ESTABLISHMENT OF CRITERIA FOR A MEASUREMENT OF NUTRITIONAL ASSESSMENT IN NEIGHBORHOOD CLINICS

A THESIS

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INTRODUCTION

Because the science of nutrition has been recognized as an essential component in the prevention and treatment of disease, increased attention is being paid to nutrition. Of particular import is the redefinition of nutrition and the development or improvement of techniques of measurement. Nutritional assessment provides information which may reflect an individual's health status; it should be able to provide information, obtained from nutritional histories as well as clinical and laboratory studies, about both under and overnutrition.

Four major methods are used in the assessment of nutritional status: dietary surveys, biochemical assessment, clinical appraisal and anthropometry. Each method provides part of a complete nutritional assessment. Dietary surveys, for example, reveal what foods are consumed and thus what nutrients are ingested by individuals. Obert (1978) observes that these data may help by identifying possible reasons for findings related to the health status of individuals and may indicate appropriate intervention measures in some cases. Biochemical appraisal uses laboratory tests to provide objective and precise information about nutrient levels in the blood and urine. Christakis (1973) comments that the interpretation of the results of such tests is often difficult and may not correlate with findings from dietary surveys or clinical appraisals (the evaluation of the physical signs of nutritional health or disease). However, a combination of dietary survey, biochemical and clinical appraisals can assist in providing a descriptive assessment of the individual, especially when such an assessment is further supported by anthropometry. Anthropometry deals with the measurements (height, weight and skinfolds) of the human body (Kamath 1977) and is a valuable source of information as a part of the nutritional assessment profile. Anthropometry has been used over the past few decades by researchers to establish criteria for nutritional status. Presently a renewed interest is being shown in this convenient method of identifying nutritional deficiencies or excesses in growth and development. The 1968 White House Conference on Food, Nutrition, and Health as noted by Christakis (1973) suggested the following anthropometric measurements for clinical evaluation for infants and pre-schoolers:

Neonates and Infants
- Weight
- Recumbent length (crown-heel)
- Head circumference

Chest circumference
Triceps skinfold

Pre-schoolers
The same as preceding category
Standing height replaces recumbent
Arm circumference (p. 21)

Statement of the Problem

Although a number of studies related to criteria for measuring children's nutritional status have been done, there is a need for further development and refinement of these assessment criteria. Both deficiency and overnutritional states require consideration. Several studies of the nutritional status of children in particular cities have been made, however, no such nutritional assessment has been made for Fort Worth, Texas children.

Purpose of the Study

The purpose of this study was to establish criteria for a measurement of the nutritional assessment of children attending the neighborhood clinics in Fort Worth, Texas, through the use of selected anthropometric measurements.

Need for the Study

Data collected from the use of selected antrhropometric measurements with children who attend neighborhood clinics in Fort Worth, Texas, may provide information for nutritional education of parents in order to improve the children's nutritional well-being. These data may also assist the administrative staff in health program planning by identifying existing nutritional problems and in nutrition intervention projects to prevent nutrition related conditions such as obesity and undernutrition. They may also provide information for the evaluation of local nutrition education programs.

Research Questions

The three research questions which were investigated in this study were as follows:

1. What are the averages for anthropometric measurements of height, weight, midarm circumference, and triceps skinfolds of children from six months to five years in age who are attending the Fort Worth neighborhood clinics?

2. Do the averages of the anthropometric measurements of the children attending the Fort Worth neighborhood clinics differ by age, sex and ethnic origin?

3. How do these findings (height, weight, midarm circumference, and triceps skinfolds) compare with those done in the Berkeley, California, study (Crawford, Hankin and Huenemann 1978)?

Limitations

The limitations of this study were:

1. The length of time for the study was a six month period. The time frame was from March 5, 1979 to September 4, 1979.

2. The sample consisted of children attending the Fort Worth, Texas, neighborhood clinics.

Definition of Terms

The following definitions are employed in this study:

Anthropometric Measurements:
The measurements include stature (recumbent length from birth to twenty-four months and standing height after twenty-four months of age), weight, and triceps skinfolds.

Anthropometry:
The science and technique of human measurements, specifically of anatomical and physiological features; also the analysis and interpretation of the data obtained. (Funk & Wagnalls 1973, p. 63)

Midarm Circumference:
Measurement, with flexible non-stretch tape, of the circumference of the upper arm midway between the tip of the acromion and olecron process, commonly used in conjunction with other anthropometric measurements.

Nutritional Status:
The health condition of an individual as influenced by his intake and utilization of nutrients, determined from the correlation of information obtained from physical, biochemical, clinical and dietary studies. (Christakis 1973, p. 80)

Nutritional Status Assessment:
An evaluation of one's nutritional state as influenced by one or more of the following methods: 1) Dietary survey (to detect a faulty diet, i.e. primary factor); 2) Medical and clinical examination (to detect conditioning factors); 3) Biochemical tests (to detect

tissue levels); 4) Anthropometric tests (to detect anatomic changes). (Frankle and Owen 1978, p. 363)

Skinfold Thickness:
Measurement, with calibrated calipers of thickness of a fold of skin at a selected body site. These measurements indicate subcutaneous fat and the state of nutriture. Commonly selected sites for measurement, particularly in nutrition surveys, are the upper arms or triceps, subscapular region (just below the shoulder blade), and upper abdomen. (Frankle and Owen 1978, p. 369)

Chapter II reviews related literature. Chapters III and IV report the methodology by which the study was done and the findings of the study itself. Chapter V provides a summary, conclusions and recommendations.

CHAPTER II

REVIEW OF LITERATURE

During the past years there has been an increased awareness and intensification of action directed toward the problems of malnutrition and obesity as they are related to health in the United States and other countries. One manifestation of this increased interest in nutrition is the fact that more attention is being directed toward its measurement and definition. Sufficient nutrition assessment must depend upon at least three factors according to Roberts (1977):

> 1. The selection of the best battery of measurements for the purpose.
> 2. The devision of standards and norms for these measurements.
> 3. Application of these measurements and standards, together with experienced observation and common sense. (p. 1)

Successful nutrition care must be based on valid data. Specific tools for the collection of these nutrition data have been developed in order to provide means for determining the nutritional status and need of the community. Owen and Lippman (1977) have suggested that the nutritional status of a population group or community is best determined by evaluating the results of dietary, biochemical, clinical and anthropometric data.

The present study considers anthropometry since the measurement of the physical dimensions and body composition may be used as one parameter in assessing nutriture. A number of body measurements may be done but the minimum measurements that indicate overnutrition, undernutrition and growth are height, weight, midarm circumference and skinfold thickness.

Nutrition Assessment

Over the years, many methods have been used to assess growth and nutriture. Individuals have been weighed and their lengths measured and compared to standardized growth charts for others at the same age. Standardized growth charts are based on measurements made on large, nationally representative samples of children at different ages. For example, the growth charts used in the Fort Worth Neighborhood Clinics were constructed by the National Center for Health Statistics (NCHS) in collaboration with the Center for Disease Control. These NCHS charts are based on data from samples representative of children in the general United States population. Computer technology was used to generate the growth curves using data from the Fels Research Institute, the NCHS Health Examination Survey

(HES) and the Health and Nutritional Examination Survey (HANES). The "pinch test" has been used for many years to determine the amount of fat stores. However, the systematic assessment of nutrition in as complete a form as is presently possible has evolved only in the last century. Anthropometry, one means of assessing nutritional status by measuring the body, according to Kanawati (1976) was probably first employed by Liharzik in the mid-19th century in the use of child weight and height tables in Vienna. One of the first men to study and write about body measurement was the Belgian, Adolphe Quetelet (1796-1874). He noted that larger numbers of measurements of many individuals were needed in order to get the range of normality. He also developed the Quetelet Index (weight/height), which expresses a relationship between the heights and weights of individuals (Jelliffe and Jelliffe 1979).

The first meeting to discuss nutritional assessment was held in Berlin in 1932 by the League of Nations Health Organization. The standards for evaluation of nutritional status were then compiled by the League of Nations in 1939 (Martin and Beal 1978). In 1949, the original meeting of the Joint Food and Agriculture Organization/World Health Organization (WHO) Expert Committe on Nutrition was held. It did not define exact procedures but described general anthropometric, dietary and clinical methods (Frankle and

Owen 1978). Finally, the World Health Organization (WHO) Expert Committee on Medical Assessment of Nutritional Status recommended that a guide with exact instructions for nutrition surveys be planned, and such a guide was published in 1966. Nutrition surveys were being conducted by countries such as Pakistan as early as 1956. However, the United States began to make such nutrition surveys in the late 1960s; two of these were the Ten-State Nutritional Survey (1968-1970) and the Preschool Nutrition Survey (1968-1970). Another survey was the Health and Nutrition Examination Survey (HANES), which was conducted from 1971 to 1972.

Anthropometry

Anthropometry is widely used for the nutritional assessment of infants and children by measuring growth, body mass and body compostion in relation to age (Keller, Donoso and De Maeyer 1976). Many different anthropometric measures for estimating body fat, body muscle and skeletal growth are used in nutritional assessment.

> These include height, weight, mid-upper arm circumference (used to assess lean body mass), various skinfold thicknesses (used to assess body fat stores), and head circumference (used to assess growth rate). ("Anthropometrics in Nutritional Assessment" 1979, p.1)

Frisancho (1974) used the arm circumference and triceps skinfolds to derive estimates of upper arm muscle size which is an indicator of protein reserve. Arm circumference has also been related to height (Quac Stick, Shakir and Morley 1974). The Quac Stick is a simple and fast tool that provides data comparable to that obtained from weight to height measurements.

Weight to length or stature measurements are standard indicators of growth. If these measurements are made at regular intervals, growth patterns may indicate nutritional deficiencies or overnutrition (Martin and Beal 1978). Foman (1976) suggests that body weight should be measured on scales capable of registering to the nearest 10 grams for infants and on beam scales for older children; infants should be unclothed, and other children unclothed or clothed only in underpants. During the first twenty-four months of life, length should be measured with the body supine; children over twenty-four months of age should be measured in a standing position.

During the past fifty years, many different growth charts have been designed. Bowditch probably designed the first growth chart for average height and weight of American children in the 1870s (Frankle and Owen 1978). In 1921, Woodbury reported average weight and heights for 172,000 children. Then in 1924, the Baldwin-Wood tables were developed. Many charts were of limited value due to the population sample. The Stuart and Meredith combined charts have been used for about thirty years, but they no longer reflect the present-day population of children. The National Center for Health Statistics have compiled and prepared new growth curves which are based on a large, nationally representative sample of children in the United States. Data from the Fels Research Institute, the Preschool Nutrition Survey, and the Health and Nutrition Examination Survey were used in the preparation of these growth curves (Hamill et al. 1979).

As with all data, accuracy and reliability of the age, measurements, and recordings are essential. Some common errors of measurement are caused by inadequate instruments, recording errors on the growth grids and reading the measurement incorrectly. See appendix 1 for other measurement errors. Detailed and precise procedures for taking and recording measurements are outlined by Foman (1976), Hamill and Moor (1976) and Owen (1973). Concern has been expressed (vant Hof and Kowalski 1977) about the actual construction of the growth curves with mixed-longitudinal data. Weight and height growth charts can facilitate uniformity in appraisal of growth and nutritional status.

One of the characteristics of man's state of nutrition is the composition of his body (Brozek and Keys 1951). Skinfold thickness, along with height for weight data, can serve as a useful aid in estimating body fat. In 1920, Mategak proposed determining body fat content by using skinfold measurements. This technique has proven to be useful in providing an index of malnourishment or obesity since the subcutaneous adipose tissue is the major part of body fat. Frisancho (1974), Hammond (1956) and Tanner and Whitehouse (1962, 1975) have developed standards for the measurement and interpretation of data obtained by the skinfold measurement. Graphs and tables used for linear growth and weight distinguish poorly on the margins of normality; therefore, skinfold thickness measurements may yield information to provide for more accurate nutrition assessment of children (Committee on Nutrition 1968).

Since a major part of body fat is deposited in subcutaneous adipose tissue (Brozek and Keys 1951), the fatness can be estimated by selecting one or several sites for measurement of the fat fold. The triceps fat fold is the easiest site to measure that provides a representative sample of body fatness (Pipes 1977). According to the data compiled in the Ten-State Nutrition Survey,

> Skinfold measurements appear to be the best single, simple and practical determination of adiposity. They reflect the amount of subcutaneous fat, and are of proven value as useful measures of total adiposity. (p. I-39)

Brans et al. (1974) have found that caliper skinfold measurements provide a simple, useful, noninvasive tool to determine body composition for nutrition studies. In a study of Cape Town (Keet, Hansen and Truswell 1970), three different groups of children (well, dehydrated and protein malnourished) were assessed to determine if skinfold measurement could be used in the children's nutrition assessment. There was a significant correlation between the skinfold thickness for age and weight and height for age. Keet, Hansen and Truswell (1970) believe skinfold measurement could be a reliable, objective measure of sub-optimal nutrition. Chen, Chowdhury and Huffman (1980) suggest that any anthropometric measurement should be simple, age independent, and should reflect the prevalence, severity and nature of the malnutrition problem. The use of the triceps skinfold seems to meet these criteria.

The Michigan State phase of the Ten-State Nutrition Survey (Garm, Rosen and McCann 1971) was used to evaluate the use of fat folds in mass-scale nutrition surveys in field conditions. The subscapular fat fold reflected higher correlations with body weight than did the triceps fat pad. They found compressed double skin-plus-fat folds relate well to weight and may be useful from childhood to the eighth decade under field conditions in mass surveys. However, Seltzer and Mayer (1967) in their experience believe the triceps skinfold has given satisfactory results as a broad screening device. Weil (1977) suggests that fatness in children can best be monitored clinically by the measurement of the skinfold thickness. Often it is not possible or practical to use elaborate laboratory techniques such as hydrometry, whole body radiopotassium, densitometry or electrolytes. Such techniques are expensive, complicated and difficult to use, and are not readily available for field use. Seltzer and Mayer (1967) believe the triceps site shows high correlation with body density values obtained by underwater weighing. The triceps skinfold is easy to measure and gives reproducible results (Foman 1974). However, Crook (1966) stopped using the triceps skinfold because of higher ratios of error variance than that of the subscapular skinfold.

In an ongoing longitudinal study of Guatemalan children (Martorell et al. 1975), the authors investigated and evaluated the sources of variability in antropometric measurements. They believe that such information can be used to train observers, to estimate the ability to reproduce specific measurements and to aid in research design and the evaluation of research findings. Their research can help eliminate some of the common errors found in measurement of the triceps skinfold.

The research of Crawford et al. (1974) reports that the best single indicator of obesity at six months of age was the weight gain from birth to six months followed by the sum of skinfolds measured at the triceps, subscapular, chest and suprailiac sites. They felt that even a simple biceps arm circumference and triceps skinfold was a better index of obesity than the height/weight tables commonly used. Foman (1974) found that skinfold measurement decreases in a large percentage of children between six and thirty-six months of age. Often as many as twelve sites have been used, but the information gained is not worth the effort expended. Shephard et al. (1969) recommend reduction in the number of measurements. The measurement site at the triceps has often been chosen for practical reasons of modesty and, thus, the cooperation of the subjects (Pett and Ogilvie 1956). In the Canadian City Dwellers study (Shephard et al. 1969), the researchers found that in children the best prediction of body density could be derived from the sum of three folds at the triceps, subscapular and suprailiac sites. They suggest using caution in endorsing the triceps, however, as it does not increase with age. Caution must also be exercised in the use of the caliper on newborn infants (Brans et al. 1974). The initial skinfold thickness decreases within 15-60 seconds after the calipers are applied due to squeezing of the water from the subcutaneous tissue. Daucey, Gandy and Gairdner (1977), using the Tanner and Whitehouse method of measuring, applied the caliper only a few seconds. They reported their data were reliable for infants during the first month of life.

Another concern regarding the skinfold thickness is the fact that the fold represents the double layer of subcutaneous fat and skin (Himes, Roche and Siervogel 1979). However, the authors suggest that further research is needed to determine if the compression makes a difference in estimating total body fat. Reports from Malina et al. (1974) indicate that their date on seven skinfold sites show increases in thickness between birth and three to six months of age, followed by a decrease between the ages eighteen and twenty-one months. The relationship between the sex of the child and the thickness of the skinfold is quite variable before the age of four, but after the fourth year, girls tend to have thicker skinfolds than do boys. The site location must be carefully measured and marked (Burkinshaw, Jones and Krupowicz 1975, Ruis, Colley and Hamilton 1971; Tanner and Whitehouse 1975). In general, fat fold measurement does have some limitations, but it is a convenient method to assess body fat. The results of the caliper correlate well with untrasonic and electrical conductivity measurements (Booth 1966).

Subcutaneous fat is distributed in varying thicknesses at different sites of the body. Because of this, Owens (1973) has reported that a conference of the American Adademy of Pediatrics has advised the use of one limb (tri-cepts) and trunkal (Subscapular) measure. In addition, several authors suggest combining arm circumference and triceps data to derive the amount of muscle mass (Vijayaraghavan, Singh and Swaminathan 1974; Martorll et al. 1976). Gurney and Jelliffee (1973) have developed a simple nomogram to aid in this calculation.

Anthropometric Tools

Indirect estimation of total body fat has been employed increasingly in recent years in an attempt to assess various aspects of body composition. Reliable instruments and standardized techniques are necessary for proper measurement of subcutaneous tissue thickness. The fat fold has often been measured by applying calipers to either side of it and reading a measured scale (Keys and Brozek 1953; Tanner and Whitehouse 1962; and Edwards et al. 1955). A number of different calipers have been designed and tested. These include Franzen, Best, Holtain and two of the more widely used, the Harpenden (English) and Lang (United States). An important factor in caliper design is a constant pressure at all jaw openings. A pressure of 10 grams per millimeter (Brozek and Keys 1951) is recommended. The scale of the instrument should be such that readings can be made to the nearest 1.0 millimeter (Edwards et al. 1955). Plastic calipers (McGaw) was compared to the Lange (Burgert and Anderson 1979). The correlation between the Lange and McGaw skinfold thickness measurements was high although the measurements with the McGaw were generally lower. Burgert and Anderson (1979) believe that in many instances the McGaw caliper would be an inexpensive and convenient tool for routine nutritional assessment.

One parameter of subcutaneous tissue size is its thickness. It has been measured directly with cuts through the skin and indirectly with roentgenographs (Brozek and Keys 1950). Ultrasound has been proven to be accurate while the method using electrical conductivity was accurate but unpleasant for the subject (Booth, Goddard and Paton 1966). Body density has been determined by weighing the subject under water (Durnin and Rahaman 1967). Some of the other tools used in anthropometric measurements are scales for weight, wall measures and blocks for height, tape measures, insertion tapes (Zerfas 1965), and the Quac Stick (Shakir and Morley 1974) for determining upper arm diameter. Small programmable calculators are becoming available that can compute quickly and accurately the standard weight, height or other measurements in percentages of the standard (el Lozy 1978). Body composition may also be determined by measuring the ^{40}K emitted from the subject by radioactive counting. This is an expensive and time consuming procedure and usually only performed in research centers (Forbes, Gallup and Hursh 1961). Although many of these methods are valuable in research laboratories, they are not practical for routine screening in the field (Gray and Gray 1980).

Anthropometry and Demography

Recent reports indicate that children of different races may grow at different rates, particularly in the first years of life. Black children appear to grow more rapidly than white, and whites grow more rapidly than Oriental children (Garn and Clark 1976). Owen and Lubin (1973) report that although black children are smaller than white children at birth and at six months, they are the same size as white children at twelve months, and they are taller and heavier than white children at two years. Other studies (Garn, Owen and Clark 1974; Garn et al. 1972) support Owen and Lubin's findings. Winegard, Soloman and Schoen (1973) report that the mean heights of three groups (black, white and a mixed group of Chinese, Japanese and Mexican) diverged after one year of age with blacks being the tallest, whites being next, and those belonging to the mixed group being the shortest.

Black and white infants did not differ in skinfold thickness, but Puerto Rican infants had significantly smaller triceps skinfolds than did either black or white infants (Johnston and Beller 1976). Children of Guatemalan and European ancestry had smaller triceps skinfold thicknesses than children living in the United States or England.

In addition to studies of ethnic differences in anthropometric measurements, some research has been done in skinfold differences between the sexes. An evaluation of the body composition of newborns in Philadelphia revealed that females had greater triceps skinfold thicknesses than males (Johnston and Beller 1976). A longitudinal study in Berkeley (Crawford, Hankin, and Huenemann 1978) revealed that, while boys were taller and heavier than girls, skinfold values were higher for girls. These anthropometric measurement differences between the sexes and among ethnic groups were also examined by Owen and Lubin (1973); they suggested that, while the differences are not enough to warrant separate charts, persons doing such research should stratify their populations using the variables of ethnicity, age and sex.

Johnston et al. (1978) present still another factor to be considered: the possible hereditary differences in triceps skinfolds. Anthropometric measurements (height, weight, head circumference, triceps skinfold and subscapular skinfold) of native Americans in Minneapolis differed from the national sample median in the Health and Nutrition Examination Survey and the United States Health Examination Survey. Oliveria and Azevedo (1974) believe that in searching for racial effect on anthropometric data the study of "rations" between measurements would be more promising than just the measurement and race by itself. Johnston, Dechow and MacVean (1975) suggest that information from their work indicates that populations from different ethnic backgrouds, reared in the same environment, display age changes similar to each other while their ethnic counterparts living in different environments do not. A comparison of triceps skinfold measurements for six month old infants in the Berkeley study (Huenemann 1974) did not show a significant difference by race.

Fat Deposit

In his review of obesity, Hammar (1974) reports that adipose tissue makes up 28 percent of the total body weight, and by the age of one, the body fat had increased sixfold from birth. At the age of one, adipose tissue makes up 20 percent of the body weight. The skinfold measurement shows a steady increase until nine months of age, and it then levels off until preadolescence (Hirsch and Knittle 1970). Crawford et al. (1974), Huenemann

(1974) and Eid (1970) found the factor associated with obesity at six months to be the accelerated weight gain from birth to six months. However, Whitelaw (1977) measured skinfold thicknesses of infants who were obese, normal or thin at birth and again at one year of age and found no significant difference. The method of feeding was not mentioned in this study, but (Oakley 1977; Ferris et al. 1979) found that the feeding of either formula or breast milk influenced the distribution of body fat in the infants. Formula-fed infants receiving solids before the age of two months had the largest skinfold (Ferris et al. 1979). Conversely, Oakley (1977) reported that breast-fed infants had a significantly greater increase of skinfold thickness than the formula-fed infants; however, infants who were fed cereal before six weeks of age were not included in Oakley's study.

Foman (1976) believes that skinfold thickness can be correlated with fat content of the body while weight to height, which is often used as an index of fatness, does not discriminate between large muscle or large fat mass. However, the Committee on Nutrition Report (1968) indicates that normal, well nourished children in intensive athletic training may have amounts of subcutaneous fat similar to that found in undernourished children. In the Tecumshe Community Health Study (Montoye, Epstein and Kjelsberg

1965) the triceps skinfold procedure for measuring fatness was used for subjects from two to 80 years of age. The skinfold thickness at the triceps showed little change with age in male subjects but increased until age 60 for the female subjects. Other studies (Mack and Johnston 1976; Garn and Haskell 1960) have shown obese children to be taller than age-matched controls as well as more advanced in skeletal maturity.

Nutrition Assessment Surveys

Nutrition surveys have been conducted throughout the world. According to Nichaman (1974), nutrition surveys are a method of gathering data on the prevalence of a condition or characteristic in a population. Nutritional assessment includes dietary surveys, clinical appraisal, anthropometry and biochemical appraisal. This information may then be used to set up parameters or standards for evaluating nutritional status.

The United States began its surveys of nutrition status in the late 1960s and early 1970s. The Ten-State Nutrition Survey (1968-1970) has been the largest and most comprehensive. The number of individuals examined was 40,847, with 50 percent being 16 years of age or younger. A large number of underweight children were found in all population groups. As income increased, so did height, weight, thickness of subcutaneous fat, and earlier attainment of maximum growth. Black children were taller than white children and were more advanced in skeletal development (Garn and Clark 1976). Frisancho (1974) in his cross-sectional sample of males and females from the Ten-State Nutrition Survey of 1968-1970 suggested that the development of subcutaneous fat, as indicated by the triceps skinfold, is continuous throughout life for females but stablizes for males at an early age. The measurements of muscularity (arm circumference) in children serve as an adequate general index of nutritional status and growth in size.

The Preschool Nutrition Survey (Owen et al. 1974) was conducted from 1968 to 1970. During this time span 3,400 children between one and six years of age were examined in thirty-six states. Again, black children were taller and heavier than white children by age two years although lighter at birth. However, in all sexes and age groups the white children had greater skinfold thickness. It was found that there were significant correlations between height, skinfold measurements and weights. Skinfold thicknesses indicated a higher body fat for white children than black children (Owen and Lippman 1977).

In 1971, the Health and Nutrition Examination Survey (HANES) began and it was completed in 1974. Findings in the one to eighteen year old age group showed black children to be taller and heavier but white children have larger triceps skinfolds at almost all ages and in both sexes (Lowenstein 1976).

Summary

The need for effective methods for measuring for nutritional status is evident. A successful nutrition assessment program depends on multiple factors. Some of the factors include proper training for personnel who perform anthropometric measurements, appropriate measurements with accurate measuring devices and a knowledge of the differences in anthropometric measurements among the variables of sex, age and racial/ethnic group. This information will provide data to aid an evaluation of the nutritional status of children.

CHAPTER III

METHODOLOGY

Population and Sample

The population for this study was the children enrolled in the five Fort Worth Public Health neighborhood clinics who came in for routine checkups from March 5, 1979 to September 1979. The children who are usually examined range from one month to five years of age. Only those children whose ages met the criteria were included in the sample; a two week time period on either side of the specific age categories of 6 months, 1 year, 1½ years, 2 years, 2½ years, 3 years, 3½ years, 4 years, 4½ years and 5 years was allowed. This was determined by using the birth date of the infant or child. During the six month period 2,857 children were screened, and 565 met the criterion for each specific age category. The children were divided into groups by racial/ethnic origin, as indicated on their health care records, according to the federal government categories of white, black, Hispanic, American Indian and Asian.

Description of the Measurements

Anthropometric measurements are routinely collected and recorded in the Child Health Record by the Public Health Clinic Teams at five clinic sites as part of well-child checkups. Each clinic site is staffed with three registered nurses and one licensed vocational nurse. All nursing staff have been trained in the past to measure and record height and weight and have received inservice training (see appendix 2) for collecting and recording the mid-arm circumference and triceps skinfold measurements. The licensed vocational nurse at each site is responsible for collecting and recording the anthropometric measurements in the medical record.

The anthropometric measurements which are collected include height, weight, triceps skinfold and arm circumference. A data collection sheet (appendix 3) was used to record the anecdotal information collected in the medical records of the Fort Worth Public Health Department.

Recumbent length was used for infants and children up to twenty-four months of age. The head is positioned against the top of the measuring board so that the line of sight is directly upward. The child is held with his legs straight, and the foot board is moved up to touch the bottom of the child's feet. The measurement is read from the tape measure on the measuring board and recorded to the nearest one-eighth of an inch.

Body weight is measured on beam balance Continental Pediatric Scales for infants up to eighteen months of age without clothing. Children eighteen months or older are clothed in underpants and weighed on beam balance Continental Scales. Weights are taken to the nearest ounce on both scales. The scales are inspected and calibrated each year.

The upper arm circumference is taken with a narrow Ross Laboratories Insertion Tape at a midpoint site with the arm relaxed. The midpoint is found by measuring the distance between the acromial process of the scapula and the tip of the elbow. Measurements are taken to the nearest 0.1 centimeter.

The skinfold is lifted by grasping a fold of skin and subcutaneous tissue between the thumb and forefinger above the marked site over the right mid-triceps. The triceps skinfold measurement is made with Lange skinfold calipers exerting a constant pressure of 10 grams per square millimeter of jaw surface. Caliper measurements are made three times and an average reading is determined.

Data Collection

For the present study, data collection forms were supplied to each clinic site. After the children were routinely seen by the clinic team, the following data were taken from the medical chart: last name, birth date, sex, racial/ethnic group, height in inches, weight in pounds, arm circumference in centimeters, and triceps skinfolds in millimeters. Age was calculated according to the birth date allowing for the two week time period allowed on either side of the ages necessary to qualify for the specific age categories. Height was converted into centimeters, weight into kilograms, and the mid-arm muscle circumference was determined when the triceps skinfold and upper arm circumference numbers were entered into the computer. The client names were removed from the data collection form by completely marking out that section with a black felt pen. Confidentiality of all information was maintained throughout the study.

Treatment of the Data

The data were entered into the computer to determine frequency distribution by age, sex and racial/ethnic groups. Means were established for length or height, weight, triceps skinfolds, arm circumference and muscle circumference by age, sex and racial/ethnic groups could then be compared to the Berkeley study. A *t*-test was performed on the difference between the means of this study and the Berkeley study. A 0.05 level of significance was used. The findings of these analyses are presented in Chapter IV.

CHAPTER IV

RESULTS

This chapter describes the findings of the study of anthropometric measurements of children in five neighborhood clinics in Fort Worth, Texas. The research questions investigated were as follows:

1. What are the averages for the anthropometric measurements of height, weight, midarm circumference, and triceps skinfolds of children six months to five years of age attending the Fort Worth neighborhood clinics?

2. Do the averages of the anthropometric measurements of the children attending the Fort Worth neighborhood clinics differ by age, sex and ethnic origin?

3. How do these findings (height, weight, midarm circumference, and triceps skinfold) compare with those done in the Berkeley, California study (Crawford, Hankin and Hunemann 1978)?

Fort Worth Findings

Population

Five hundred sixty-five children composed the sample. This sample was made up of 297 males and 268 females.

The racial/ethnic distribution was as follows: 186 blacks (33 percent, 82 white (15 percent), 285 Hispanic (50 percent), and 12 Asian (2 percent). There were no American Indians; therefore, that racial/ethnic category was not presented in the present study. Fifty-eight percent of the children were sampled at age six month (177), age 1 year (81) and age 1½ years (72). The numbers of children within each age grouping are listed in table 1.

TABLE 1

FREQUENCY OF SUBJECTS AT SUCCESSIVE AGES
BY RACIAL/ETHNIC GROUP AND SEX

Age	White		Black		Asian		Hispanic		Total	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6 months	10	16	30	39	1	2	38	41	79	98
1 year	13	5	16	8	2	1	23	13	54	27
1½ years	7	2	19	9	1	0	17	17	44	28
2 years	4	2	8	8	0	1	13	12	25	23
2½ years	2	1	10	2	1	0	14	13	27	16
3 years	0	2	5	4	0	1	10	9	15	16
3½ years	2	2	2	5	0	0	7	6	11	13
4 years	4	4	6	8	2	0	12	13	24	25
4½ years	1	3	0	3	0	0	4	7	5	13
5 years	1	1	2	2	0	0	10	6	13	9

Research Question One

The averages for the anthropometric measurement of height, weight and triceps skinfold are listed in table 2 by age categories, sex and racial/ethnic groups. The height, weight and triceps skinfold averages are discussed in the next section.

TABLE 2

MEAN LENGTH OR HEIGHT, WEIGHT AND TRICEPS SKINFOLDS
BY AGE, SEX AND RACIAL/ETHNIC ORIGIN

Age and Racial/ Ethnic Origin	Frequency of Subjects		Length or Height cm.		Weight kg.		Triceps Skinfolds mm.	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6 months								
Mean	79	98	67.1	64.4	7.9	7.1	8.6	7.8
Black	30	39	67.1	65.3	7.9	7.1	9.7	8.8
Hispanic	38	41	67.2	64.6	8.1	7.2	8.2	7.1
Asian	1	2	67.3	66.4	7.1	7.4	6.0	8.0
White	10	16	66.4	61.7	7.9	7.0	7.5	7.4
1 year								
Mean	54	27	75.3	73.8	10.0	9.3	8.9	8.0
Black	16	8	76.8	75.3	10.0	9.4	9.1	8.0
Hispanic	23	13	75.4	72.0	10.3	9.4	9.0	7.9
Asian	2	1	66.0	77.5	10.0	9.3	9.0	8.0
White	13	5	74.6	75.1	9.7	9.1	8.8	8.2
1½ years								
Mean	44	28	80.9	79.7	11.0	10.5	9.3	8.7
Black	19	9	81.6	80.6	10.9	10.4	10.5	10.4
Hispanic	17	17	79.4	79.4	11.0	10.6	8.1	7.9
Asian	1	0	81.3	. . .	9.9	. . .	8.0	. . .
White	7	2	82.6	78.7	11.6	10.9	8.9	8.0
2 years								
Mean	25	23	86.1	83.0	12.3	11.4	9.4	8.4
Black	8	8	86.1	84.6	12.0	11.4	9.9	8.4
Hispanic	13	12	86.4	81.9	12.5	11.3	9.2	8.0
Asian	0	1	. . .	83.8	. . .	11.6	. . .	8.0
White	4	2	84.5	82.6	12.1	12.5	9.0	11.0
2½ years								
Mean	27	16	88.9	88.8	13.6	13.0	9.1	8.4
Black	10	2	91.4	91.4	14.2	13.9	8.7	10.0
Hispanic	14	13	89.3	88.6	13.7	13.0	9.7	8.2
Asian	1	0	94.0	. . .	13.2	. . .	8.0	. . .
White	2	1	72.4	86.4	11.1	11.8	8.0	8.0

TABLE 2—Continued

Age and Racial/ Ethnic Origin	Frequency of Subjects		Length or Height cm.		Weight kg.		Triceps Skinfolds mm.	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
3 years								
Mean	15	16	90.6	92.3	13.9	14.2	9.1	9.5
Black	5	4	89.0	92.6	14.0	13.7	9.2	9.5
Hispanic	10	9	91.4	93.0	13.9	14.7	9.1	9.0
Asian	0	1	. . .	87.6	. . .	13.8	. . .	12.0
White	0	2	. . .	90.8	. . .	13.2	. . .	11.0
3½ years								
Mean	11	13	96.7	96.5	14.5	14.4	7.6	9.7
Black	2	5	97.2	97.8	13.4	14.9	7.0	10.8
Hispanic	7	6	95.3	95.1	14.1	13.7	7.7	8.3
Asian	0	0	. . .	. . .	. . .	. . .	. . .	. . .
White	2	2	101.3	97.8	17.4	15.2	8.0	11.0
4 years								
Mean	24	25	99.1	95.5	15.4	15.3	9.6	9.3
Black	6	8	101.6	101.2	16.6	16.1	12.3	10.6
Hispanic	12	13	98.5	91.4	15.7	14.8	8.7	8.0
Asian	2	0	101.0	. . .	15.2	. . .	7.0	. . .
White	4	4	97.2	97.6	15.3	15.6	9.8	11.0
4½ years								
Mean	5	13	101.2	101.1	15.6	16.8	8.0	9.2
Black	0	3	. . .	107.7	. . .	20.3	. . .	10.0
Hispanic	4	7	103.0	99.4	16.2	16.5	8.5	9.1
Asian	0	0	. . .	. . .	. . .	. . .	. . .	. . .
White	1	3	94.0	98.4	13.2	14.1	6.0	8.7
5 years								
Mean	13	9	104.7	104.7	17.6	16.8	8.7	8.8
Black	2	2	109.9	106.4	20.0	16.8	10.0	7.0
Hispanic	10	6	104.1	102.5	17.5	16.0	8.6	9.3
Asian	0	0	. . .	. . .	. . .	. . .	. . .	. . .
White	1	1	100.3	114.9	15.0	22.0	8.0	10.0

Research Question Two

Difference in Height

Boys

No one male racial/ethnic group was consistently taller by age than any other group. Figure 1 shows that at 6 months of age the four groups were similar with only 0.9 cm difference between the tallest and shortest boys. At ages 1 and 5 the black boys are, respectively, 2.2 cm and 9.6 cm taller than white boys. A complete set of figures were available in half of the categories (ages 6 months, 1 and 1½ years, 2½ years and 4 years); however partial sets of data were collected for the remaining groupings. No data were available for 2, 3, 3½, 4½ and 5 years old Asian boys. The year old group of Asian boys were 1.3 cm shorter than the 6 month old Asian boys. Hispanic boys appear to be taller in two groups--3 years and 4½ years--but data are missing for two of the four groups in each of these categories. At both 4 and 5 years black boys are taller than any of the other three ethnic groups.

The mean heights for black boys increased from 67.1 cm at 6 months to 109.9 cm by age 5 years, a mean height increase of 42.8 cm. The mean heights for white boys increased from 67.1 cm at age 6 months to 100.3 cm by age 5 years, a mean height increase of 33.2 cm. The Asian

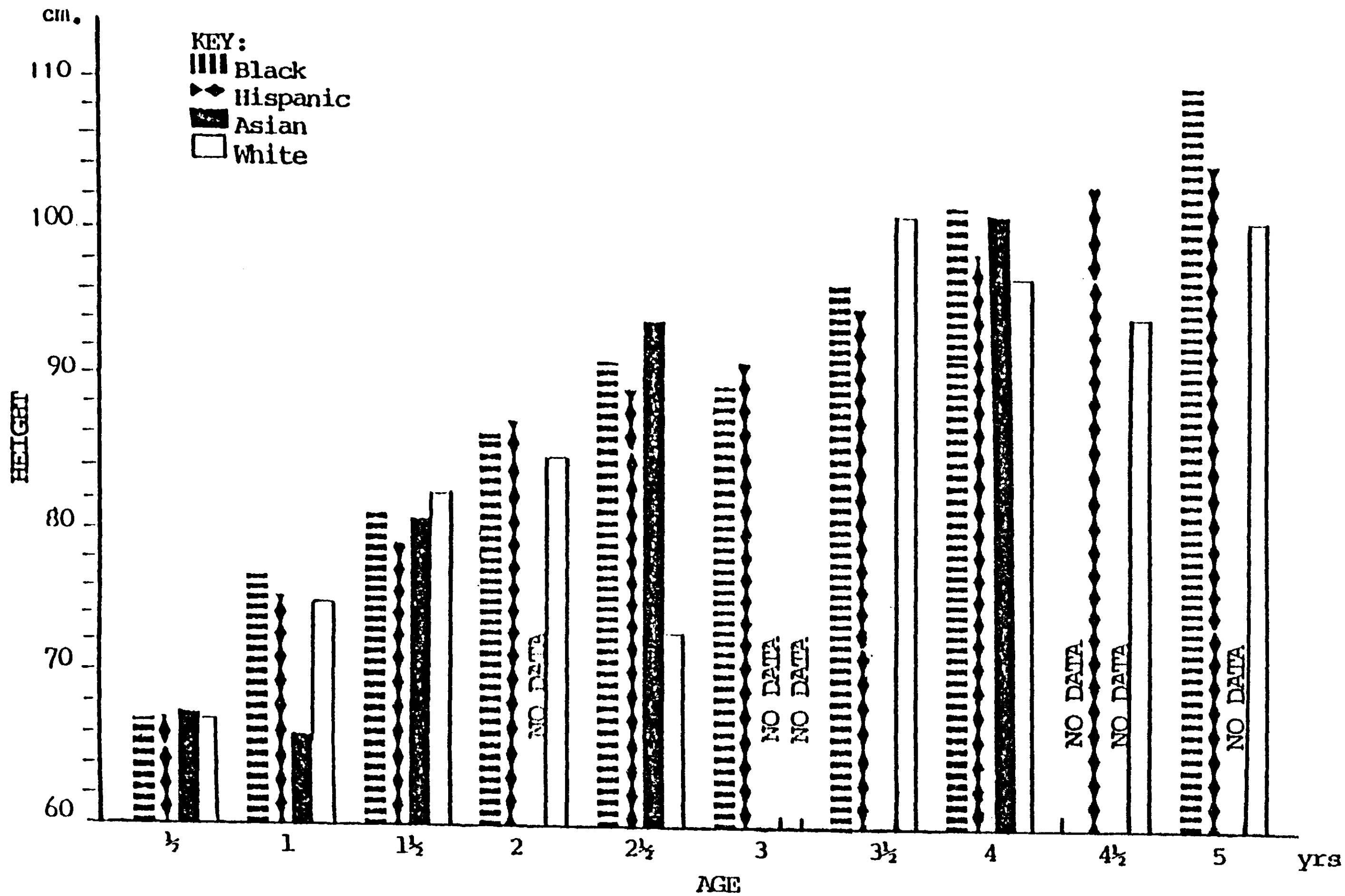


Fig. 1. Mean heights of boys by age and racial/ethnic group.

boys' mean height, on data available, increased from 67.3 cm at 6 months to 101.0 cm at 4 years of age. No data were available for 5 year old Asian boys. The difference in increase in mean height between white and black boys is 9.6 cm. Mean heights for Hispanic boys increased from 67.2 cm at 6 months of age to 104.1 cm at age 5 years, an increase in mean heights between black and Hispanic is 6.0 cm and between white and Hispanic boys is 3.6 cm.

Girls

The black girls were taller than the other groups at ages 1½, 2, 2½, 3½, 4 and 4½ years as shown in figure 2. Asian girls were taller at 6 months and 1 year of age, but data were incomplete for Asian girls in five age categories. At 6 months of age white girls were the shortest (61.7 cm) of the four groups, and at five years, they were the tallest (114.9 cm). Hispanic girls were tallest only at age 3 years. The differences between their mean height and that of black girls were only 0.4 cm at 3 years of age.

Overall, the mean heights for white girls increased from 61.7 cm at age 6 months to 114.9 cm at age 4, an increase of 53.2 cm. The mean height of black girls increased from 65.3 cm at age 6 months to 106.4 cm at age 5 years, an increase in mean height of 41.4 cm. Asian girls'

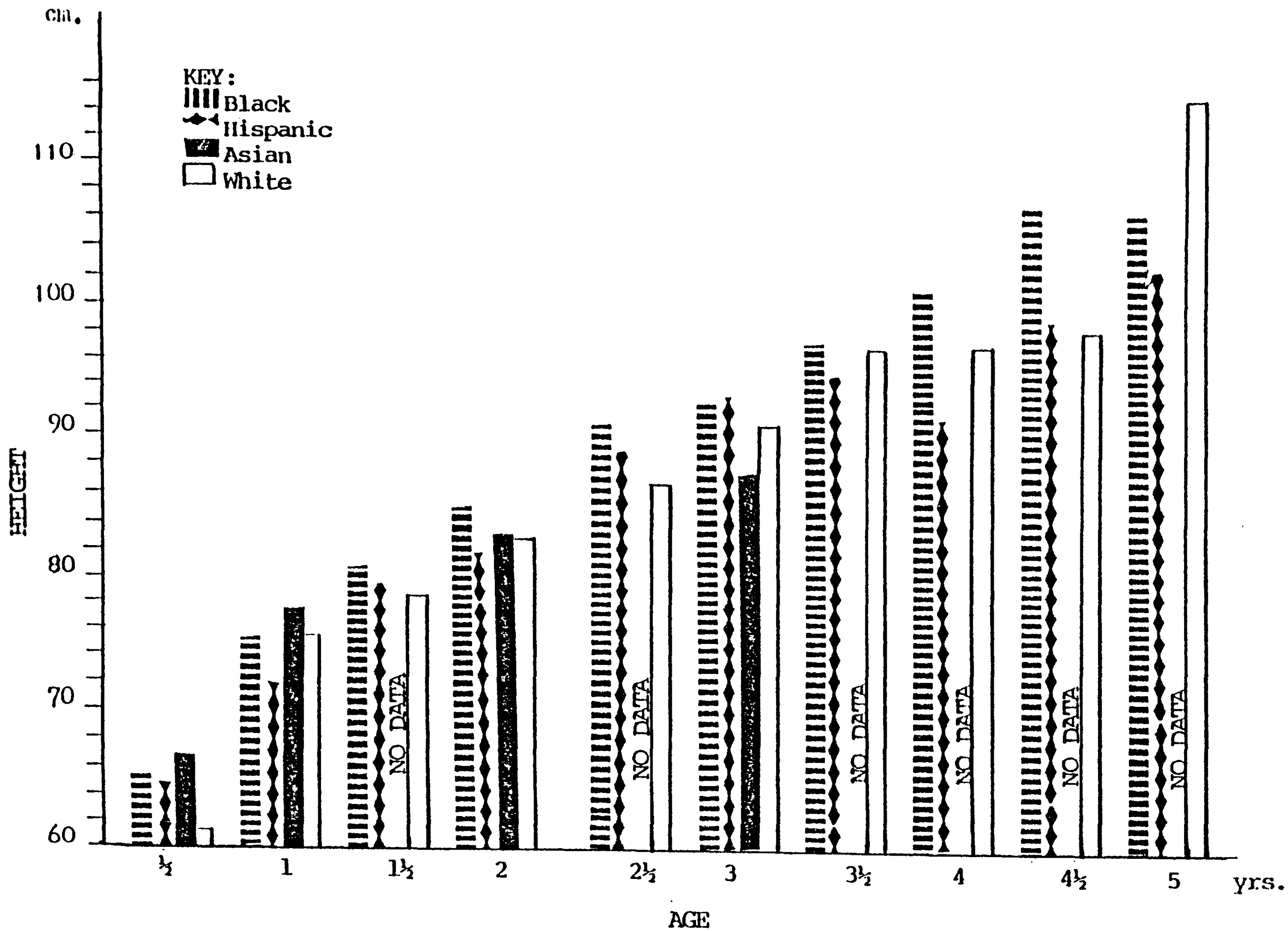


Fig. 2. Mean heights for girls by age and racial/ethnic group.

mean heights increased from 66.4 cm at 6 months of age to 87.6 cm by age 3 years. No data on heights were available for Asian girls after age 3 years. The mean heights of Hispanic girls ranged from 64.6 cm at 6 months of age to 102.5 cm by 5 years of age, an increase of 37.9 cm in mean height.

The difference in the increase in mean height bebween white and black girls was 11.8 cm. The difference in mean height between black and Hispanic girls is 3.5 cm and between white and Hispanic girls was 15.3 cm. Black girls were, on the average, taller in 6 of 10 age comparisons.

Differences in Weight

Boys

No one racial/ethnic group was consistently heavier by age than any other group of boys. Black boys were heavier only at age 2½ years, 4 years and 5 years (see figure 3). Weights were, on the average, heavier in white boys at age 1½, 3½, and 4 years. The Asian boys at 6 months had the lowest weight of 7.1 kg. Data from 5 age categories were not available for Asian boys. The mean weights of Hispanic boys were heavier than the other groups at age 1, 2, and 4½ years.

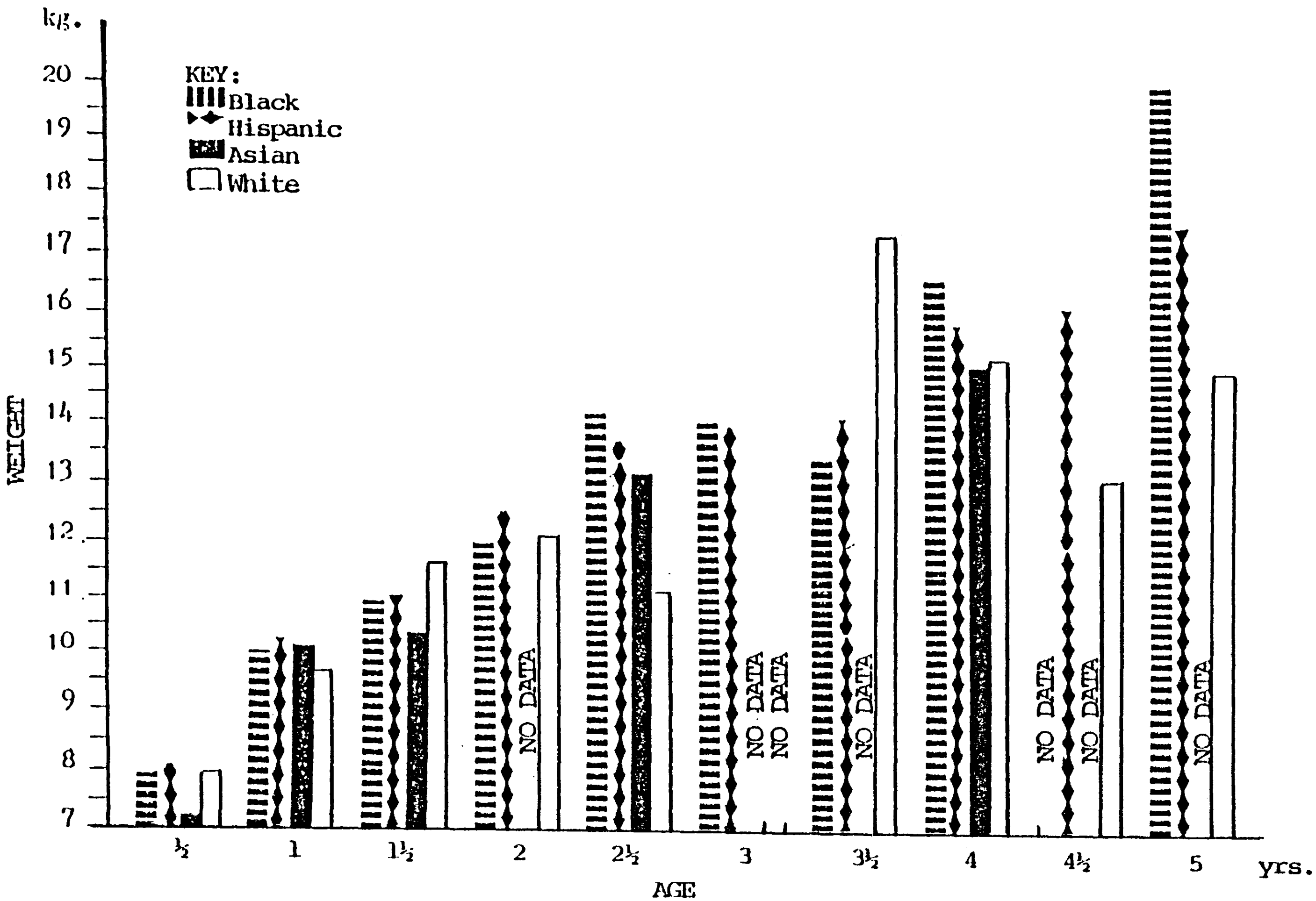


Fig. 3. Mean weight of boys by age and racial/ethnic group.

The mean weights for white boys increase irregularly each year from 7.9 kg at age 6 months to 15.0 kg at age 5 years, an increase in mean weight of 7.1 kg. The increase in mean weights between the same ages for black boys is 7.9 kg to 20.0 kg, an increase in mean weight of 12.1 kg. The difference in the increase of mean weight between white and black boys is 5.0 kg. The increase in mean weights for Hispanic boys is 8.1 kg at 6 months of age to 17.5 kg at 5 years, an increase of 9.4 kg. Asian boys' mean weights increased from 7.1 kg. to 15.2 kg at 4 years, an increase of 8.1 kg. The difference in the increase of mean weight between white and Hispanic boys was 2.3 kg and between black and Hispanic boys was 2.7 kg.

Girls

At ages 6 months and 1 year (see figure 4) girls of all racial/ethnic groups are similar. White girls are heavier at 1½, 2, 3½, and 4 years of age. Black girls are heavier at 2½, 4 and 4½ years of age. Hispanic girls were slightly heavier than the others only at age 3 years. In six out of the ten age categories data were not available for Asian girls.

For white girls the mean weight increased from 7.0 kg at age 6 months to a peak of 22.0 kg at age 5 years, an increase of 15.0 kg. Black girls had a mean weight

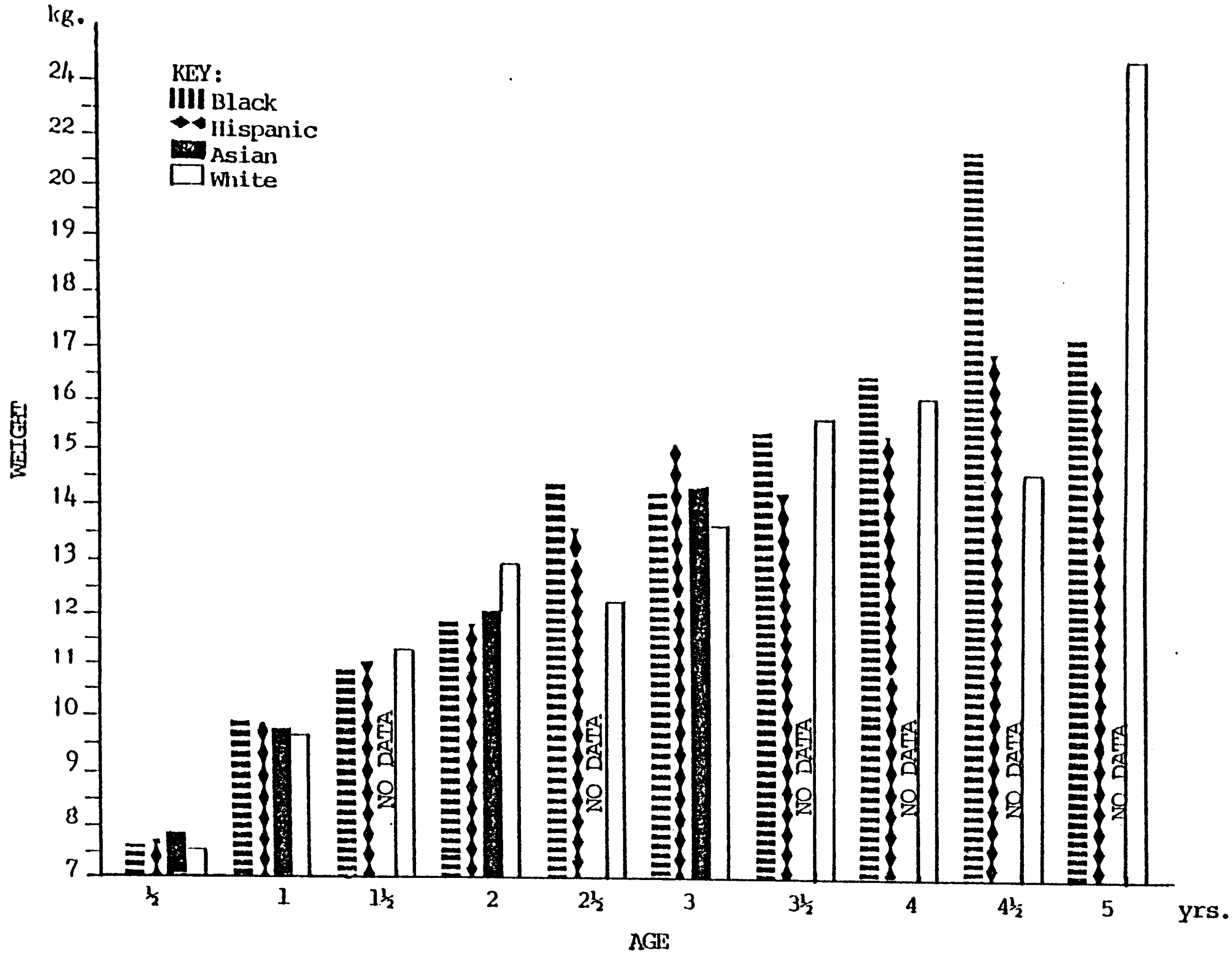


Fig. 4. Mean weight of girls by age and racial/ethnic groups.

increase from 7.1 kg at age 6 months to 16.8 kg at age 5 years, an increase of 9.7 kg. For Hispanic girls the mean weight increased from 7.2 kg at 6 months of age to 16.0 kg at 5 years of age, an increase of 8.8 kg. The Asian girls' mean weight increased from 7.4 kg at 6 months of age to 13.8 kg at 3 years of age, an increase of 6.4 kg. No data were available for Asian girls at 3½, 4, 4½, and 5 years of age.

Difference in Triceps Skinfolds

Boys

Black boys show higher median skinfolds data in 7 out of the 10 age categories as indicated by table 2 and figure 5. The exceptions occur in ages 2½ and 3½ years with no data reported for black boys at age 4½ years. The lowest value was reported for the Asian boys at 6 months of age. All racial/ethnic groups were similar at 1 year of age.

The mean triceps skinfolds for black boys varied from a low of 7.0 mm at age 6 months to a high of 12.3 mm at age 5 years for a difference of 4.3 mm. The range for white boys was 7.6 mm (6 months) to 9.7 mm (5 years), a difference of 2.0 mm. Asian boys had triceps skinfolds range from 6.0 mm at age 6 months to 9.0 mm at age one year. No data for Asian boys were available for 2, 3, 3½, 4½

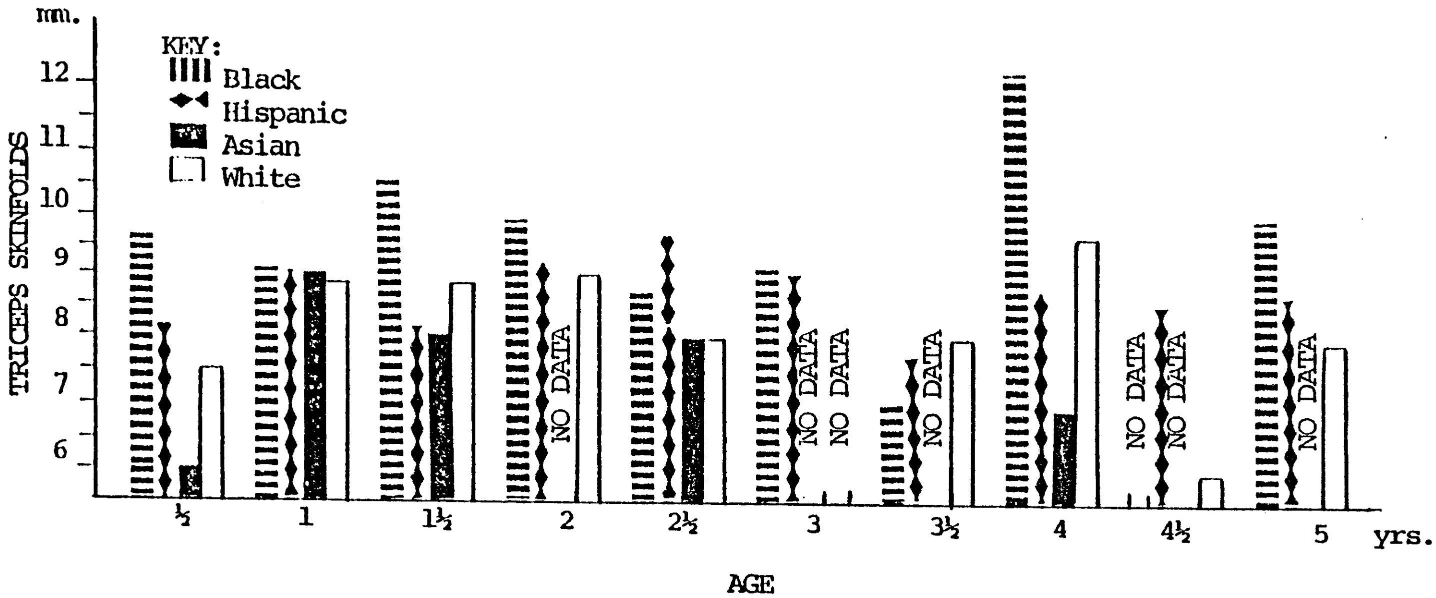


Fig. 5. Mean triceps skinfolds of boys by age and racial/ethnic group.

and 5 years of age. The mean triceps skinfolds of Hispanic boys varied from a low of 7.7 mm at 3½ years to a high of 9.7 mm at 2½ years of age.

Girls

The triceps skinfolds of white girls was higher than the other three groups in 5 out of 10 age categories: ages 1, 2, 2½, 4 and 5 years of age (see table 2 and figure 6). All racial/ethnic groups were similar at 1 year of age. Black girls had higher mean triceps skinfolds at 6 months, 1½, 2½, and 4½ years of age. The highest reading was reported for the Asian group at 3 years of age, and the lowest values were for Hispanic girls at 6 months and black girls at 5 years of age.

For black girls, the mean triceps skinfolds varied from a low of 7.0 mm to a high of 10.8 mm for a difference of 3.8 mm. The white girls' values ranged from a low of 7.4 mm to a high of 11.0 mm. For Asian girls, only 4 age categories were reported; these varied from 8.0 mm to 12.0 mm with a difference of 4.0 mm. Mean triceps skinfolds of Hispanic girls varied from 7.1 mm to 9.3 mm, a difference of 2.2 mm.

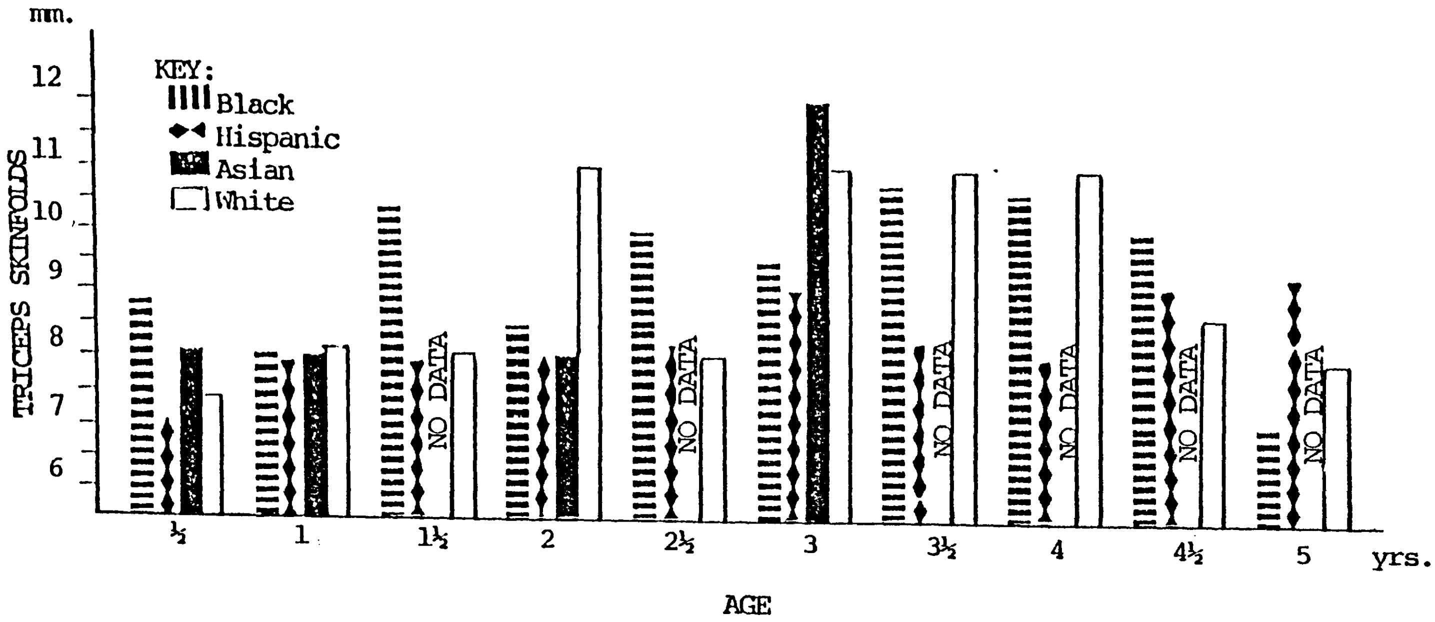


Fig. 6. Mean triceps skinfolds of girls by age and racial/ethnic group.

Comparison Findings

Research Question Three

In this section the findings of the Fort Worth study are compared to the Berkeley study, which was done by Crawford, Hankin and Huenemann in 1978. The Berkeley sample consisted of 448 children. The sample was 71 percent white, 19 percent black, 6 percent Asian and 4 percent other (including Hispanic, American Indian, Filipino and Vietnamese). The racial/ethnic groups in the Fort Worth study differ from the Berkeley population as the distribution was 15 percent white, 33 percent black, 2 percent Asian and 50 percent Hispanic with no American Indians nor any other racial/ethnic groups being represented.

The comparisons of the means of the anthropometric measurements of height, weight and triceps skinfold by age, sex and racial/ethnic origin in the Berkeley study and this study are listed in table 3. Too few children in this study were sampled in each age category to make complete comparisons on the basis of the variable of racial/ethnic origin.

TABLE 3

COMPARISONS OF MEAN ANTHROPOMETRIC MEASUREMENTS BY AGE SEX AND RACIAL/ETHNIC ORIGIN IN THE BERKELEY AND FORT WORTH SAMPLES

Sex and Age	Number		Height cm.		Weight kg.		Triceps Skinfolds mm.	
	Berkeley	Fort Worth	Berkeley	Fort Worth	Berkeley	Fort Worth	Berkeley	Fort Worth
White								
Boys								
6 mo.	158	10	68.5	66.4	8.2	7.9	8.0	7.5
1 yr.	139	13	76.9	74.6*	10.4	9.7*	8.7	8.8
2 yr.	121	4	88.4	84.5*	12.9	12.1	8.8	9.0
3 yr.	105	0	95.7	. . .	14.8	. . .	9.0	. . .
4 yr.	94	4	102.5	97.2	16.7	15.3	8.4	9.8
Girls								
6 mo.	161	16	66.2	61.7	7.6	7.0*	8.0	7.4
1 yr.	145	5	74.7	75.1	9.6	9.1	8.7	8.2
2 yr.	126	2	86.9	82.6	12.2	12.5	9.2	11.0
3 yr.	113	2	94.9	90.8	14.3	13.2	9.7	11.0
4 yr.	101	4	101.9	97.6	16.4	15.6	8.8	11.0
Black								
Boys								
6 mo.	44	30	68.0	67.1	8.2	7.9	8.2	7.9*
1 yr.	32	16	77.1	76.8	10.3	10.0	8.5	9.1
2 yr.	18	8	88.4	86.1*	12.1	12.9	9.0	8.9
3 yr.	14	5	96.3	89.0	14.9	14.0	8.1	9.2
4 yr.	12	6	103.4	101.6	17.3	16.6	8.6	12.3

*$P \leq 0.05$: Fort Worth differs from Berkeley

TABLE 3--Continued

Sex and Age	Number		Height cm.		Weight kg.		Triceps Skinfolds mm.	
	Berkeley	Fort Worth	Berkeley	Fort Worth	Berkeley	Fort Worth	Berkeley	Fort Worth
	Black							
Girls								
6 mo.	41	39	66.1	65.3*	7.5	7.1*	8.2	8.8
1 yr.	25	8	75.1	75.3	9.5	9.4	8.1	8.0
2 yr.	17	8	86.6	84.6	11.7	11.4	8.5	8.4
3 yr.	10	4	94.9	92.6	13.7	13.7	8.8	9.5
4 yr.	8	4	101.7	101.2	15.7	16.1	7.5	10.6
	Asian							
Boys								
6 mo.	14	1	66.9	67.3	8.0	7.1	8.6	6.0
1 yr.	13	2	75.3	66.0	9.8	10.0	8.7	9.0
2 yr.	11	0	86.3	...	11.9	...	8.5	...
3 yr.	10	0	93.1	...	13.7	...	8.7	...
4 yr.	11	2	99.5	101.0	15.5	15.2	8.5	8.0
Girls								
6 mo.	14	2	67.3	66.4	8.0	7.4	8.4	8.0
1 yr.	12	1	75.4	77.5	10.0	9.3	9.0	8.0
2 yr.	8	1	87.1	83.8	12.3	11.6	8.6	8.0
3 yr.	8	1	94.8	87.6	14.3	13.8	8.8	12.0
4 yr.	7	0	101.9	...	16.5	...	9.6	...

*$P \leq 0.05$: Fort Worth differs from Berkeley

As reported in the Berkeley study whites and blacks were similar in height until two years of age; then blacks have higher values. No similar data were reflected in the Fort Worth study. The averages for the heights and weights of males and females are compared by six month intervals in figures 7 and 8.

In the Berkeley study the boys were taller and heavier than the girls for the children at all ages. This was not true in this study. The mean body weights for males and females were varied, and boys were heavier only at six months, one year, and five years of age. Boys were taller than the girls in the Fort Worth study except at age three as shown in figures 7 and 8. At all age categories of the Berkeley study the boys and girls were taller and heavier than the boys and girls in the Fort Worth sample. Yet when the data are examined in the Fort Worth study the Hispanics were not taller or heavier than the other racial/ ethnic groups. When the Fort Worth means for heights are compared to the Berkeley data by age and race, the Berkeley averages were consistently higher as illustrated by figures 7 and 8.

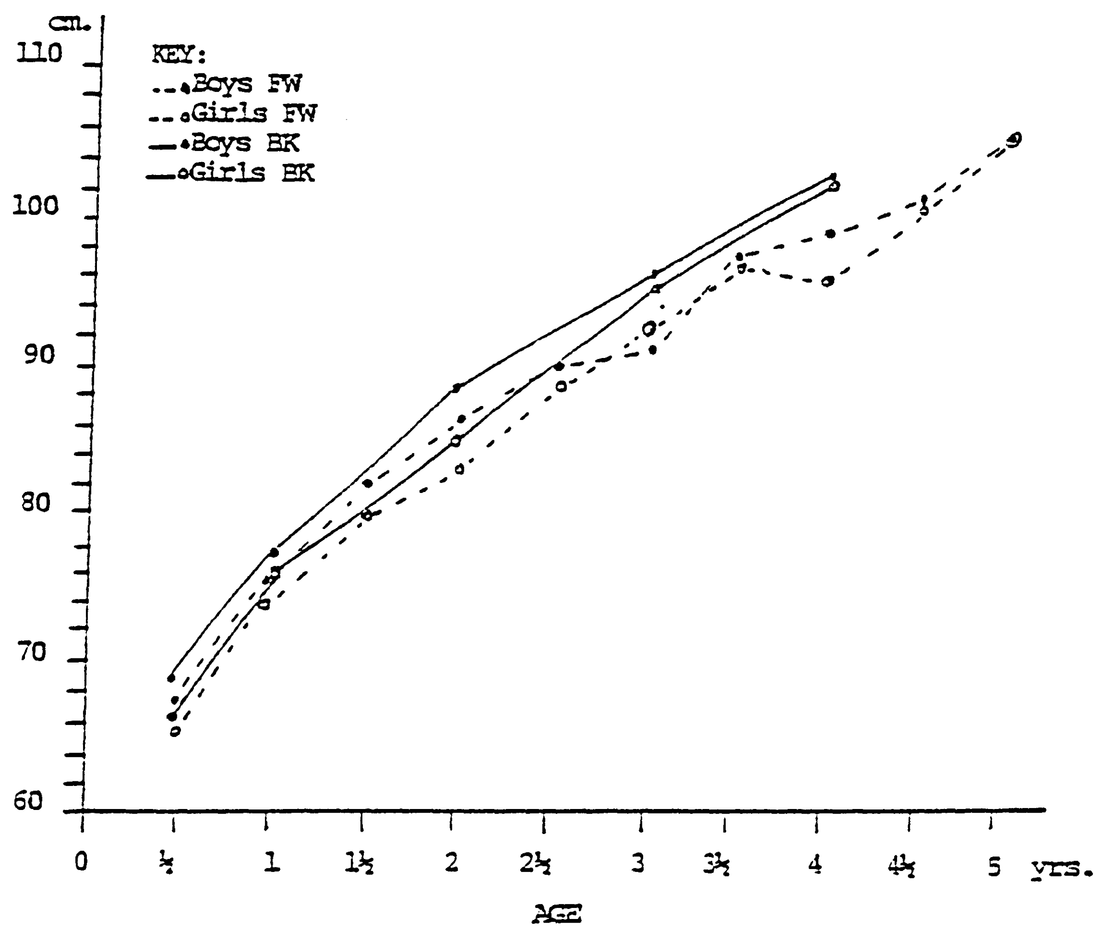


Fig. 8. Mean heights for boys and girls by six month intervals for the Berkeley and Fort Worth studies.

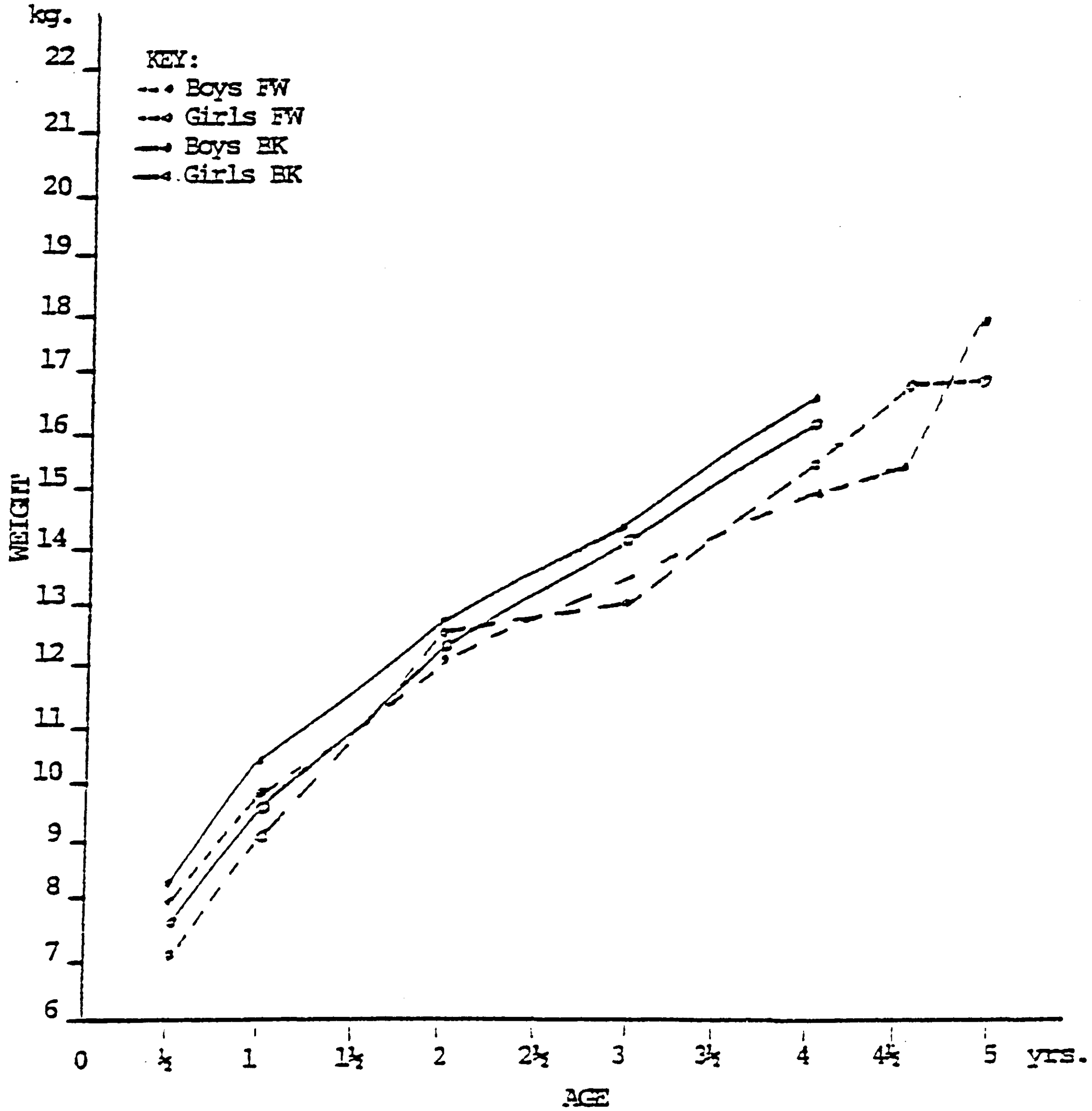


Fig. 7. Mean body weight for boys and girls by six month intervals for Berkeley and Fort Worth studies.

The Berkeley study reported girls had higher triceps skinfold values than the boys. This was not observed in the Fort Worth study as may be seen in figure 9, which plots the means of the measure of body fat by six month intervals for both studies. The boys in the Fort Worth study had higher measurements until age three, when the values began to decrease. However, the overall trend showed higher skinfold values for the triceps for the Fort Worth data than for the Berkeley data. Although there was no specificity among the racial/ethnic groups, the small numbers of Asians would limit interpretation of these data.

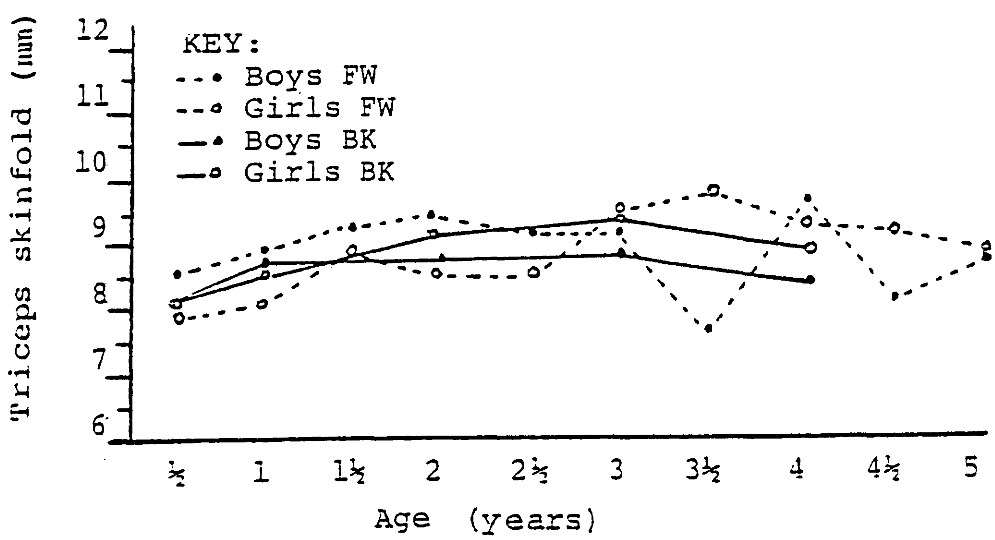


Fig. 9. Mean triceps skinfolds for boys and girls by six month intervals for Berkeley and Fort Worth studies.

The height and weight values of the Berkeley and Fort Worth studies, when plotted displayed curves that were parallel, indicating that the values were consistently higher for all the children in the Berkeley sample. Although there were differences between the Berkeley and Fort Worth heights and weights, the children in the Fort Worth sample were within normal limits for their growth patterns (see figures 10, 11, 12 and 13).

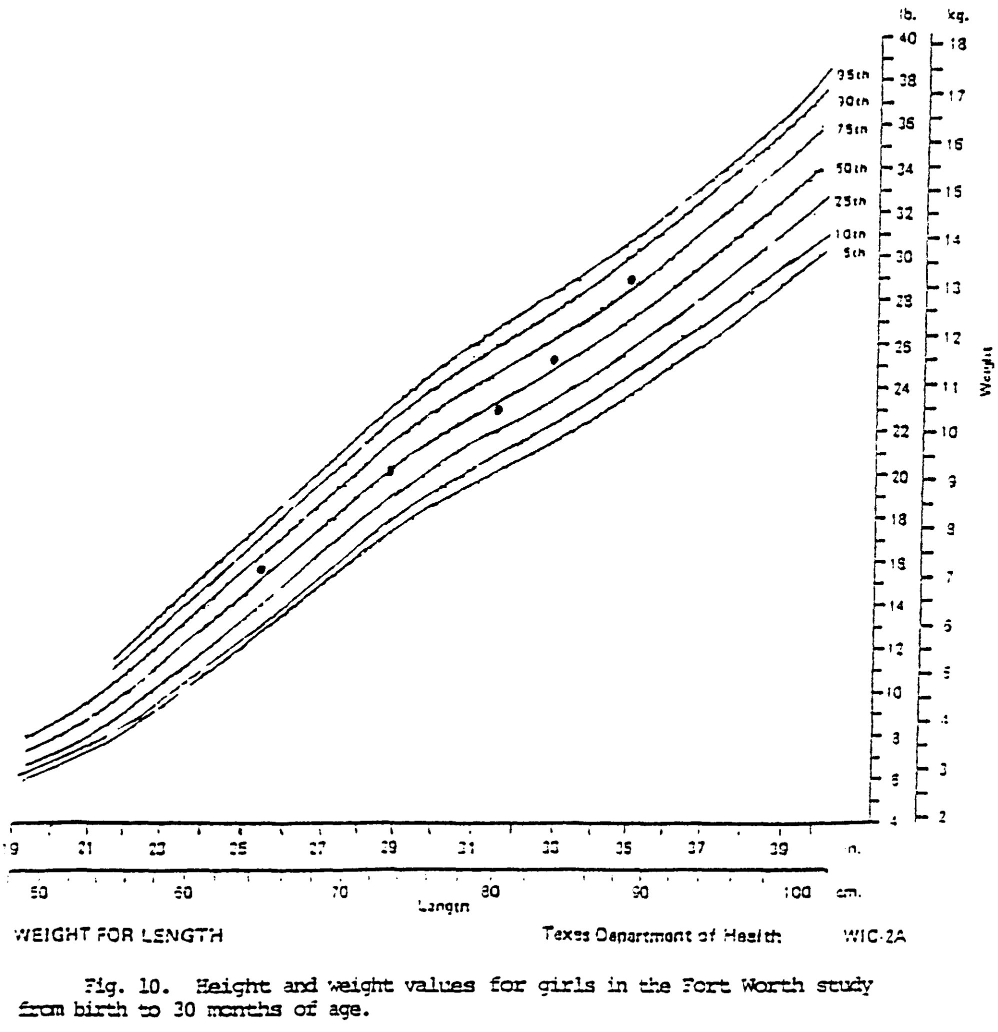


Fig. 10. Height and weight values for girls in the Fort Worth study from birth to 30 months of age.

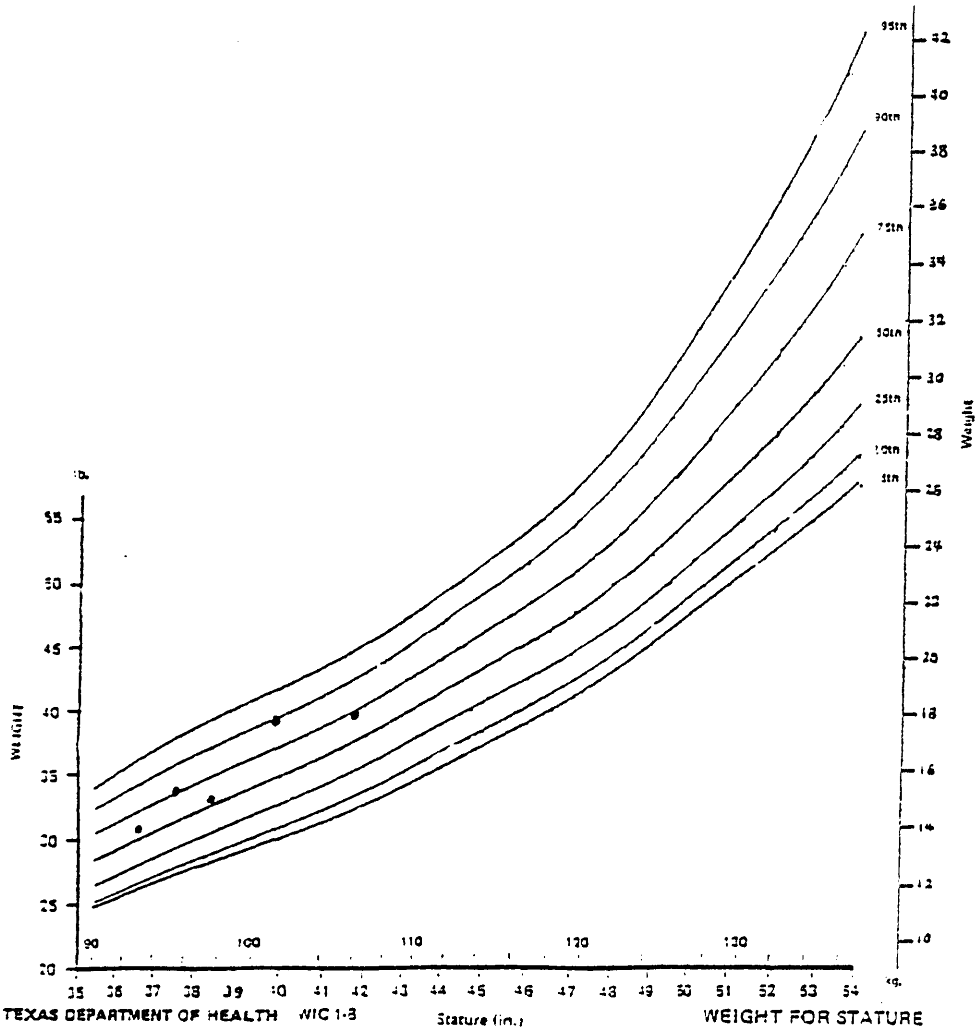


Fig. 11. Height and weight values for girls in the Fort Worth study from 2 to 5 years of age.

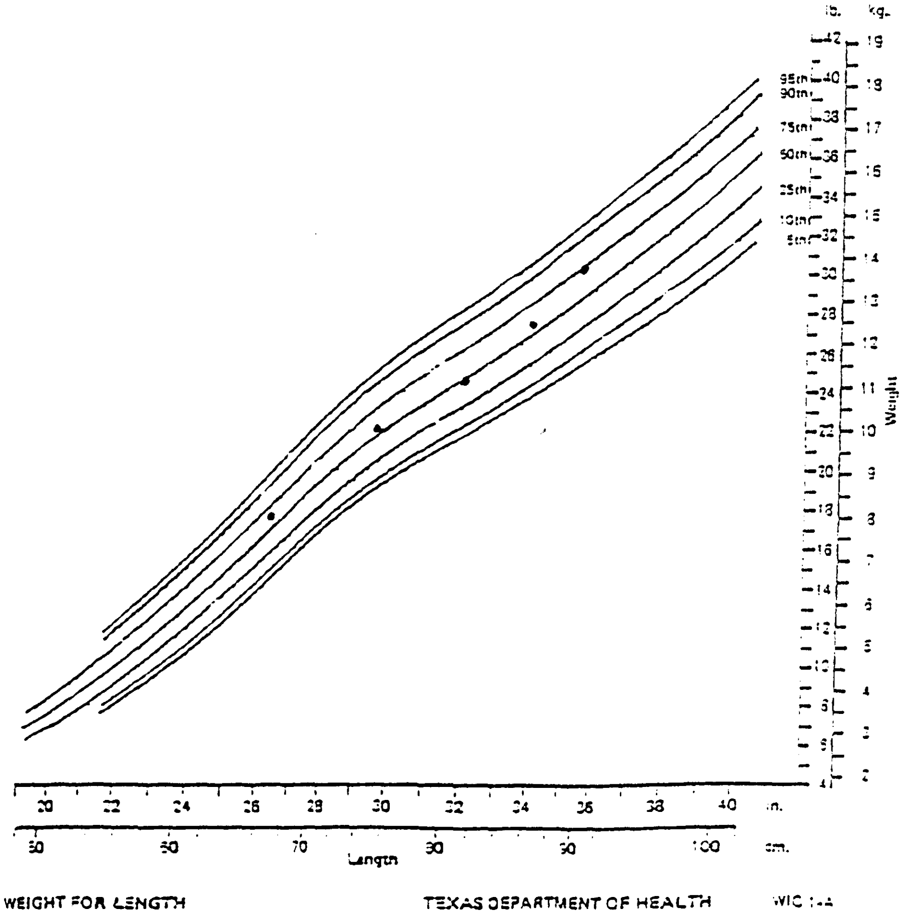


Fig. 12. Height and weight values for boys in the Fort Worth study from birth too 30 months of age.

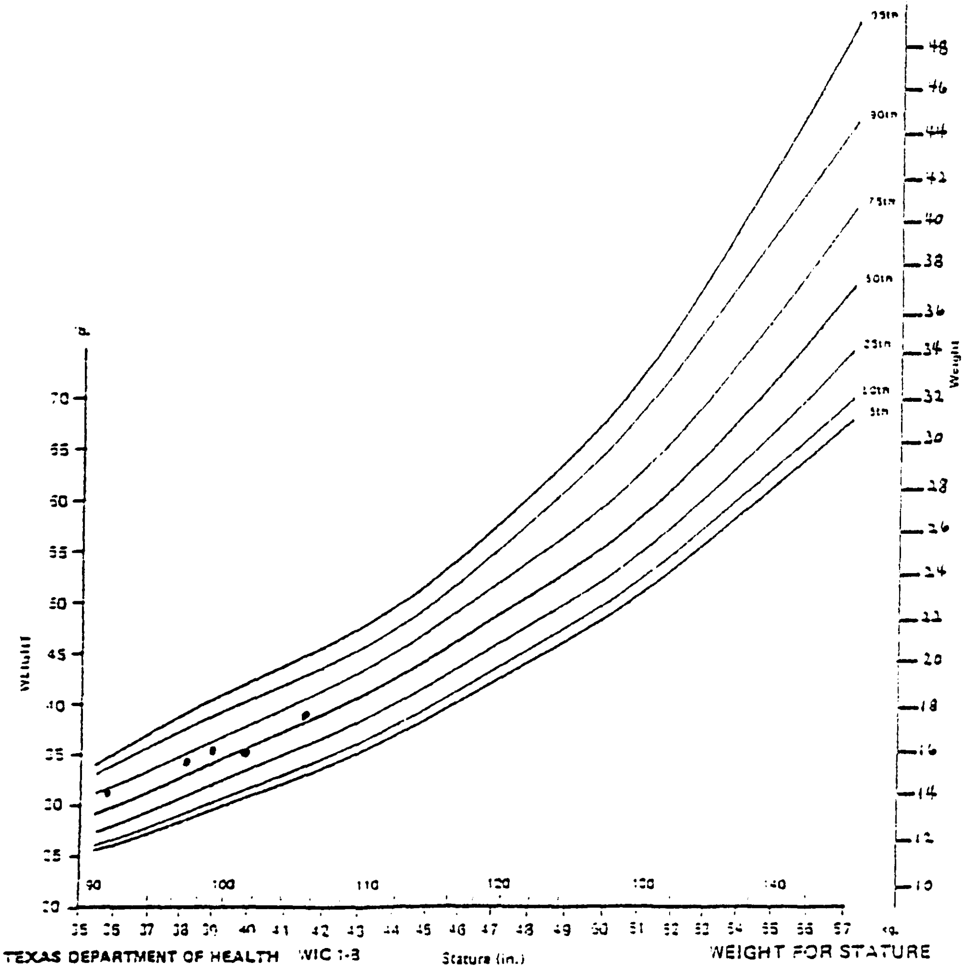


Fig. 13. Height and weight values for boys in the Fort Worth study from 2 to 5 years of age.

The differences between this study and the Berkeley *t*-test values for height, weight, and triceps skinfolds were statistically significant at the 0.05 level for the one year old, white males for height and weight, and six months old white females for weight. There was a significant difference for black six months old males for the triceps skinfold measurement, height for the two year old black males and the six months old black females for height and weight. In each of the measurements that showed significance for the Fort Worth population (see table 4), the mean values were smaller than the mean values of the Berkeley study.

TABLE 4

t-TEST VALUES FOR HEIGHT, WEIGHT AND TRICEPS SKINFOLDS BY AGE, RACIAL/ETHNIC ORIGIN AND SEX

Age, Racial/Ethnic Origin and Sex	t-Test Values			N-1
	Height	Weight	Triceps	
6 mo. White Male	-1.6636	-0.9090	-1.0000	9
6 mo. White Female	-2.1262	-2.8996*	-1.0959	15
6 mo. Black Male	-1.5115	-1.7915	3.2591*	29
6 mo. Black Female	-2.1893*	-3.3548*	1.7040	38
6 mo. Asian Male	. . . .**	. . . .**	. . . .**	. .**
6 mo. Asian Female	-2.5713	-1.7142	-0.2000	1
1 yr. White Male	-2.7079*	-2.3341*	0.1603	12
1 yr. White Female	0.4749	-0.7442	-1.0207	4
1 yr. Black Male	-0.2537	-0.8548	1.0973	15
1 yr. Black Female	0.2740	-0.3056	-0.1366	7
1 yr. Asian Male	-0.7323	0.4000	0.3000	1
1 yr. Asian Female	. . . .**	. . . .**	. . . .**	. .**
2 yr. White Male	-3.7748*	-2.8174	0.2191	3
2 yr. White Female	-3.4399	0.0457	1.8000	1
2 yr. Black Male	-1.3474	-2.6357*	1.2002	7
2 yr. Black Female	-1.3589	-0.5016	-0.1130	7
2 yr. Asian Male	. . . .**	. . . .**	. . . .**	. .**
2 yr. Asian Female	. . . .**	. . . .**	. . . .**	. .**
3 yr. White Male	. . . .**	. . . .**	. . . .**	. .**
3 yr. White Female	-2.1579	-1.1579	0.4333	1
3 yr. Black Male	-1.6172	-1.2236	1.3750	4
3 yr. Black Female	-0.8835	0.0000	1.0844	3
3 yr. Asian Male	. . . .**	. . . .**	. . . .**	. .**
3 yr. Asian Female	. . . .**	. . . .**	. . . .**	. .**
4 yr. White Male	-1.4129	-0.9539	1.6395	3
4 yr. White Female	-2.3699	-0.8219	1.7041	3
4 yr. Black Male	-0.8125	-0.5796	1.4807	5
4 yr. Black Female	-0.2252	0.3838	2.5033	7
4 yr. Asian Male	2.3078	-0.4286	-1.5000	1
4 yr. Asian Female	. . . .**	. . . .**	. . . .**	. .**

*$P \leq 0.05$: Fort Worth differs from Berkeley
**Insufficient data available

CHAPTER V

SUMMARY, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to establish criteria for a measurement of the nutritional assessment of children attending the neighborhood health clinics in Fort Worth, Texas, through the use of selected anthropometric measurements. The measurement of the skinfold will aid in the assessment of the subcutaneous body fat and caloric status.

The research questions of this study were as follows:

1. What are the averages for anthropometric measurements of height, weight, midarm circumference, and triceps skinfolds of children from six months to five years in age who are attending the Fort Worth neighborhood clinics?

2. Do the averages of the anthropometric measurements of the children attending the Fort Worth neighborhood clinics differ by age, sex and ethnic origin?

3. How do these findings (height, weight, midarm circumference, and triceps skinfolds) compare with those done in the Berkeley, California, study (Crawford, Hankin and Huenemann 1978)?

The children in the ten age groups were selected.

The age groups were 6 months, 1 year, 1½ years, 2 years, 2½ years, 3 years, 4 years, and 5 years. The children were divided by sex and racial/ethnic groups of black, white, Hispanic and Asian. Three anthropometric measurements were obtained. They were height, weight and triceps skinfold. No consistent pattern was found in the height, weight or triceps skinfold measurement by age, sex and racial/ethnic group.

Discussion

The children in the Berkeley study were primarily white while the children in the Fort Worth study were primarily Hispanic. In addition, the racial/ethnic groups in the Fort Worth sample were not similar to the racial/ethnic groups ordinarily seen in the Fort Worth neighborhood clinics. The distribution of children normally is 48 percent black, 35 percent Hispanic, 2 percent Asian and 15 percent white. The sample did not reflect these percentages.

Data were missing in many of the age categories for older children; in other categories the numbers were small. Over half of the population in the Fort Worth study were 6 months, 12 month and 18 months old; this distribution is due to the fact that immunizations are required at these ages thus more children in these age groups are presented in the clinics for health care. Again at age four, the number of children examined increased because the children were returning for booster immunizations.

Conclusions

No consistent pattern was found in the height, weight or triceps skinfold measurements by age, sex and racial/ethnic group. However, there was a statistically significant difference for one year old, white males for height and weight, and six month old white females for weight. There was also a significant difference for black six month old males for the triceps skinfold measurement, height for the two year old black males and the six month old black females for height and weight.

Even though a statistically significant difference was found between the samples, the findings for this study indicated that the children regardless of age, sex, and racial/ethnic backgroud, were all within the normal range when plotted on the National Center for Health Statistics (NCHS) growth curves.

Recommendations

Based on the findings of this study, the following recommendations are offered.

1. The study should be replicated utilizing a larger sample size in all age categories

2. A more typical racial/ethnic sample of the Fort Worth neighborhood population should be provided by stratifying the sample
3. A replication of the study with children of a differing population, such as another Public Health Agency in this area, should be done and the results compared to the results of the present study

APPENDICES

APPENDIX 1

COMMON MEASUREMENT ERRORS

Height	Feet not against wall Shoes not removed Head not in proper plane Back not against measure Block not brought down to crown of head
Length	Shoes not removed Head not in right place Foot board not brought up correctly
Weight	Scale inaccurate Infant wearing diaper Child wearing clothes Child is moving
Triceps skinfold	Mid-point incorrectly marked Caliper jaw at wrong site Reading done late Arm not loose by side
Arm circumference	Tape streches Mid-arm point incorrectly marked Arm not hanging by side Tape is too tight or loose
All measurements	Improperly trained personnel Reading and recording errors Equipment adjust improperly

APPENDIX 2

STAFF INSERVICE
ANTHROPOMETRIC MEASUREMENT

Arm Circumference and Triceps Skinfold Thickness

Time Frame: 2 hours 30 minutes

10 minutes Pretest

5 minutes <u>Introduction and motivation</u>

Brief discussion regarding:

1. Importance of anthropometric measurements in determining nutritional problems

2. Review of proper procedures for obtaining weight and heights

3. Primary reasons for nutritional assessment screening

4. Importance of proper techniques, correct readings and accurate recording of data

5 minutes Background: Discuss and list 5 points for using triceps skinfold (validity, simple, rapid, easily interpreted, can be used in clinic or field)

5 minutes Description of tape and skinfold caliper.

1. Tape: narrow, nonstretchable, flexible material made of steel or fiberglass.

2. Skinfold caliper: standard contact surface area or "pinch" area of 20-40 mm and exert a pressure of 10 gm/mm.

20 minutes Discussion of the site determination for locating the midpoint of the upper arm for mid-upper-arm circumference and triceps skinfold measurement.

15 minutes	Instructor will demonstrate procedure for locating the midpoint of the upper arm, measurement of the mid-upper-arm circumference and measurement of the triceps skinfold thickness.
60 minutes	Return demonstration by the staff. Distribute equipment, handouts and divide up into pairs. Practice on each partner with supervision of the instructor.
20 minutes	Summary: briefly stress importance of accurate reading and proper techniques. Ask for and answer any questions. State that the Clinic Supervisor and Nutritionist will rotate through all clinics to observe each staff member the next week.
10 minutes	Posttest

Locating Midpoint of Upper Arm Circumference

Instructions

1. The best site to measure the triceps skinfold and mid-upper-arm circumference is at the midway point of the right arm. The child's arm should be bent at the elbow at 90° angle, palm up. The infant's right hand or forearm should be gently restrained with the elbow flexed at 90° angle and the forearm pressed gently against the infant's abdomen. He should be held in the lap of the mother in a semi-upright position, his right side adjacent to but not touching her body, and his head facing forward.

2. Exact location is critical because the amount of subcutaneous fat increases from the elbow to the shoulder.

3. Marks are placed at the right acromial process of the scapula (bony protrusion on posterior of the upper shoulder) and the olecranon process of the below (bony point of the elbow).

4. The distance between these marks is measured with the tape and the midpoint marked.

5. The tape is placed around the arm, snug but not constricting the soft tissue. The reading is made as the arm hangs relaxed to the nearest 0.1 cm.

Triceps Skinfold Thickness

Instructions

1. Measurement is taken at the previously marked midpoint of the upper right arm, posterior side.

2. For children the measurement is made with the arm hanging free at the side. Infants should be held by the mother as described in the instruction for determining the midpoint.

3. At a side 1 centimeter above the midpoint mark, the examiner grasps the layer of skin and subcutaneous tissue with the first finger and thumb of one hand, pulling it away from the underlying tissue, and continues to hold it until the measurement is completed.

4. Readings should be made to the nearest 1.0 millimeter 2 to 3 seconds after aligning the lines.

5. Three readings should be taken and averaged.

PRE/POSTTEST

Anthropometric Measurement

INSTRUCTIONS:

1. Write your name on the answer sheet.

2. Do not write on the test.

3. When you have completed the test, please place both your answer sheet and test on the table in front of the room.

QUESTIONS:

1. The five reasons for using the tricep skinfold measurements are:

2. The type of tape that is preferred for arm circumference and midpoint measurement is:

3. When reading the skinfold caliper the reading should be made to _____mm approximately _____ seconds after application of the caliper.

4. When identifying the level of measurement of the triceps skinfold, marks are placed at three points:

5. What are the primary reasons for nutritional assessment screening:

ANSWER SHEET

PRE/POSTTEST

Anthropometric Measurement

ANSWERS:

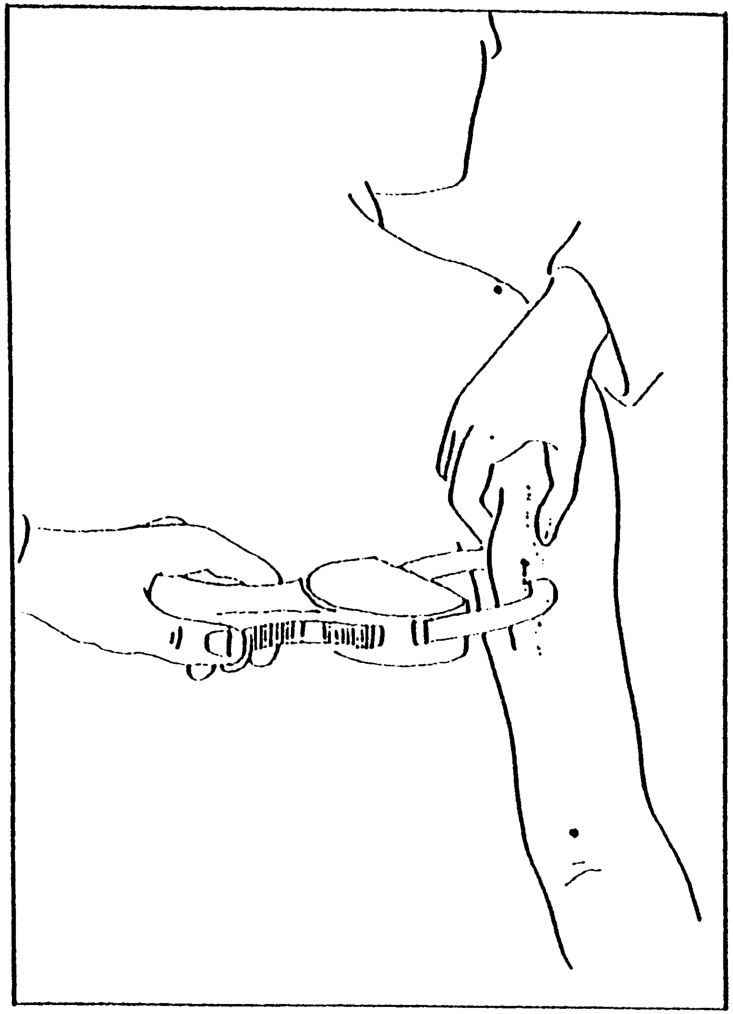
1. a. Validity
   b. Simple
   c. Rapid
   d. Easily interpreted
   e. Can be used in field or clinic

2. Non-stretchable material of fiberglass or steel

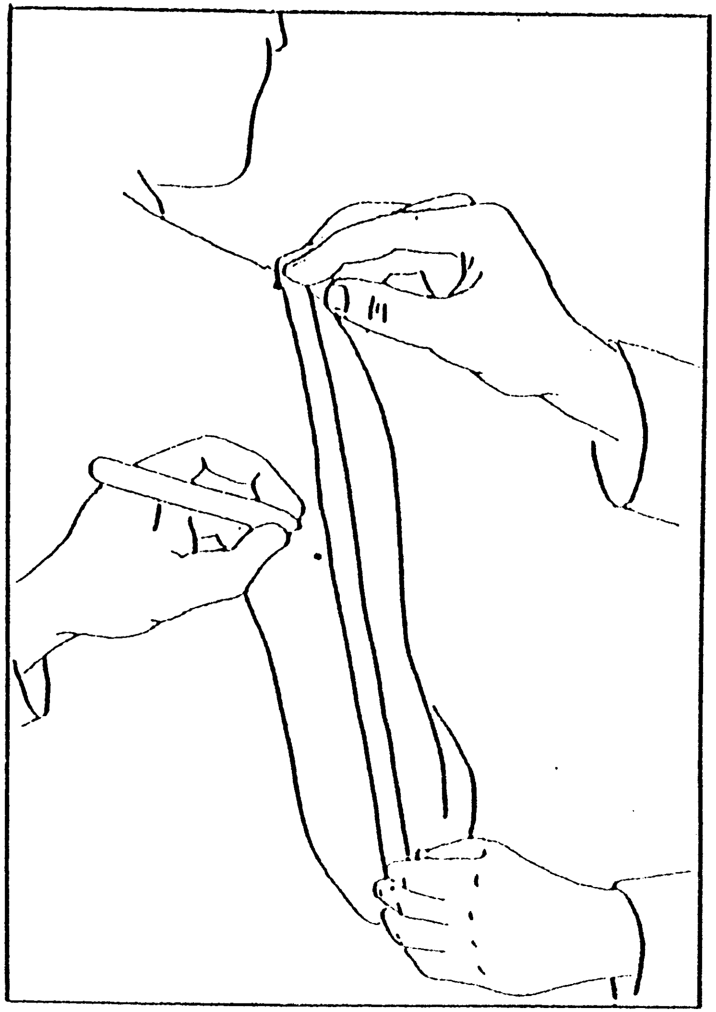
3. a. 1.0 mm
   b. 3 seconds

4. a. Acromion process
   b. Olecranon process
   c. Midpoint

5. a. Identification of individuals at nutritional risk
   b. Provide for intervention



Measurement of Triceps Skinfold



Locating Midpoint of Upper Arm

APPENDIX 3

DATA COLLECTION SHEET

Anthropometric Measurements

Date: Clinic:

Name	Birthdate	Age	Sex	Race	Height		Weight		Triceps Skinfold mm.	Midarm Circumference
					In.	cm.	lbs.	Kg.		

APPENDIX 4

PUBLIC HEALTH DEPARTMENT
1800 UNIVERSITY DRIVE
FORT WORTH, TEXAS 76107
870-7200 / AREA CODE 817

CITY OF FORT WORTH, TEXAS

February 1, 1979

To Whom It May Concern:

Mrs. Louella J. Williams has permission to use data for her thesis from the records of the Neighborhood Clinics of the Fort Worth Public Health Department.

APPROVED:

W. V. Bradshaw

W. V. Bradshaw, Jr., M.D.
Director, Department of Public Health

WVB:jw

BIBLIOGRAPHY

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Abraham, S., Lowenstein, F. W., and O'Connell, D. E. Preliminary findings of the first health and nutrition examination survey, United States 1971-1972: Anthropometric and clinical findings (U. S. Department of Health, Education, and Welfare Publication No. HRA 75-1229). Washington, D. C.: U. S. Government Printing Office, 1975.

The American Dietetic Association. Handbook of clinical dietetics. New Haven: Yale University Press, 1981.

Anthropometrics in nutritional assessment: Techniques and application. Nutrition & the M.D., May, 1979, 1-3.

Booth, R. A. D., Goddard, B. A., and Paton, A. Measurement of fat thickness in man: A comparison of ultrasound, Harpenden calipers and electrical conductivity. The British Journal of Nutrition, 1966, 20, 719-725.

Booyens, J., Luitingh, M., Edwards, H., and van Rensburg, C. F. W. J. Skinfold thickness measurements in assessment of nutritional status of Indian and white schoolchildren. South African Medical Journal, 1977, 52, 1044-1048.

Brans, Y. W., Summers, J. E., Dweck, H. S., and Cassady, G. A non-invasive approach to body composition in the neonate: Dynamic skinfold measurements. Pediatric Research, 1974, 8, 215-222.

Brook, C. G. D. Fat in the newborn. Archives of Disease in Childhood, 1979, 54, 845-848.

Brozek, J., and Keys, A. The evaluation of leanness-fatness in man: A survey of methods. Nutrition Abstracts and Reviews, 1950, 20, 247-256.

Brozek, J., and Keys, A. The evaluation of leaness-fatness in man: Norms and interrelationships. The British Journal of Nutrition, 1951, 5, 194-205.

Burgert, S. L., and Anderson, C. F. A comparison of triceps skinfold values as measured by the plastic McGaw caliper and the Lange caliper. The American Journal of Clinical Nutrition, 1979, 32, 1531-1533.

Burkinshaw, L., Jones, P. R. M., and Krupowicz, D. W. Observer error in skinfold thickness measurements. Human Biology, 1973, 45, 273-279.

Buzina, R., and Uemura, K. Selection of the minimum anthropometric characteristics to assess nutritional status. Advances in Experimental Medicine and Biology, 1974, 49, 271-285.

Caliendo, M. A. Nutrition and preventive health care. New York: Macmillan Publishing Company, 1981.

Chase, H. P., Kumar, V., Dobbs, J. M., Sauberlich, H. E., Hunter, R. M., Burton, R. S., and Spalding, V. Nutritional status of preschool Mexican-American migrant farm children. American Journal of Diseases of Children, 1971, 122, 316-324.

Chen, L. C., Chowdhury, A., and Huffman, S. Anthropometric assessment of energy-protein malnutrition and subsequent risk of mortality among preschool aged children. The American Journal of Clinical Nutrition, 1980, 33, 1836-1845.

Christakis, G. M. (Ed.). Nutritional assessment in health programs. American Journal of Public Health (Supplement), 1973, 63, (Part 2).

Coates, T. J., and Thoresen, C. E. Treating obesity in children and adolescents: A review. American Journal of Public Health, 1978, 68, 143-151.

Committee on Nutrition. Measurement of skinfold thickness in childhood. Pediatrics, 1968, 42, 538-543.

Crawford, P. B., Hankin, J. H., and Huenemann, R. L. Environmental factors associated with preschool obesity. Journal of the American Dietetic Association, 1978, 72, 589-596.

Crawford, P. B., Keller, C. A., Hampton, M. C., Pacheco, F. P., and Huenemann, R. L. An obesity index for six-month-old children. The American Journal of Clinical Nutrition, 1974, 27, 706-711.

Crispen, S., Kerry, E., Fox, H. M., and Kies, C. Nutritional status of preschool children. II. Anthropometric measurements and interrelationships. The American Journal of Clinical Nutrition, 1968, 21, 1280-1284.

Crook, G. H., Bennett, C. A., Norwood, W. D., and Mahaffey, J. A. Evaluation of skinfold measurements and weight chart to measure body fat. Journal of the American Medical Association, 1966, 198, 157-162.

Dauncey, M. J. and Gairdner, D. (Correspondence). Archives of Disease in Childhood, 1978, 53, 606-607.

Dauncey, M. J., Gandy, G., and Gairdner, D. Assessment of total body fat in infancy from skinfold thickness measurements. Archives of Disease in Childhood, 1977, 52, 223-227.

Dugdale, A. E., and Griffiths, M. Estimating fat body mass from anthropometric data. The American Journal of Clinical Nutrition, 1979, 32, 2400-2403.

Durnin, J. V. G. A., and Rahaman, M. M. The assessment of the amount of fat in the human body from measurements of skinfold thickness. The British Journal of Nutrition, 1967, 21, 681-689.

Edwards, D. A. W., Hammond, W. H., Healy, M. J. R., Tanner, J. M., and Whitehouse, R. H. Design and accuracy of calipers for measuring subcutaneous tissue thickness. The British Journal of Nutrition, 1955, 9, 133-143.

Eid, E. E. Follow-up study of physical growth of children who had excessive weight gain in first six months of life. British Medical Journal, 1970, 2, 74-76.

el Lozy, M. Measuring malnutrition. The Lancet, 1974, 2, 175.

________. Programmable calculators in the field assessment of nutritional status. The American Journal of Clinical Nutrition, 1978, 31, 1718-1719.

Ferris, A. G., Beal, V. A., Laus, M. J., and Hosmer, D. W. The effect of feeding on fat deposition in early infancy. Pediatrics, 1979, 64, 397-401.

Flynn, M. A., Murthy, Y., Clark, J., Comfort, G., Chase, G., and Bentley, A. E. T. Body composition of Negro and white children. Archives of Environmental Health, 1970, 20, 604-607.

Foman, S. J. Infant nutrition (2nd ed.). Philadelphia: Saunders Company, 1974.

________. Nutritional disorders of children (U. S. Department of Health, Education, and Welfare Publication No. HSA 76-5612). Washington, D. C.: U. S. Government Printing Office, 1976.

Forbes, G. B., Gallup, J. and Hursh, J. B. Estimation of of total body fat from potassium-40 content. Science, 1961, 133, 101-102.

Frankle, R. T., and Owen, A. Y. Nutrition in the community. Saint Louis: Mosby Company, 1978.

Frisancho, A. R. Triceps skin fold and upper arm muscle size norms for assessment of nutritional status. The American Journal of Clinical Nutrition, 1974, 1971, 24, 541-546.

Funk & Wagnalls New Comprehensive International Dictionary of the English Language, encyclopedic ed. (1973), s. v. "anthropometry."

Garn, S. M. Anthropometry in clinical appraisal of nutritional status. The American Journal of Clinical Nutrition, 1962, 11, 418-431.

Garn, S. M. and Clark, D. C. Problems in the nutritional assessment of Black individuals. American Journal of Public Health, 1976, 66, 262-267. (a)

Garn, S. M. and Clark, D. C. Trends in fatness and the origins of obesity. Pediatrics, 1976, 57, 443-456. (b)

Garn, S. M. and Cole, P. E. Do the obese remain obese and the lean remain lean? American Journal of Public Health, 1980, 70, 351-353.

Garn, S. M. and Haskell, J. A. Fat thickness and developmental status in childhood and adolescence. A.M.A. Journal of Diseases of Children, 1960, 99, 746-751.

Garn, S. M., Owen, G. M., and Clark, D. C. The question of race differences in stature norms. Ecology of Food and Nutrition, 1974, 3, 319-320.

Garn, S. M., Rosen, N. N., and McCann, M. B. Relative values of different fat folds in a nutritional survey. The American Journal of Clinical Nutrition, 1971, 24, 1380-1381.

Garn, S. M., Sandusky, S. T., Nagy, J. M., and McCann, M. B. Advanced skeletal development in low-income Negro children. Journal of Pediatrics, 1972, 80, 965-969.

Goodhart, R. S. and Shils, M. E. Modern Nutrition in Health and Disease (5th ed.). Philadelphia: Lea & Febiger, 1973.

Grant, A. Nutritional assessment: Guidelines for dietitians (2nd ed.). Snohomish, Washington: Snohomish Publishing Company, 1979.

Gray, G. E. and Gray, L. K. Anthropometric measurements and their interpretation: Principles, practices, and problems. Journal of the American Dietetic Association, 1980, 77, 534-539.

Gurney, J. M., and Jelliffe, D. B. Arm anthropometry in nutritional assessment: Nomogram for rapid calculation of muscle circumference and cross-sectional muscle and fat areas. The American Journal of Clinical Nutrition, 1973, 26, 912-915.

Guthrie, H. A., Owen, G. M., and Guthrie, C. M. Factor analysis of measures of nutritional status of preschool children. The American Journal of Clinical Nutrition, 1973, 26, 497-502.

Hamill, P. V. V., Drizd, T. A., Johnson, C. L., Reed, R. B., Roche, A. F., and Moore, W. M. Physical growth: National center for health statistics percentiles. The American Journal of Clinical Nutrition, 1979, 32, 607-629.

Hamill, P. V. V., and Moore, W. M. Contemporary growth charts: Needs, construction, and application. Dietetic Currents, 1976, 3, 21-24.

Hammer, S. L. Obesity: Early identification and treatment. Pediatric Annals, 1975, 4, 250-257.

Hammond, W. H. Body measurements of preschool children. Nutrition Abstracts and Reviews, 1956, 26, 455.

Hawk, L. J., and Brook, C. G. D. Influence of body fatness in childhood on fatness in adult life. British Medical Journal, 1979, 1, 151-152.

Healthy people: The surgeon general's report on health promotion and disease prevention (U. S. Department of Health, Education, and Welfare Publication No. PHS 79-55071). Washington, D. C.: U. S. Government Printing Office, 1979.

Himes, J. H., Roche, A. F., and Siervogel, R. M. Compressibility of skinfolds and the measurement of subcutaneous fatness. The American Journal of Clinical Nutrition, 1979, 32, 1734-1740.

Hirsch, J. The adipose-cell hypothesis. The New England Journal of Medicine, 1976, 295, 389-390.

Hirsch, J., and Knittle, J. L. Cellularity of obese and nonobese human adipose. Federation Proceedings, 1970, 29, 1516-1521.

Huenemann, R. L. Environmental factors associated with preschool obesity. Journal of the American Dietetic Association, 1974, 64, 480-487.

Infant body composition of skinfold measurements. Nutrition Reviews, 1975, 33, 7-9.

Jelliffe, D. B., and Jelliffe, E. F. P. Midarm muscle volume: A suggestion. The American Journal of Clinical Nutrition, 1979, 32, 2170-2172. (a)

Jelliffe, D. B., and Jelliffe, E. F. P. Underappreciated pioneers Quetelet: Man and index. The American Journal of Clinical Nutrition, 1979, 32, 2519-2521. (b)

Jenicek, M., and Demirjian, A. Triceps and subscapular skin-fold thickness in French-Canadian school-age children in Montreal. The American Journal of Clinical Nutrition, 1972, 25, 576-581.

Johnston, F. E., and Bellar, A. Anthropometric evaluation of the body composition of black, white, and Puerto Rican newborns. The American Journal of Clinical Nutrition, 1976, 29, 61-65.

Johnston, F. E., Dechow, P. C., and MacVean, R. B. Age changes in skinfold thickness among upper class school children of differing ethnic backgrounds residing in Guatemala. Human Biology, 1975, 47, 251-262.

Johnston, F. E., and Mack, R. W. Obesity in urban black adolescents of high and low relative weight at 1 year of age. American Journal of Diseases of Children, 1978, 132, 862-864.

Johnston, F. E., McKigney, J. I., Hopwood, S., and Smelker, J. Physical growth and development of urban native Americans: A study in urbanization and its implications for nutritional status. The American Journal of Clinical Nutrition, 1978, 31, 1017-1027.

Kamath, S. Nutritional assessment. In L. Malasanes, V. Barkauskas, M. Moss, and K. Stoltenberg-Allen, Health assessment. Saint Louis: Mosby Company, 1077.

Kanawati, A. H. Assessment of nutritional status in the community. In D. S. McLaren (Ed.), Nutrition in the community. New York: Wiley & Sons, 1976.

Keet, M. P., Hansen, J. D. L., and Truswell, A. S. Are skinfold measurements of value in the assessment of suboptimal nutrition in young children? Pediatrics, 1970, 45, 965-972.

Keller, W., Donoso, G., and DeMaeyer, E. M. Anthropometry in nutritional surveillance: A review based on results of the WHO collaborative study on nutritional status. The American Journal of Clinical Nutrition, 1976, 46, 591-604.

Keyes, A., and Brozek, J. Body fat in man. Physiological Reviews, 1953, 33, 245-325.

Krause, M. V., and Mahan, L. K. Food, nutrition and diet therapy (6th ed.). Philadelphia: Saunders Company, 1979.

Laditan, A. A. O., and Ayeni, O. Measurements of skinfold thickness and musculature in the assessment of growth and nutritional status of malnourished children. Journal of Human Nutrition, 1977, 31,

Lowenstein, F. W. Preliminary clinical and anthropometric findings from the first health and nutrition examination survey, USA, 1971-1972. The American Journal of Clinical Nutrition, 1976, 29, 918-927.

Mack, R. W., and Johnston, F. E. Height, skeletal maturation and adiposity in adolescents with high relative weight at one year of age. Annals of Human Biology, 1979, 6, 77-83.

Malina, R. M., Habicht, J.-P., Yarbrough, C., Martorell, R., and Klein, R. E. Skinfold thicknesses at seven sites in rural Guatemalan Ladino children birth through seven years of age. Human Biology, 1974, 46, 453-469.

Martin, E. A. and Beal, V. A. Roberts' nutrition work with children (4th ed.). Chicago: University of Chicago Press, 1978.

Martorell, R., Habicht, J.-P., Yarbrough, C., Guzman, G., and Klein, R. E. The identification and evaluation of measurement variability in the anthropometry of preschool children. American Journal of Physical Anthropology, 1975, 43, 347-352.

Martorell, R., Yarbrough, C., Lechtig, A., Delgado, H., and Klein, R. E. Upper arm anthropometric indicators of nutritional status. The American Journal of Clinical Nutrition, 1976, 29, 46-53.

McLaren, D. S. Nutrition in the community. New York: John Wiley and Sons, 1976.

McLeish, D., Rueckl, A. E., and Sondel, S. (Eds.). Nutrition screening and assessment manual. Madison: Wisconsin Department of Health, 1978.

Mitchell, H. S., Rynbergen, H. J., Anderson, L., and Dribble, M. V. Nutrition in health & disease (16th ed.). New York: Lippincott Company, 1976.

Montoye, H. J., Epstein, F. H., and Kjelsberg, M. O. The measurement of body fatness. The American Journal of Clinical Nutrition, 1965, 16, 417-427.

Nichaman, M. A. Developing a nutritional surveillance system. The Journal of the American Dietetic Association, 1974, 65, 15-17.

Oakley, J. R. Differences in subcutaneous fat in breast- and formula-fed infants. Archives of Disease in Childhood, 1977, 52, 79-80.

Oakley, J. R., Parsons, R. J., and Whitelaw, G. L. Standards for skinfold thickness in British new-born infants. Archives of Disease in Childhood, 1977, 52, 287-290.

Obert, J. C. Community nutrition. New York: John Wiley, 1978.

Oliveria, M. P. M. S., and Azevedo, E. S. Racial differences in anthropometric traits in school children of Bahia, Brazil. American Journal of Physical Anthropology, 1977, 46, 471-476.

Overfeeding in the first year of life. Nutrition reviews, 1973, 31, 116-118.

Owen, G. M. The assessment and recording of measurements of growth of children: Report of a small conference. Pediatrics, 1973, 51, 461-465.

Owen, G. M., Kram, K. M., Garry, P. J., Lowe, J. E., and Lubin, A. H. A study of nutritional status of preschool children in the United States, 1968-1970. Pediatrics (Supplement), 1974, 53, 597-646.

Owen, G. M., and Lippman, G. Nutritional status of infants and young children: U. S. A. Pediatric Clinics of North America, 1977, 24, 211-227.

Owen, G. M., and Lubin, A. H. Anthropometric differences between black and white preschool children. American Journal of Diseases of Children, 1973, 126, 168-169.

Parizkova, J., and Roth, Z. The assessment of depot fat in children from skinfold thickness measurement by Holtain (Tanner/Whitehouse) caliper. Human Biology, 1972, 44, 613-620.

Pett, L. B., and Ogilvie, G. F. The Canadian weight-height survey. Human Biology, 1956, 28, 177-188.

Pike, R. L., and Brown, M. L. Nutrition: An integrated approach (2nd ed.). New York: John Wiley, 1975.

Pipes, P. L. Nutrition in infancy and childhood. Saint Louis: Mosby Company, 1977.

Preliminary findings of the first health and nutrition examination survey, United States, 1971-1972: Anthropometric and clinical findings (U. S. Department of Health, Education, and Welfare Publication No. HRA 75-1229). Washington, D. C.: U. S. Government Printing Office, 1975.

Roa, K. V., and Singh, D. An evaluation of the relationship between nutritional status and anthropometric measurements. The American Journal of Clinical Nutrition, 1970, 23, 83-93.

Roa, D. H., Vijayaraghavan, K., and Sastry, J. G. A comparison of skinfold measurements by Harpenden and Best calipers. Annals of Human Biology, 1974, 1, 443-446.

Roberts, S. L. Nutrition assessment manual. Iowa City: University of Iowa Hospitals and Clinics, 1977.

Robinson, C. H., and Lawler, M. R. Normal and therapeutic nutrition (15th ed.). New York: Macmillan, 1977.

Ruiz, L., Colley, J. R. T., and Hamilton, P. J. S. Measurements of triceps skinfold thickness an investigation of sources of variation. British Journal of Preventive & Social Medicine, 1971, 25, 165-167.

Sanchez, C. L., and Jacobson, H. N. Anthropometry measurements, a new type. The American Journal of Clinical Nutrition, 1978, 31, 1116-1117.

Seltzer, G. C., and Mayer, J. Greater reliability of the triceps skin fold over the subscapular skin fold as an index of obesity. The American Journal of Clinical Nutrition, 1967, 20, 950-953.

Shakir, A., and Morley, D. Measuring malnutrition. The Lancet, 1974, 1, 749-759.

Shephard, R. J., Jones, G., Ishii, K., Kaneko, M., and Olbrecht, A. J. Factors affecting body density and thickness of subcutaneous fat. The American Journal of Clinical Nutrition, 1969, 22, 1175-1189.

Skinfold thickness and body fat. Nutrition reviews, 1968, 26, 104-107.

Talwar, P. P. Developing indices of nutritional level from anthropometric measurements on women and young children. American Journal of Public Health, 1975, 65, 1170-1174.

Tanner, J. M., and Whitehouse, R. H. Standards for subcutaneous fat in British children. British Medical Journal, 1962, 1, 446-450.

Tanner, J. M., and Whitehouse, R. H. Revised standards for triceps and subscapular skinfolds in British children. Archives of Disease in Childhood, 1975, 50, 142-145.

Ten state nutrition survey, 1968-1970 (U. S. Department of Health, Education, and Welfare Publication No. HSM 72-8130). Washington, D. C.: U. S. Government Printing Office, 1972.

vant Hof, M. A., and Kowalski, C. J. Construction of growth standards from mix-longitudinal data. Human Biology, 1977, 49, 593-603.

Vijayaraghavan, K., Singh, D., and Swaminathan, M. C. Arm circumference and fat fold at triceps in well-nourished Indian school children. Indian Journal of Medical Reserach, 1974, 62, 994-1001.

Well, W. B. Medical progress--current controversies in childhood obesity. The Journal of Pediatrics, 1977, 91, 175-187.

Whitelaw, A. Infant feeding and subcutaneous fat at birth and at one year. The Lancet, 1977, 2, 1098-1099.

Winegard, J., Solomon, I. L., and Schoen, E. J. Parent-specific height standards for preadolescent children of three racial groups, with method for rapid determination. Pediatrics, 1973, 52, 555-560.

Zerfas, A. J. The insertion tape: A new circumference tape for use in nutritional assessment. The American Journal of Clinical Nutrition, 1975, 28, 782-787.

Zerfas, A. J., and Neumann, C. G. Office assessment of nutritional status. Pediatric Clinics of North America, 1977, 24, 253-272.