences on body composition and body fat distribution in childhood in Southern Italy. *International Journal of Obesity* 18:596-601.**
- Annest J.L., Sing C.F., Biron P., Mongeau J.G. (1983) Familial aggregation of blood pressure and weight in adoptive families III: Analysis of the role of shared genes and shared household environment in explaining family resemblance for height, weight and selected weight/height indices. *American Journal of Epidemiology* 117:492-506.**
- Bailey D.A., Carter J.E.L., Mirwald R.L. (1982) Somatotypes of Canadian men and women. *Human Biology* 54:813-828.**
- Baumgartner T.A., Jackson A.S. (1991) Measurement for Evaluation in Physical Education and Exercise Science, 4th edition. Dubuque, IA: Wm.C. Brown.**
- Beall C.M., Goldstein M.C. (1992) High prevalence of excess fat and central fat patterning among Mongolian pastoral nomads. *American Journal of Human Biology* 4:747-756.**
- Beunen G., Malina R.M., Ostyn M., Renson R., Simons J., Van Gerven D. (1983) Fatness, growth and motor fitness of Belgian boys 12 through 20 years of age. *Human Biology* 55:599-613.**
- Birkbeck J.A., Lee M., Myers G.S., Alfred B.M. (1971) Nutritional status of British Columbia Indians II: Anthropometric measurements, physical and dental examinations at Ahousat and Anaham. *Canadian Journal of Public Health* 62:403-414.**
- Biron P., Mongeau J.G., Bertrand D. (1977) Familial resemblance of body weight and weight/height in 374 homes with adopted children. *Journal of Pediatrics* 91:555-558.**
- Borecki I.B., Rice T., Pérusse L., Bouchard C., Rao D.C. (1995) Major gene influence on the propensity to store fat in trunk versus extremity depots: Evidence from the Québec Family Study. *Obesity Research* 3:1-8.**

- Bouchard C. (1985) Reproducibility of body composition and adipose tissue measurements in humans. In Roche A.F. (ed.): *Body Composition Assessments in Youth and Adults*. Colombus, OH: Ross Laboratories, pp. 9-13.
- Bouchard C. (1989) Genetic factors in obesity. *Medical Clinics of North America* 73:67-81.
- Bouchard C., Demirjian A., Malina R.M. (1980a) Heritability estimates of somatotype components based on familial data. *Human Heredity* 30:112-118.
- Bouchard C., Demirjian A., Malina R.M. (1980b) Genetic pleiotropism in skeletal lengths and breadths. In Ostyn M., Beunen G., Simons J. (eds.): *Kinanthropometry II*. Baltimore: University Park Press, pp. 78-87.
- Bouchard C., Lortie G. (1984) Heredity and endurance performance. *Sports Medicine* 1:38-64.
- Bouchard C., Malina R.M. (1983) Genetics for the sport scientist: Selected methodological considerations. *Exercise and Sport Science Reviews* 11:275-305.
- Bouchard C., Malina R.M., Pérusse L. (1997) *Genetics of Fitness and Performance*. Champaign, IL: Human Kinetics (In press).
- Bouchard C., Pérusse L. (1988) Heredity and body fat. *Annual Review of Nutrition* 8:259-277.
- Bouchard C., Pérusse L., Leblanc C., Tremblay A., Thériault G. (1988) Inheritance of the amount and distribution of human body fat. *International Journal of Obesity* 12:205-215.
- Bouchard C., Shephard R.J. (1994) Physical activity, fitness and health: The model and key concepts. In Bouchard C., Shephard R.J., Stephens T. (eds.): *Physical Activity, Fitness and Health*. Champaign IL: Human Kinetics, pp. 77-88.
- Bouchard C., Tremblay A., Després J.P., Nadeau A., Lupien P.J., Thériault G., Dussault J., Moorjani S., Pinault S., Fournier G. (1990) The response to long-term overfeeding in identical twins. *New England Journal of Medicine* 322:1477-1482.
- Bouchard C., Tremblay A., Pérusse L., Leblanc C., Thériault G., George V. (1989) Cohabitation, activity level, and energy intake in parent-child resemblance for selected biological traits. *American Journal of Human Biology* 1:209-215.
- Broussard B.A., Johnson A., Himes J.H., Story M., Fichtner R., Hauck F., Bachman-Carter K., Hayes J., Frohlich K., Gray N., Valway S., Gohdes D. (1991) Prevalence of obesity in American Indians and Alaska Natives. *American Journal of Clinical Nutrition* 53:1535s-1542s.
- Byard P.J., Siervogel R.M., Roche A.F. (1983) Sibling correlations for weight/stature² and calf circumference: Age changes and possible sex linkage. *Human Biology* 55:677-685.

- Carter J.E.L., Heath B.H. (1990) *Somatotyping-Development and Applications*. New York, NY: Cambridge University Press.
- Caspersen C.J., Powell K.E., Christenson G.M. (1985) Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports* 100:126-131.
- Chumlea W.C., Guo S., Kuczmarski R.J., Johnson C.L., Leahy C.K. (1990) Reliability for anthropometric measurements in the Hispanic Health and Nutrition Examination Survey (HHANES 1982-1984). *American Journal of Clinical Nutrition* 51:902s-907s.
- Claessens A.L.M., Vanden Eynde B., Renson R., Van Gerven D. (1990) The description of tests and measurements. In Simons J., Beunen G.P., Renson R., Claessens A.L.M., Vanreusel B., Lefevre J.A.V. (eds.) *Growth and Fitness of Flemish Girls. The Leuven Growth Study*. Champaign, IL: Human Kinetics. pp. 21-39.
- Clarke H.H. (1971) *Physical and Motor Tests in the Medford Boy's Growth Study*. Englewood Cliffs, NJ: Prentice-Hall.
- Clark P.J. (1956) The heritability of certain anthropometric characters as ascertained from measurements of twins. *American Journal of Human Genetics* 8:49-54.
- Coodin F.J., Dilling L.A., Haworth J.C., Ellestad-Sayad J. (1980) Growth and nutrition of Manitoba preschool Indian children III: Anthropometry. *Human Biology* 52:563-578.
- Cressie N.A.C., Withers T.T., Craig N.P. (1986) The statistical analysis of somatotype data. *Yearbook of Physical Anthropology* 29:197-208.
- Darby W.H., Salsbury C.G., McGanity W.J., Johnson H.F., Bridgeforth E.B., Sandstead H.R. (1956) A study of the dietary background and nutriture of the Navajo Indian. *Journal of Nutrition* 60 (Suppl.2):3-85.
- Després J.P., Moorjani S., Lupien P.J., Tremblay A., Nadeau A., Bouchard C. (1990) Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. *Arteriosclerosis* 10:497-511.
- Devor E.J., Crawford M.H. (1984) Familial resemblance for neuromuscular performance in a Kansas Mennonite community. *American Journal of Physical Anthropology* 64:289-296.
- Donner A. (1979) The use of correlation and regression in the analysis of familial resemblance. *American Journal of Epidemiology* 110:335-342.
- Donner A., Eliasziw M. (1991) Methodology for inferences concerning familial correlations: A review. *Journal of Clinical Epidemiology* 44:449-455.
- Donner A., Koval J.J. (1980) The estimation of intraclass correlation in the analysis of family data. *Biometrics* 36:19-25.

- Ducimetiere P., Richard J.L. (1989) The relationship between subsets of anthropometric upper versus lower body measurements and coronary heart disease risk in middle-aged men: The Paris Prospective Study I. *International Journal of Obesity* 13:111-122.
- Ducimetiere P., Richard J.L., Cambiaie F. (1986) The pattern of subcutaneous fat distribution in middle-aged men and the risk of coronary heart disease: The Paris Prospective Study. *International Journal of Obesity* 10:229-240.
- Dufour D.L., Staten L.K., Reina J.C., Spurr G.B. (1994) Anthropometry and secular changes in stature of urban Colombian women of differing socioeconomic status. *American Journal of Human Biology* 6:749-760.
- Engström L.M., Fischbein S. (1977) Physical capacity in twins. *Acta Geneticae Medicae et Gemellologiae* 26:159-165.
- Eschwey M.J. (1994) The Relationship of Acculturation to the Growth Status of Mexican American Children 6 Through 12 Years Residing in Minnesota. Ph.D. Dissertation, University of Texas at Austin.
- Espenschade A.S. (1963) Restudy of relationships between physical performances of school children and age, height, and weight. *Research Quarterly* 34:144-153.
- Eveleth P.B., Tanner J.M. (1976) *Wordwide Variation in Human Growth*. Cambridge: Cambridge University Press.
- Eveleth P.B., Tanner J.M. (1990) *Wordwide Variation in Human Growth*, 2nd edition. Cambridge: Cambridge University Press.
- Fitness Canada (1983) *Fitness and Lifestyle in Canada*. Ottawa, ON: Government of Canada.
- Fitness Canada (1985) *Physical Fitness of Canadian Youth*. Ottawa, ON: Government of Canada.
- Fitness Canada (1986) *Canadian Standardized Test of Fitness: Operations Manual*, 3rd edition. Ottawa, ON: Government of Canada.
- Friedlander Y., Kark J.D., Kaufmann N.A., Berry E.M., Stein Y. (1988) Familial aggregation of body mass index in ethnically diverse families in Jerusalem: The Jerusalem Lipid Research Clinic. *International Journal of Obesity* 12:237-247.
- Frisancho A.R. (1990) *Anthropometric Standards for the Assessment of Growth and Nutritional Status*. Ann Arbor: University of Michigan Press.
- Frisancho A.R. (1993) *Human Adaptation and Accommodation: Enlarged and Revised Edition of Human Adaptation*. Ann Arbor: University of Michigan Press.
- Gardner L.I., Stern M.P., Haffner S.M., Gaskill S.P., Hazuda H.P., Relethford J.H., Eifler C.W. (1984) Prevalence of diabetes in Mexican Americans: Relationship to percent of gene pool derived from Native American sources. *Diabetes* 33:86-92.

- Garn S.M., Leonard W.R., Hawthorne V.M. (1986) Three limitations to the body mass index. *American Journal of Clinical Nutrition* 44:996.
- Garn S.M., Ryan A.S., Robson J.K.R. (1982) Fatness-dependence and utility of the subscapular/triceps ratio. *Ecology of Food and Nutrition* 12:173-177.
- Gibson R.S. (1990) *Principles of Nutritional Assessment*. Oxford: Oxford University Press.
- Gittelsohn J., Harris S.B., Thorne-Lyman A.L., Hanley A.J.G., Barnie A., Zinman B. (1996) Body image concepts differ by age and sex in an Ojibway-Cree community in Canada. *Journal of Nutrition* 126:2990-3000.
- Godin G., Shephard R.J. (1973) Activity patterns of the Canadian Eskimo. In Edholm O.G., Gunderson E.K.E. (eds.): *Polar Human Biology*. Chichester: Heinemann Books, pp. 193-215.
- Gordon D. (1990) Prehistoric occupations at Lake Temagami. In Bray M., Thomson A. (eds.): *Temagami: A Debate on Wilderness*. Toronto, ON: Dundurn Press, pp. 153-184.
- Hall T.R., Hickey M.E., Young T.B. (1991) The relationship of body fat distribution to non-insulin-dependent diabetes mellitus in a Navajo community. *American Journal of Human Biology* 3:119-126.
- Hamill P.V.V., Johnston F.E., Lemeshow S. (1973) Body weight, stature, and sitting height: White and Negro youths 12-17 Years, United States. *Vital and Health Statistics, Series 11*, No. 126.
- Haubenstricker J.L., Seefeldt V.D., Branta C.F. (1991) Motor performance norms for children and adolescents. Motor Performance Study. Unpublished manuscript, Department of Physical Education and Exercise Science, Michigan State University.
- Hawk L.J., Brook C.G.D. (1979) Family resemblances of height, weight, and body fatness. *Archives in Disease of Childhood* 54:877-879.
- Health and Welfare Canada (1980) *Anthropometry Report: Height, Weight and Body Dimensions*. Ottawa, ON: Government of Canada.
- Health and Welfare Canada (1992) *Aboriginal Health in Canada*. Ottawa, ON: Government of Canada.
- Heller C.A., Scott E.M., Hammes L.M. (1967) Height, weight, and growth of Alaskan Eskimos. *American Journal of Diseases of Children* 113:338-344.
- Heller R., Garrison R.J., Havlik R.J., Feinleib M., Padgett S. (1984) Family resemblances in height and relative weight in the Framingham Heart Study. *International Journal of Obesity* 8:399-405.
- Herskind A.M., McGue M., Sørensen T.I.A., Harvald B. (1996) Sex and age specific assessment of genetic and environmental influences on body mass index in twins. *International Journal of Obesity* 20:106-113.

- Hertzog K.P., Garn S.M., Hempy H.O. (1969) Partitioning the effects of secular trend and ageing on adult stature. *American Journal of Physical Anthropology* 31:111-116.
- Himes J.H., Mueller W.H. (1977a) Aging and secular change in adult stature in rural Colombia. *American Journal of Physical Anthropology* 46:275-280.
- Himes J.H., Mueller W.H. (1977b) Age-associated statural loss and socioeconomic status. *Journal of the American Geriatrics Society* 25:171-174.
- Hodgins B.W., Benidickson J. (1989) *The Temagami Experience*. Toronto, ON: University of Toronto Press.
- Huang Y. (1994) Relationship of Sociodemographic and Physical Activity Variables to Physical Fitness of Taiwanese Junior High School Students. Ph.D. Dissertation, University of Texas at Austin.
- ICNND (1964a) Blackfeet Indian Reservation, Nutrition Survey, August-September 1961. Washington, DC: ICNND.
- ICNND (1964b) Fort Belknap Indian Reservation Nutrition Survey, August-October 1961. Washington DC: ICNND.
- Jamison P.L. (1970) Growth of Wainwright Eskimos: Stature and weight. *Arctic Anthropology* 7:86-94.
- Jamison P.L., Zegura S. (1970) An anthropometric study of the Eskimos of Wainwright, Alaska. *Arctic Anthropology* 7:125-143.
- Johnston F.E., Hamill P.V.V., Lemeshow S. (1972) Skinfold thickness of children 6-11 years, United States, Vital and Health Statistics, Series 11, No.120.
- Johnston F.E., Laughlin W.S., Harper A.B., Ensroth A.E. (1982) Physical growth of St. Lawrence Island Eskimos: Body size, proportions and composition. *American Journal of Physical Anthropology* 58: 397-401.
- Johnston F.E., McKigney J.I., Hopwood S., Smelker J. (1978) Physical growth and development of urban native Americans: A study of urbanization and its implications for nutritional status. *American Journal of Clinical Nutrition* 31:1017-1027.
- Johnston F.E., Schell L.M. (1979) Anthropometric variation of Native American children and adults. In Laughlin W.S., Harper A.B. (eds.): *The First Americans: Origins, Affinities and Adaptations*. New York: Gustar Fischer, pp. 275-290.
- Katzmarzyk P.T., Malina R.M., Song T.M.K, Bouchard C. (1997) Physique and indicators of metabolic fitness in youth. *Medicine and Science in Sports and Exercise* 29:(in press).
- Klika, R. (1995) Growth, Maturity and Motor Characteristics of Competitive Alpine Skiers Aged 8-18 years. Ph.D. Dissertation, University of Texas at Austin.

- Knight D. (1977) The Montreal River and the Shield Archaic. Ph.D. Dissertation, University of Toronto.
- Knowler W.C., Pettitt D.J., Saad M.F., Charles M.A., Nelson R.G., Howard B.V., Bogardus C., Bennett P.H. (1991) Obesity in the Pima Indians: Its magnitude and relationship with diabetes. *American Journal of Clinical Nutrition* 53:1543s-1551s.
- Knowler W.C., Pettitt D.J., Savage P.J., Bennett P.H. (1981) Diabetes incidence in Pima Indians: Contributions of obesity and parental diabetes. *American Journal of Epidemiology* 113:144-156.
- Komi P.V., Klissouras V., Karvinen E. (1973) Genetic variation in neuromuscular performance. *Internationale Zeitschrift Fur angewndte Physiologie* 31:289-304.
- Korkeila M., Kaprio J., Rissanen A., Koskenvuo M. (1991) Effects of gender and age on the heritability of body mass index. *International Journal of Obesity* 15:647-654.
- Kovar R. (1977) Somatotypes of twins. *Acta Universitatis Carolinae Gmn Gymnica* 13: 49-59.
- Kovar R. (1981) Sledovani podobnosti mezi rodici a jejich potomky v nekterych motorickych projevech. *Teorie a Praxe Telesne Vychovy* 29:93-98.
- Kramer A.A., Green L.J., Croghan I.T., Buck G.M., Ferer R. (1986) Bivariate path analysis of twin children for stature and biiliac diameter: estimation of genetic variation and co-variation. *Human Biology* 58:517-525.
- Kraus B.S. (1961) The western Apache: Some anthropometric observations. *American Journal of Physical Anthropology* 19:227-236.
- Lee M., Birkbeck J.A. (1977) Anthropometric measurements and physical examinations of Indian populations from British Columbia and the Yukon Territories, Canada. *Human Biology* 49:581-591.
- Leonard W.R., DeWalt K.M., Stansbury J.P., McCaston M.K. (1995) Growth differences between children of highland and coastal Ecuador. *American Journal of Physical Anthropology* 98:47-57.
- Leonard W.R., Katzmarzyk P.T., Comuzzie A.G., Crawford M.H., Sukernik R.I. (1994) Growth and nutritional status of the Evenki reindeer herders of Siberia. *American Journal of Human Biology* 6:339-350.
- Lohman T.G., Roche A.F., Martorell R. (eds.) (1988) *Anthropometric Standardization Reference Manual*. Champaign, IL: Human Kinetics.
- Longini I.M., Higgins M.W., Hinton P.C., Moll P.P., Keller J.B. (1984) Genetic and environmental sources of familial aggregation of body mass in Tecumseh, Michigan. *Human Biology* 56:733-757.

- Maes H., Beunen G., Vlietinck R., Lefevre J., Van Den Bossche C., Claessens A., Derom R., Lysens R., Renson R., Simons J., Vanden Eynde B. (1993) Heritability of health- and performance-related fitness: Data from the Leuven Longitudinal Twin Study. In Duquet W., Day J.A.P. (eds.): *Kinanthropometry IV*: London: Spon, pp. 140-149.
- Maes H., Beunen G., Vlietink R., Neale M.C., Thomis M., Vanden Eynde B., Lysens R., Simons J., Derom C., Derom R. (1996) Inheritance of physical fitness in 10-yr-old twins and their parents. *Medicine and Science in Sports and Exercise* 28:1479-1491.
- Malina R.M. (1975) Anthropometric correlates of strength and motor performance. *Exercise and Sport Science Reviews* 3:249-274.
- Malina R.M. (1990) Research on secular trends in auxology. *Anthropologischer Anzeiger* 48:209-227.
- Malina R.M. (1993) Ethnic variation in the prevalence of obesity in North American children and youth. *Critical Reviews in Food Science and Nutrition* 33:389-396.
- Malina R.M. (1994) Anthropometry, strength and motor fitness. In Ulijaszek S.J., Mascie-Taylor C.G.N. (eds.): *Anthropometry: The Individual and the Population*. Cambridge: Cambridge University Press, pp. 160-177.
- Malina R.M. (1995) Anthropometry. In Maud P.J., Foster C. (eds.): *Physiological Assessment of Human Fitness*. Champaign, IL: Human Kinetics, pp. 205-219.
- Malina R.M. (1996) Regional body composition: Age, sex and ethnic variation. In Roche A.F., Heymsfield S.B., Lohman T.G. (eds.): *Human Body Composition*. Champaign, IL: Human Kinetics, pp. 217-255.
- Malina R.M., Bouchard C. (1991) *Growth, Maturation and Physical Activity*. Champaign, IL: Human Kinetics.
- Malina R.M., Buschang P.H. (1985) Growth, strength and motor performance of Zapotec children, Oaxaca, Mexico. *Human Biology* 57:163-181.
- Malina R.M., Hamill P.V.V., Lemeshow S. (1973) Selected body measurements of children 6-11 years, United States. *Vital and Health Statistics, Series 11*, No. 123.
- Malina R.M., Hamill P.V.V., Lemeshow S. (1974) Body dimensions and proportions, White and Negro children 6-11 years, United States. *Vital and Health Statistics, Series 11*, No. 143.
- Malina R.M., Katzmarzyk P.T., Song T.M.K., Theriault G., Bouchard C. (1997) Somatotype and cardiovascular risk factors in healthy adults. *American Journal of Human Biology* 9:11-19.
- Malina R.M., Moriyama M. (1991) Growth and motor performance of Black and White children 6-10 years of age: A multivariate analysis. *American Journal of Human Biology* 3:599-611.

- Malina R.M., Mueller W.H. (1981) Genetic and environmental influences on the strength and motor performance of Philadelphia school children. *Human Biology* 53:163-179.
- Malina R.M., Mueller W.H., Holman J.D. (1976) Parent-child correlations and heritability of stature in Philadelphia Black and White children 6 to 12 years of age. *Human Biology* 48:475-486.
- Malina R.M., Pena Reyes M.E. (1993) Relative fat distribution: Relationship to skeletal maturation, growth status, and performance. *American Journal of Human Biology* 6:19-24.
- Malina R.M., Selby H.A., Buschang P.H., Aronson W.L., Little B.B. (1983) Assortative mating for phenotypic characteristics in a Zapotec community in Oaxaca, Mexico. *Journal of Biosocial Science* 15:273-280.
- Malina R.M., Skrabanek M.F., Little B.B. (1989) Growth and maturity status of Black and White children classified as obese by different criteria. *American Journal of Human Biology* 1:193-199.
- McIntyre L., Shah C.P. (1986) Prevalence of hypertension, obesity and smoking in three Indian communities in northwestern Ontario. *Canadian Medical Association Journal* 134:345-349.
- Merrett D.M.S. (1992) Anthropometric Correlates of Motor Performance in Preschool Children. M.A. Thesis, University of Texas at Austin.
- Miller P.S. (1970) Secular changes among the western Apache. *American Journal of Physical Anthropology* 33:197-206.
- Mitchell E.A. (1977) Fort Temiskaming and the Fur Trade. Toronto, ON: University of Toronto Press.
- Mitchell L.E., Nirmala A., Rice T., Reddy P.C., Rao D.C. (1993) The impact of energy intake and energy expenditure of activity on the familial transmission of adiposity in an Indian population. *American Journal of Human Biology* 5:331-339.
- Moll P.P., Burns T.L., Lauer R.M. (1991) The genetic and environmental sources of body mass index variability: The Muscatine Ponderosity Family Study. *American Journal of Human Genetics* 49:1243-1255.
- Moore W.M. (1972) Physical growth of North American Indian and Alaska Native children. In Moore W.M., Silverberg M.M., Read M.S. (eds.): *Nutrition, Growth and Development of North American Indian Children*. DHEW Publication No (NIH) 72-26. Washington, DC, pp. 35-46.
- Montoye H.J., Frantz M.E., Kozar A.J. (1972) The value of age, height, and weight in establishing standards of fitness for children. *Journal of Sports Medicine and Physical Fitness* 12:174-179.
- Mueller W.H. (1976) Parent-child correlations for stature and weight among school aged children: A review of 24 studies. *Human Biology* 48:379-397.

- Mueller W.H., Malina R.M. (1976) Differential contribution of stature phenotypes to assortative mating in parents of Philadelphia Black and White school children. *American Journal of Physical Anthropology* 45:269-276.
- Mueller W.H., Malina R.M. (1980) Genetic and environmental influences on growth of Philadelphia Black and White schoolchildren. *Annals of Human Biology* 7:441-448.
- Mueller W.H., Titcomb M. (1977) Genetic and environmental determinants of growth of school-aged children in a rural Colombian population. *Annals of Human Biology* 4:1-15.
- Must A., Dallal G.E., Dietz W.H. (1991) Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht^2) and triceps skinfold thickness. *American Journal of Clinical Nutrition* 53:839-846.
- Najjar MF, Rowland M (1987) Anthropometric reference data and prevalence of overweight, United States, 1976-80. *Vital and Health Statistics, Series 11, No. 238*.
- NIH (1985) National institutes of health consensus development conference statement. *Annals of Internal Medicine* 103:1073-1077.
- Nirmala A., Mitchell L.E., Rice T., Reddy P.C., Rao D.C. (1993) Assessment of adiposity in an Indian population: Familial correlations. *Genetic Epidemiology* 10:133-143.
- Pérusse L., Leblanc C., Bouchard C. (1988) Inter-generation transmission of physical fitness in the Canadian population. *Canadian Journal of Sport Sciences* 13:8-14.
- Pérusse L., Lortie G., Leblanc C., Tremblay A., Thériault G., Bouchard C. (1987) Genetic and environmental sources of variation in physical fitness. *Annals of Human Biology* 14:425-434.
- Pett L.B., Ogilvie G.F. (1956) The report on Canadian average weights, heights and skinfolds. *Human Biology* 28:177-188.
- Poehlman E.T., Tremblay A., Després J.P., Fontaine E., Pérusse L., Thériault G., Bouchard C. (1986) Genotype-controlled changes in body composition and fat morphology following overfeeding in twins. *American Journal of Clinical Nutrition* 43:723-731.
- Poehlman E.T., Tremblay A., Marcotte M., Pérusse L., Thériault G., Bouchard C. (1987) Heredity and changes in body composition and adipose tissue metabolism after short-term exercise-training. *European Journal of Applied Physiology* 56:398-402.
- Price R.A., Cadoret R.J., Stunkard A.J., Troughton E. (1987) Genetic contributions to human fatness: An adoption study. *American Journal of Psychiatry* 144:1003-1008.
- Price R.A., Ness R., Laskarzewski P. (1990) Common major gene inheritance of extreme overweight. *Human Biology* 62:747-765.

- Ramirez M.E. (1993) Familial aggregation of subcutaneous fat deposits and the peripheral fat distribution pattern. *International Journal of Obesity* 17:63-68.
- Rarick G.L., Oyster N. (1964) Physical maturity, muscular strength, and motor performance of young school-age boys. *Research Quarterly* 35:523-531.
- Rice T., Bouchard C., Pérusse L., Rao D.C. (1995) Familial clustering of multiple measures of adiposity and fat distribution in the Québec Family Study: A trivariate analysis of percent body fat, body mass index, and trunk-to-extremity skinfold ratio. *International Journal of Obesity* 19:902-908.
- Roche A.F., Siervogel R.M., Chumlea C., Webb, P. (1981) Grading body fatness from limited anthropometric data. *American Journal of Clinical Nutrition* 34:2831-2838.
- Rode A., Shephard R.J. (1994) Growth and fitness of Canadian Inuit: Secular trends, 1970-1990. *American Journal of Human Biology* 6:525-541.
- Rode A., Shephard R.J. (1995) Modernization of lifestyle, body fat content and body fat distribution: A comparison of Igloodik Inuit and Volochanka nGanasan. *International Journal of Obesity* 19:709-716.
- Rotimi C., Cooper R. (1995) Familial resemblance for anthropometric measurements and relative fat distribution among African Americans. *International Journal of Obesity* 19:875-880.
- Sánchez-Andrés A. (1995) Genetic and environmental influences on somatotype components: Family study in a Spanish population. *Human Biology* 67:727-738.
- Savard R., Bouchard C., Leblanc C., Tremblay A. (1983) Familial resemblance in fatness indicators. *Annals of Human Biology* 10:111-118.
- Schaefer O. (1977) Are Eskimos more or less fat than other Canadians? A comparison of skinfold thickness and ponderal index in Canadian Eskimos. *American Journal of Clinical Nutrition* 30:1623-1628.
- Selby J.V., Newman B., Quesenberry C.P., Fabsitz R.R., King M.C., Meaney F.J. (1989) Evidence of genetic influence on central body fat in middle-aged twins. *Human Biology* 61:179-193.
- Shephard R.J. (1986) *Fitness of a Nation: Lessons from the Canada Fitness Survey*. New York: Karger.
- Siegel S.R. (1995) *Growth and Maturity Status of Female Soccer Players from Late Childhood Through Early Adulthood*. M.A. Thesis, University of Texas.
- Song T.M.K., Malina R.M., Bouchard C. (1993) Familial resemblance in somatotype. *American Journal of Human Biology* 5:265-272.
- Song T.M.K., Pérusse L., Malina R.M., Bouchard C. (1994) Twin resemblance in somatotype and comparisons with other twin studies. *Human Biology* 66:453-464.

- Sørensen T.I.A., Holst C., Stunkard A.J. (1992a) Childhood body mass index-genetic and familial environmental influences assessed in a longitudinal adoption study. *International Journal of Obesity* 16:705-714.
- Sørensen T.I.A., Holst C., Stunkard A.J., Skovgaard L.T. (1992b) Correlations of body mass index of adult adoptees and their biological and adoptive relatives. *International Journal of Obesity* 16:227-236.
- Speck F.G. (1915) Family Hunting Territories and Social Life of Various Algonkian Bands of the Ottawa Valley. Canada Department of Mines, Geological Survey Memoir 70; No.8, Anthropological Series. Ottawa: Government Printing Bureau.
- SPSS (1990) SPSS Reference Guide. Chicago,IL: SPSS Inc.
- Statistics Canada (1981) Canada Health Survey. The Health of Canadians. Ottawa, ON: Government of Canada.
- Statistics Canada (1987) General Social Survey Analysis Series: Health and Social Support. Ottawa, ON: Government of Canada.
- Statistics Canada (1995) 1993 Community Profiles: Temagami (POH 2H0). Ottawa, ON: Government of Canada.
- Story M., Tompkins R.A., Bass M.A., Wakefield L.M. (1986) Anthropometric measurements and dietary intakes of Cherokee Indian teenagers in North Carolina. *Journal of the American Dietetic Association* 86:1555-1560.
- Stunkard A.J., Harris J.R., Pedersen N.L., McClearn G.E. (1990) The body-mass index of twins who have been reared apart. *New England Journal of Medicine* 322:1483-1487.
- Sugarman J.R., White L.L., Gilbert T.J. (1990) Evidence for a secular change in obesity, height, and weight among Navajo Indian schoolchildren. *American Journal of Clinical Nutrition* 52:960-966.
- Susanne C. (1975) Genetic and environmental influences on morphological characteristics. *Annals of Human Biology* 2:279-287.
- Szathmary E.J.E. (1994) Insulin dependent diabetes mellitus among Aboriginal North Americans. *Annual Review of Anthropology* 23:457-482.
- Szathmary E.J.E., Holt N. (1983) Hyperglycemia in Dogrib Indians of the Northwest Territories, Canada: Association with age and a centripetal fat distribution of body fat. *Human Biology* 55:493-515.
- Szopa J. (1982) Familial studies on genetic determination of some manifestations of muscular strength in man. *Genetica Polonica* 23:65-79.
- Tambs K., Moum T., Eaves L., Neale M., Midthjell K., Lund-Larsen P.G., Næss S., Holman J. (1991) Genetic and environmental contributions to the variance of the body mass index in a Norwegian sample of first- and second-degree relatives. *American Journal of Human Biology* 3:257-267.

- Tanner J.M. (1988) Human growth and constitution. In Harrison G.A., Tanner J.M., Pilbeam D.R., Baker P.T. (eds.): *Human Biology: An Introduction to Human Evolution, Variation, Growth and Adaptability*, 3rd edition. New York: Oxford University Press, pp. 339-435 .
- Tanner J.M. (1994) Introduction: Growth in height as a mirror of the standard of living. In Komlos J. (ed.): *Stature, Living Standards, and Economic Development: Essays in Anthropometric History*. Chicago, IL: University of Chicago Press, pp. 1-6.
- Temme-Augama-Anishnabai (1990) The Native dimension: Key dates. In Bray M., Thomson A. (eds.): *Temagami: A Debate on Wilderness*. Toronto: Dundurn Press, pp. 147-152.
- Tichet J., Vol S., Balkau B., Le Clesiau H., D'Hour A. (1993) Android fat distribution by age and sex: The waist hip ratio. *Diabete et Metabolisme* 19:273-176.
- Tiret L., Ducimetiere P., Andre J.L., Gueguen R., Herbeth B., Spycherelle Y., Rakotova R., Cambien F. (1991) Family resemblance in body circumferences and their ratios: The Nancy Family Study. *Annals of Human Biology* 18:259-271.
- Township of Temagami (1994) *Community Economic Profile 1994*. Temagami, ON: Corporation of the Township of Temagami.
- Trotter M., Gleser G. (1951) The effect of ageing on stature. *American Journal of Physical Anthropology* 9:311-324.
- Vandenburg S.G. (1962) How stable are heritability estimates from six anthropometric studies. *American Journal of Physical Anthropology* 20:331-338.
- Van Itallie T.B., Abraham S. (1985) Some hazards of obesity and its treatment. In Hirsch J., Van Itallie T.B. (eds.): *Recent Advances in Obesity Research, IV*, London: John Libbey, pp. 1-19.
- Weiss K.M., Ferrell R.E., Hanis C.L. (1984) A new world syndrome of metabolic diseases with a genetic and evolutionary basis. *Yearbook of Physical Anthropology* 27:153-178.
- West K.M. (1974) Diabetes in American Indians and other Native populations of the New World. *Diabetes* 23:841-855.
- Young T.K. (1993) Diabetes mellitus among Native Americans in Canada and the United States: An epidemiological review. *American Journal of Human Biology* 5:399-414.
- Young T.K., Sevenhuysen G. (1989) Obesity in northern Canadian Indians: Patterns, determinants, and consequences. *American Journal of Clinical Nutrition* 49:786-793.

Young T.K., Szathmary E.J.E., Evers S., Wheatley B. (1990) Geographical distribution of diabetes among the Native population of Canada: A national survey. *Social Science in Medicine* 31:129-139.

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