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ABSTRACT

This study investigated (1) the nutritional status of urban American disadvantaged children, (2) the relationship of nutritional status to mental growth and development, (3) the relationship of physical maturation to the development of perceptual-motor factors of intelligence, and (4) if found, the effects of undernutrition on intellectual achievement and physical development. Subjects were 60 Detroit 5-year-olds, half of whom were disadvantaged. Sex and race were also controlled in the sample. Results showed few, if any, nutritional deficiencies. Negro children appeared slightly taller and heavier as a group when compared to the norms of Caucasian children measured over 3 decades ago. With the exception of a marked positive correlation between height and psychological performance test scores in boys, no relationship between physical measures and intelligence test scores was found. It was felt that if a nutritional deficiency existed in the children, it was at a level that permitted physiological adaptation by the child so that growth was not appreciably affected. Re-examination of the data is suggested, since results imply that other factors exert a more profound influence on mental development in the children studied than do nutritional and physical growth variables, per se. (Author/DR)

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NUTRITION AND MENTAL DEVELOPMENT

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The clinical effects of undernutrition in children, manifested in delayed physical growth and maturation, have been well-documented in the nutritional literature. Recently, however, studies of protein and calorie-undernourished children in underdeveloped countries have revealed alterations in intellective functioning as well as the classic physical manifestations. Treatment by long-term dietary improvement programs apparently produces remission of the physical symptoms, but in many instances there is not a concomitant improvement of the mental capacities of these children. Their intellectual, psychological and neuromuscular capacities are found to be 10 to 25 per cent below those of normal children (1) (2) (3).

These studies are but a small sample of the rapidly-expanding body of literature on the relationship of nutritional status to intellectual functioning. The studies to which this body of literature refers, however, have all been conducted with severely undernourished children in developing countries. The importance of conducting such studies with the disadvantaged child in this country has been pointed out (4) (5).

This current study is focused on the interactions of anthropometric, biochemical, dietary, and perceptual-motor variables. More specifically, these are the questions: What is the nutritional status of urban American disadvantaged children? What is the relationship of nutritional status to mental growth and development? If undernutrition is found will it be reflected in delayed intellectual achievement as well as retarded physical development? What is the relationship of physical maturation to the development of perceptual-motor factors of intelligence? Is the lower intellectual capacity of disadvantaged children related to undernutrition as well as to psychosocial environmental factors?

Urban American five-year-old children were the population studied. The original sample consisted of 240 Detroit five-year-olds, half of whom were disadvantaged children. Sex and race were also to be controlled in the sampling. The original eight-celled sampling design called for thirty children per cell. The limitations on research funds during the first year necessitated a re-appraisal of the design and procedure to meet budgetary restrictions.

First, we concentrated data collection on the disadvantaged Negro children of both sexes. This was not an arbitrary decision but reflected an expressed need for nutritional appraisal of these children (6). We also felt that concentrating on children of one race would afford us the opportunity of examining the feasibility of utilizing existing normative data for evaluation which we subsequently found to be feasible.

Second, we decided to hold in abeyance the biochemical evaluations because of the relatively large cost of these appraisals. We felt that although no definitive judgments would be rendered regarding the nutritional status of the children without biochemical appraisal, the anthropometric measurements and dietary intake data would reveal gross nutritional inadequacies and point out future direction.

The sample of children studied during the first year were selected from client lists of families having four to five-year-old children who were registered at PRESCAD, an agency which offers health services to children of disadvantaged families either free or on a reduced cash basis. Two hundred and fifty families met our research standards for family income level and mother-father educational level. Letters, telephone calls, home visits, and the provision of transportation resulted in the participation of 22 families out of the 250 contacted. This year (1969) families were reached through the Archdiocese Opportunity Program (Head Start). By arranging free admission to a local amusement park for participating families, the 38 children necessary to complete the sample of 60 (30 males, 30 females) were recruited. Data collection was completed on August 15, 1969.

The presentation of the data has been divided into four sections: (1) Anthropometry, (2) dietary assessments, (3) biochemical studies, and (4) psychological appraisal. Each section includes details of the methodology employed, a critique on the procedure, and presentation of results and discussion of each measure.

Anthropometry

Methodology:

All of the physical measurements were made by the same professional on the children in stocking feet without sweater or outdoor clothing. The following were the procedures used:

(a) Height and Weight. Two measurements of height were recorded to the nearest sixteenth of an inch and averaged together according to the method outlined by Jeliffe (7). Weight was measured to the nearest ounce on a beam balance scale.

(b) Skinfold Thickness. The Lange skinfold calipers were used on the left arm to assess upper arm (triceps) skinfold according to the method described by the Committee on Nutritional Anthropometry (8).

(c) Head Circumference. A flexible steel measuring tape was applied over the maximum circumference of the head (over the glabella and supraorbital ridges anteriorly and the occiput posteriorly).

(d) Skeletal Assessment. One X-ray of the left hand and wrist for each child was taken using the precautions for subjects outlined by Garn (9) to minimize exposure.

Discussion

Nutritional and other environmental factors as well as family-line heredity and race have been shown to have significant influences on height and weight

(10) (11) (12). Family line heredity as a growth-influencing factor can be held constant by obtaining measurements of both parents (13). For our sample, however, this step would present an almost insurmountable obstacle, since over half of the children taking part in our study were members of one parent families. Disadvantaged urban Negro families have been shown to lack biological fathers as a consistent family member (14).

Studies of differences in height and weight of American Negro and Caucasian children apparently can be attributed to a large degree on environment rather than race according to Meredith (15) and Scott (16). It would appear, therefore, that the use of normative data drawn from representative samples will provide valid yardsticks for assessing the nutritional adequacy of a deprived population. Figures one through four show the heights and weights of the children studied plotted against two sets of percentile values derived from two groups of children drawn from different socioeconomic backgrounds. The "Boston" percentiles are based on repeated measurements of a group of Caucasian children belonging to families of the lower economic brackets, but having regular health supervision and free from important defects or chronic disease. These children were of North European descent and lived in or near Boston. The "Iowa" percentiles, on the other hand, represent measurements of children who might be classified as an advantaged population since they come predominantly from families in the managerial and professional classes. These children were all of Northwest European descent (17).

Figure 1 compares the height measurements of the boys who participated in our study with the percentiles of heights of the Boston and Iowa norms. This comparison reveals that the distribution of height brackets the range of percentiles of both normative series, the shortest boy falling below the third percentile while the tallest boy is above the 97th percentile of both sets of norms with the measurements of the other children having positions scattered throughout the percentile ranks. The heights of eleven boys were below the 50th Boston percentile, while nineteen were above. The mean value for height of our sample (43.3) lies between the 50th and 75th percentile of the "Boston" children.

The weight distributions of the boys in our sample range from above the third percentile to above the 97th percentile of the "Boston" norms as shown in Figure 2. Thirteen boys are below the 50th "Boston" percentile; seventeen are above. The median value (42.30 pounds) lies between the 50th and 75th percentile. Comparing the boys in our study to the "Iowa" children reveals a similar percentile distribution except that, as might be expected, the boys in our sample are slightly shorter and weigh slightly less than the advantaged "Iowa" children. The mean height of our sample (43.3 inches) lies below the 50th percentile by half an inch, and the median weight of our boys (42.30 pounds) lies below the 50th percentile by half a pound.

The heights and weights of the girls in our sample presented in figures three and four demonstrate essentially the same picture of percentile distribution as the boys in our study. The mean value for height (43.1 inches) and the median for weight (41.5 pounds) of the girls are above the 50th "Boston" percentile. The mean value for height is one tenth of an inch below the 50th "Iowa" percentile but the median for weight is above the 50th "Iowa" percentile. This last finding is rather interesting in view of the layman's stereotyped perception of a disadvantaged child as being thin to the point of emaciation and short in stature, almost to the point of dwarfishness.

Thus, the height and weight measurements of our sample of disadvantaged children are well within the range of the currently accepted norms. Indeed, the percentile distributions closely approximate those of the "advantaged" children. The six differences found in our preliminary study are minimized, but the girls still appear to be very slightly taller and heavier than the boys which is in agreement with other studies (18).

In Kwashiorkor, an extreme form of protein-calorie undernutrition occurring in early childhood, weight is proportionately more affected than height (19) (20) (21). A most zealous search for incidence of undernutrition on our sample therefore might lead us to consider the use of other standards for evaluating the weight of those children in our sample whose weight falls below the 10th "Boston" percentile for their age. But it is here that we are faced with the issue of what standard should be used to designate a judgment of undernutrition from one cross-sectional measurement of a population since several have been suggested (7) (22) (23) (24) (25).

Arbitrarily selecting Jeliffe's criterion (68 per cent of average weight) as one yardstick for determining malnutrition in our population, it is of interest to note that none of the fifteen children (nine girls and six boys) whose weight is below the 25th percentile of the "Boston" norms even remotely approaches the weight level suggested by Jeliffe as indicative of malnutrition.

The lightest boy in our sample who weighs 34.7 pounds is 6.2 pounds heavier than the proposed standards for diagnosing malnutrition (28.5). Similarly, the weight of the lightest girl in our study is 8.3 pounds above the "malnutrition" level.

We have thus far examined in detail the lower end of the weight distribution of our sample for undernutrition. However, pediatric concerns with problems of overnutrition (26) coupled with the finding that obesity in adults is more common in the lower socioeconomic groups (27) emphasize the importance of including an evaluation of our children for the amount of subcutaneous fat to complete the nutritional picture. The data on skinfold thickness assume particular relevance in this respect since this measure has been proposed as a criterion of obesity (28). It will be noted from Figs. 2 and 4 that eight boys and five girls were above the 90th "Boston" percentile in weight. However, of these children only one boy had a triceps skinfold measurement above 12 mm. which is indicative of obesity (28).

Because smaller head circumferences have been found to be associated with undernutrition and also intelligence test performance in the severely undernourished young child (1) (2) (30) and mental retardation (32), this measurement would seem of particular import for our study. Using the norms compiled by Nellhaus (31), which represent composite international and interracial graphs and closely approximate the values of the "Boston" norms, the distribution of head circumference measurements of our sample of children were within plus and minus two standard deviations with the exception of two boys. The mean value for the boys in our study matched that proposed by Nellhaus (20.20 inches) as did that of the girls (19.9). From our point of view this is a predictable result since head circumference was inferred to be related to stature by earlier studies in the 1920's and 30's. We feel that because of renewed recent interest in this area, a more detailed pursuit of possible relationship between head circumference and stature is in order.

While assessments of nutritional status usually include measurements of the external dimensions of body size, it was also of interest to us to assess skeletal age which is known to be retarded by chronic malnutrition (33) (34).

The methodology used for skeletal assessments of our population was as follows:

X-rays of the left hands were assessed according to the methodology developed by Greulich and Pyle (35), with a slight modification. One age was assigned to each group of phalanges rather than to each separate phalanx. That is to say, the five distal phalanges were assigned one skeletal age; the four middle phalanges were assigned one skeletal age, and the proximal phalanges were assigned one skeletal age.

The resulting skeletal assessments of the children who participated in our study were compared to means and standard deviations derived by Stuart and his associates in the Department of Maternal and Child Health at the Harvard School of Public Health in Boston (35).

The skeletal ages of the girls are distributed between plus three and minus three standard deviations of the "Boston" norms and have a mean skeletal age of 57.9 months which is below the "Boston" mean of 58.1 months by only 0.2.

The skeletal ages of the boys show a similar pattern of distribution with a mean skeletal age of 58.14, which is 1.9 months above the "Boston" mean. The wide range of skeletal age (32 to 75 months in girls and 38 to 77 months in boys) suggests a more detailed examination of the children whose skeletal ages are located at the extremes of the distribution is in order. This should further highlight the incidence of over- or undernutrition in our sample. The extent and disparity of height and weight within normal growth channels are regarded as discriminators of genetic and nutritional influences on growth (36). By employing this approach we feel it is possible to pinpoint growth failure or accelerated maturation which has been shown to be related to overnourishment (37).

It should be emphasized here that these judgments are based on assessments of X-rays for purposes of rapid determination of skeletal age. We feel that a more detailed skeletal assessment is warranted. Specifically differential analysis of the X-rays for cortical bone thickness, lines of arrested growth, and separation of the bones of the hand into distinct groups for assessments of skeletal age would seem to be suggested by other detailed investigations of skeletal assessments of undernourished children (38) (39) (40) (41).

All of our measurements of the body size of the Negro disadvantaged children studied thus seem to point rather surprisingly to a child who is slightly taller and heavier than his lower middle-class "disadvantaged?" Caucasian counterpart. The index of physical maturation (skeletal age assessment) used revealed progress that was consistent with the measurements of external body dimensions. As a group, the children in our study did not exhibit gross nutritional inadequacies. Not only were all of the physical measures of our children bracketed within the ranges of measurements of children who were known not to have dietary inadequacies but also the mean and median height and weight values approached those of "advantaged" Caucasian children.

Two explanations may account for these findings. First, our children may be exhibiting evidence of secular change so that generational increments in height and weight due to improved health conditions are reflected in larger body builds than children measured three generations ago (18). A second hypothesis suggested by the data is that a nutritional threshold is in operation. Our children may be experiencing food intakes that are "borderline" so that the child is able to adapt physiologically and thus growth discrepancies are not apparent. The dietary and laboratory data presented in the following sections will help to shed some light on these issues.

Dietary Assessment

To obtain the data on food intake, a nutritionist conducted individual interviews with the mother while her child was being given the psychological tests in an adjacent room. These interviews varied from thirty minutes to an hour in length. The instrument used was our revision of the interview schedule published by the Children's Bureau (42).

Each child's dietary intake for one day was calculated only from Form A - 24 Hour Recall, since our preliminary results indicated that there were no significant differences between the mean values of nutrients obtained from Form A and Form B Dietary History.

The mean values for each nutrient are presented in Table 2. Before commenting on the results, however, we should like to preface the discussion with some observations pertaining to the dynamics of the interview, the content of the interview schedule, and the relationship between the anthropometric and dietary intake data which we feel influence the interpretation.

At both extremes of nutrient intake, the anthropometric data exhibited little if any relationship to the values calculated from the reported food intake. At the lowest end of the spectrum, the dietary intake of Case #105, a girl, was reported to contain less than fifty per cent of the Recommended Dietary Allowances (RDA) for calories, calcium, iron, ascorbic acid, thiamine, riboflavin, and niacin. The ascorbic acid level reported was less than eight per cent of the RDA. Protein intake, the only nutrient approaching the level of the RDA, was reported at sixty-two per cent of the allowances. In most studies, levels of nutrient intake below two-thirds of the recommended allowances are regarded as indicative of undernutrition. One might assume, therefore, that there would be evidence of severe growth failure. However, no such assumption could be substantiated from the anthropometric data. Both height and weight measurements of this child were between the 25th and 50th "Boston" percentiles. The skeletal age was assessed at fifty-eight months.

At the opposite extreme, the dietary data reported for subject 11, a boy, ostensibly supports a judgment of overnutrition. Nutrient calculations for protein, calories, iron, and the vitamins revealed an intake that ranged from one and a half to two and one-half times the recommended allowances. Calcium was calculated as one and one-third of the RDA. The anthropometric data collected, however, confirmed no such picture of overnutrition. This child's weight lay between the 10th and 25th percentile of the "Boston" norms and was between the 3rd and 10th percentile for height. The skeletal age was 53.5 months.

In addition, many problems were encountered in interviewing the mothers. Very often mothers had difficulty remembering exactly what the child being studied had eaten and what his food habits were. This was particularly true of mothers who had four or more children. They also found it hard to estimate food amounts, even when dishes and tableware used with other groups to help in the discrimination of size of servings were shown to them. In a few instances poor responses seemed to be due to apathy. In other interviews, the reverse was felt to be true. The mothers were so anxious to cooperate that they gave answers that they thought would be the "right" ones, rather than the true ones. It sometimes was impossible for the mothers to answer questions accurately: children often spent the daytime hours with and were fed by other people; fathers out of work and on strike could not provide food money; separated parents fed children on different days; emotional problems within the family restricted children's appetites.

All of the concerns that we have raised regarding the validity of the dietary intake data make a precise and definitive evaluation questionable. In addition, the question of which criterion to use to judge dietary adequacy and how this criterion should be employed have not yet been precisely resolved. With samples of population in this country, the Recommended Dietary Allowances of the Food and Nutrition Board of the National Academy of Sciences, National Research Council are the criterion used by most investigators. However, there are differing opinions among investigators regarding a diagnosis of nutritional insufficiency since the RDA are not recommendations for minimum nutrient intake. It is most generally agreed that food intakes yielding nutrients below two-thirds of the RDA are judged inadequate (43), although opinions vary from total uselessness of the RDA as a criterion of adequate nutrition (44) to the requirement that the total allowances for all of the nutrients should be met to substantiate a judgment of optimum nutrition (45).

This scrutiny of factors influencing our data would seem to support only the broadest interpretation of adequacy of nutrient levels of the food intake of our children. Similar concerns about dietary data collected from middle-class groups have been expressed by other investigators (46) (44) (45). Using this frame of reference for our discussion of the food intake data shown in Table 2 several trends do emerge.

Protein and riboflavin seem to be the nutrients most abundant in the dietary of the children studied since all of the children had reported intakes of this nutrient which were above the 1968 Recommended Dietary Allowances except 1 (Case #105). Also, more than two-thirds of the protein intake was reported to have come from animal sources. Food intakes which yielded values less than two-thirds of the RDA for thiamine or riboflavin occurred least frequently, lending further credence to the view that the foods from the meat group, particularly pork, are most abundant in the diets of the children.

Sources of ascorbic acid were most often lacking in the children's diets. Low levels (less than two-thirds of the RDA) occurred in 30 per cent (18 children) of the children's diets studied. The levels of other nutrients found to be low and their observed frequency in descending order were: iron -- 27 per cent (14 children), vitamin A -- 22 per cent (13 children), calcium -- 18 per cent (11 children), niacin -- 17 per cent (10 children), Kcalories -- 15 per cent (9 children). Thiamine was found to be low in the dietaries of three children, and only Case 105, previously discussed, was low in riboflavin. Of those subjects with reported low intakes, only one child (105) was low in all categories except protein and vitamin A; one child was low in six nutrients, one child's intake was low in five nutrients; three children were low in four nutrients, five children were low in three nutrients; seven children were low in two nutrients; and eleven children were found to have low intake of one of these nutrients: calcium, iron, vitamin A, ascorbic acid, thiamine, or niacin. However, we should like to emphasize that of those diets characterized as "low" (less than two-thirds of the RDA) the dietary intake of five children or less yielded nutrient values below 50 per cent of the RDA for Kcalories, calcium, iron, vitamin A, ascorbic acid, and niacin.

Further analysis revealed another dimension to the data. Seven children had reported intakes which were above 150 per cent (2400 Kcalories) of the RDA for Kcalories, yet their physical measurement revealed no obesity. Further, 45 of the diets of the children ranged from 150 per cent (45 grams) to over 250 per cent (75 grams) of the RDA for protein. Fourteen had over 150 per cent (3150 I.U.) of the RDA for vitamin A. Eighteen intakes revealed amounts in a range of 150 to 250 per cent (60 mg. to 100 mg.) of the RDA for ascorbic acid. Fifteen of the diets yielded intakes of 150 per cent of the RDA (1.2) for thiamine, 33 of the diets showed intakes of 150 per cent (1.35 mg.) of the RDA for riboflavin. Four of the dietaries yielded intakes of over 150 per cent of the RDA for niacin (16.5 mg.).

Relevant to our over-all research focus, it is of particular interest to note that deficiencies of the two nutrients, protein and calories, which have been suggested as etiological agents in the psychological and neurological changes accompanying Kwashiorkor seem to be rarely lacking in the diets of the children studied. The indications in the literature pointing to the low iron content of children's diets (47) (48) were of special interest to us because of the high incidence of nutritional anemia found in disadvantaged populations (49) (50), the relationship between nutritional anemia and excessive milk intake (51) (52) (53) and (54), and the reported practice of the prolonged use of bottle feedings by lower socioeconomic groups (55). We therefore added direct questions relating to milk intake to the interview. Our results indicate that the mean intake of milk of children in our study was 13.1 ounces per child per day. Twenty-one children were reported to be drinking one cup or less and eight children two to three cups. Two children were reported as drinking 30 ounces which is more than three cups of milk, the standard nutritional recommendations for adequacy of milk intake. Thus the seeming lower levels of iron cannot be accounted for by excessive milk drinking. Rather, the low intake of milk probably accounts for the prevalence of what seems to be low levels of calcium in the diets of some of our children.

The dietary forms were also analyzed by frequency distribution to provide information about the food habits and meal frequencies of the children since there is a dearth of information about the food habits of disadvantaged Negro children.

We found that only one child did not feed himself. Over half the mothers reported their child as being most hungry in the morning which probably accounts for the finding that over 90 per cent of the children ate breakfast seven days a week. The meal most frequently missed was lunch, three children having no lunch at all. However, these three were all reported as having a mid-morning and mid-afternoon snack. Mid-afternoon apparently was the most frequent time for extra meal feedings, snacks being reported by three-fourths of the mothers. Slightly less than half the children have an evening snack, and less than a fourth of the group have something to eat mid-morning.

Precise information as to the composition of the "meals" and "snacks" was not available from the data collected, but several assumptions can be made from the data presented in the next table. The extensiveness of ice cream, cookies, and candy in the diets of the children studied is a rather predictable result. However, the results which show "meat for lunch" and "meat at the evening meal" as being consumed by the entire group with "breakfast meat" eaten by more than three-fourths of the children is rather surprising in view of the stereotyped notion that diets of disadvantaged children are primarily composed of high carbohydrate-low quality protein foods such as potatoes, rice, and dried beans. This result coupled with the apparent prevalence of eggs, fish, chicken, liver, and cheese in the children's food intake tends to confirm our finding that protein is one of the nutrients least likely to be lacking in the diets of our children. The lower frequency of typically Southern foods such as corn bread, grits, "greens," and pigs' feet is of interest in terms of defining preferential food items and refuting rather widely-held beliefs about the food item content of the disadvantaged Negro child. The number of the more expensive, sugar-coated cereals mentioned is also worth noting in this regard. There is also an apparent group preference for beef over "typical" cuts of pork. Items such as pigs' feet and spare ribs were mentioned as being eaten by less than 10 per cent of the children.

The data on dietary intake like the anthropometric data do not lend themselves to utilization as precise and exclusive measurements of nutritional status. The rationale for this statement lies partly in the previously-discussed difficulties of collecting and interpreting food intake data with great precision and partly in the fact that food intake data cannot reveal insights into how the food is utilized by the child. Recognizing these limitations, it becomes obvious that a judgment drawn from the dietary intake data of food deprivation which may lead to severe undernutrition is surely not justified for our sample children. Other recent studies have made similar observations (56) (57). Rather it is of interest to note the middle-class meal patterning and prevalence of middle-class foods in the dietaries. We feel that exploring the relationship between weight and nutrient intake and the interrelationships between the nutrients on an individual case basis would provide additional insight into dietary adequacy.

Biochemical Assessments

The difficulties inherent in the collection of a 24-hour urine specimen, the relatively insensitive method of assay of the two nutrients, thiamine and riboflavin, from a randomly voided specimen of urine (42), and the budget limitations of our project led us to consider only laboratory determinations of selected nutrients available from the blood. The children were transported to the metabolic laboratory at The Children's Hospital of Michigan where the blood samples were taken and analyzed under the direction of Dr. C. F. Whitten. Thirty children (15 boys and 15 girls) were randomly selected from the group of 38 Head Start children on whom we had collected dietary assessments, anthropometry, and psychological measures. These children had participated in Head Start for a period from two weeks to nine months, which is perhaps a crucial point since Head Start in Detroit has a well developed food program.

The laboratory determinations carried out were hemoglobin, hematocrit, transketolose, albumin, total protein, iron, iron-binding capacity, ascorbic acid, vitamin A, and beta carotene. Thus, we hoped to obtain information about the prevalence or absence of iron-deficiency anemia, protein levels, recent thiamine intakes, ascorbic acid levels, and recent intakes and stores of vitamin A. The methods used were those outlined by the Children's Bureau (42). At the time of this report, two determinations were not completed--beta carotene and vitamin A.

The results of the tests completed are presented in Table 3. Two children were below the minimum standards for hemoglobin but exhibited no other laboratory evidence of iron deficiency. Hematocrit, iron binding capacity, and serum iron were within normal levels even in the two children with low hemoglobin values. These latter measures are also perhaps more sensitive assessments of iron deficiency since some investigators feel that they detect earlier stages of iron depletion (58). One of the two children exhibiting low hemoglobin levels had a reported dietary intake that was low in iron, although it was above the 50 per cent level of the RDA. The other child had a reported intake of iron-containing foods well above two-thirds of the RDA for iron.

Blood level of ascorbic acid was low in only one child whose reported dietary intake of this nutrient was above the RDA. Normal levels of ascorbic acid were found in the blood of the other 29 children although ten had reported dietary intakes deficient in vitamin C with four falling below the 50 per cent level of the RDA. Two explanations are suggested for this discrepancy. First, since ascorbic acid blood levels respond to recent ingestion of this vitamin (17), it is possible that these children received a food source of this nutrient in close proximity to the time when the blood sample was taken although specific instructions were given to parents and teachers about the need for food abstinence prior to testing. Second, since the food intakes have been shown to vary greatly on a day-to-day basis (59), perhaps the twenty-four-hour recall cannot reflect these variations. Reported food intakes yielding underamounts of vitamin A in 11 children in our laboratory group are not corroborated by the normal range of vitamin A blood levels found, although it should be remembered that the laboratory assessment used discriminates stores of vitamin A rather than recent intake. In contrast to this picture of the poor relationships of biochemical assessment to recorded food intakes, the laboratory assessments do confirm our finding that protein was the nutrient in most abundance in the dietaries of the children studied and that foods from the meat group supply a major part of the food intake. With the exception of the serum total protein value for one child, laboratory determinations of protein adequacy were within normal ranges albeit controversy exists regarding the use of serum albumin levels and plasma protein levels for discriminating parometers of protein status (58).

These rather conflicting results suggest two perceptions. First, that food intake data is a very gross measure of nutritional status, a point which we have previously emphasized. Perhaps in reporting twenty-four hour food intakes on their children, mothers emphasize foods that they perceive as being highest in nutritional value. Further probing by the interviewer is possible but would tend to suggest answers and distort data. The second point is that food intakes of disadvantaged groups vary markedly from day to day since shopping and eating patterns are projected as being greatly influenced by the arrival of the "pay check." Intakes assessed by the use of 24-hour recall cannot reflect this variation of food intake. The analysis of the diet histories which deal with long term food intake should clarify some of these issues.

The laboratory assessments, however, generally tend to correlate well with anthropometric findings of normally distributed height and weight, the average heights and weights falling between the 50th and 75th "Boston" percentile. This tends to corroborate our earlier point that if nutritional deficiency exists, it is "borderline." The children in our study seem able to adapt physiologically to make maximum use of the nutrients they are ingesting.

Beyond this general appraisal, the results of analysis of the biochemical dietary and anthropometric data strongly emphasize the merit of individualized scrutiny of data in order to arrive at a more quantified evaluation.

Psychological Assessment

Studies attempting to relate nutritional status to mental development have reported the use of various tests for psychological assessment with populations in this and other countries. A positive correlation has been observed between the intersensory development and measurements of head circumference and height in samples of Guatemalan and Indian children judged to be undernourished (1) (60). Experience here has demonstrated that the recognition of geometric forms used in the previous study does not discriminate between the mental development of disadvantaged urban American children and that of middle-class urban American children of school age (61). A correlation between physical measurements and the Columbia Mental Maturity Test has also been found in an American urban disadvantaged population (30). We, however, felt that the content of this instrument is largely based on language skills and thus reflective of sociocultural factors rather than measuring physiological variables. Other investigators have reported the use of the Gesell and Goodenough tests with younger children than were included in our sample (62) (63).

Our criteria used for selection of an instrument to assess mental development were these: (a) tests that have primarily a non-verbal character because of the initial age of the subjects and the class of the population to be tested, (b) tests that utilized fine motor coordination skills as well as psychological variables were felt to be more physiologically oriented and thus to have a closer relationship to nutritional and anthropometric assessments, and (c) the attention span of the population studied.

The results of the responses of twenty-two of the children last year to two tests (the Goodenough Draw-A-Man and the Seguin-Goddard Form Board) and three performance subtests of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) led us to select the performance tests of the WPPSI as our testing instruments. This choice, as we reported in our preliminary findings, was based on the children's responses to the testing instrument and the suggestion of a relationship between the WPPSI subtests and skeletal age, the only psychological and physical measures that proved related.

The performance test items of the WPPSI were administered to the thirty-eight children within one week of the collection of dietary and anthropometric data in the Head Start Center where the children were enrolled. We also decided to include a vocabulary test as an optional item. The examiner was instructed to give the vocabulary test after the administration of the WPPSI and only if the child was cooperative. Thirty-four children completed both tests.

The scaled score equivalents of raw scores on the WPPSI ranged from 60 to 115 with a mean value of 89.2. According to Wechsler (64) the children thus ranked from one child below the first percentile to one child above the 80th percentile, the mean falling below the 25th percentile by only 0.8 of a point. This distribution would indicate that our children as a group are on the low side of the normal range. The intelligence quotients derived from the raw scores on the Peabody Picture Vocabulary Test Form A ranged from 37 to 120 IQ with a mean IQ of 73.4 (65). The raw scores of the children were distributed from below the first percentile to the 93rd percentile with the mean raw score falling at the fifth percentile.

Rank order correlation was used to determine the relationship between the WPPSI scores and the measurements of height, head circumference, and skeletal age. No significant relationship could be found between the physical measurements of either sex and their respective psychological test scores with the exception of one marked positive correlation--the height of the boys and their performance test scores (r = .80). This suggests that further exploration by other statistical methods may be fruitful in uncovering other relationships.

Summary

The dietary appraisals, biochemical evaluations, and anthropometry used to assess the nutritional status of sixty disadvantaged Negro five-year-old children disclosed few, if any, nutritional deficiencies. The children appeared slightly taller and heavier as a group than their Caucasian counterparts measured over three decades ago. Secular changes as reflected in generational height and weight increments and earlier physical maturation perhaps plays a major role in accounting for this finding. The results of our study should not be interpreted as implying that either the children were supplied with food or utilizing their food at an optimum level or that nutritional insufficiency does not exist. Rather, we feel that if a nutritional deficiency exists in our sample of children it is at a level that permits physiological adaptation by the child so that growth is not appreciably affected. Further precision in the definition of nutritional status of these children will be achieved by pursuing the relationships of various assessments lying at the extremes of the distributions on an individual basis.

The question of whether the children studied are a representative sample of "disadvantaged" children living in Detroit is perhaps a moot but important point. While it is true that over 60 per cent of the sample were children enrolled in Head Start Programs, over thirty per cent were not. Parental concerns over providing an optimum environment for the child which motivates Head Start enrollment and attendance probably extends to a consideration of the importance of providing adequate nutrition also. We are convinced, however, that most parents regardless of socioeconomic group share this value, particularly with regard to younger children unless there is a psychological or emotional problem. It should also be remembered that motivation for participation in our study cannot be solely attributed to a desire to increase knowledge. The Head Start parents were "paid" for their participation, i. e., free admission and rides at a local amusement park for the entire family. Without this inducement, we found it impossible to recruit families.

Studies of children in Columbus, Ohio showed similar nutritional findings lending further credence to our perceptions of the "typicalness" of the socioeconomic level of our children (66). In contrast, preliminary reports of surveys in southern areas, such as Texas and Mississippi, indicate some growth retardation and a small incidence of low levels of nutrient intake but no frank cases of deficiency diseases (66). This suggests that perhaps in northern urban areas where there is a substantial amount of redevelopment, nutritional conditions improve along with other environmental factors particularly for children.

With the exception of a marked positive correlation between height and psychological performance test scores in boys, no relationship between physical measures and intelligence test scores could be uncovered. Again as with the interpretation of nutritional status, this statement does not imply that no such relationships exist. A re-examination of these data using other statistical techniques appears a next step in view of current interest in this topic.

Our results strongly imply that factors other than nutrition exert a more profound influence on mental development in the children we studied than do nutritional and physical growth variables, per se. The finding of IQ scores on a performance test which ranked from below the first percentile (IQ = 60) to above the 80th percentile (IQ = 115) supports this judgment.

Acknowledgment

I wish to express my deep appreciation to Dr. Irving Sigel, former Chairman of Research, The Merrill-Palmer Institute. His inspired guidance and insightful support brought this project to fruition.

TABLE I

NUTRIENT YIELD OF DIETARIES COMPARED TO THE RECOMMENDED DIETARY ALLOWANCES

	Kcalories	Protein (gm)	Calcium (gm)	Iron (mg)	Vitamin A (IU)	Ascorbic Acid (mg)	Thiamine (mg)	Ribo-flavin (mg)	Niacin (mg)
RDA	1600	30	0.8	10.0	2500	40.0	0.8	0.9	11.0
Mean Values (Boys)	1657	58.6	0.73	8.47	3876	67.6	1.06	1.93	10.7
Mean Values (Girls)	1489	57.0	0.67	8.76	2647	57.2	.793	1.16	9.9
Number of Children Above 150% of RDA*	7	45	4	3	14	18	18	33	4
Number of Children 66-2/3% of RDA* or above	51	60	49	46	47	42	57	59	55
Number of Children below 66-2/3% of RDA*	9	0	11	14	13	18	3	1	10
Number of Children below 50% of RDA*	3	0	4	5	4	5	0	1	1

* RDA = Recommended Dietary Allowances (1968)

GROUP FREQUENCY OF FOOD EATEN

Foods Eaten by 90% or More Children	Foods Eaten by 75% or More	Foods Eaten by 50% or More	Foods Eaten by 25% or More	Foods Eaten by More Than 10%
Eggs	Raw Vegetables	Jelly & Jam	Ham	Popsicles
Bread	Soft Drinks	Potato Chips	Salami	Frosty Flakes
Fish	Cake	Orange Juice	Tuna Fish	Cream of Wheat
"Meat at Evening Meal"	Crackers	"Greens"	Lunch Meat	Raisin Bran
Sandwiches	Liver	Cabbage	Tomatoes	Biscuits
Chicken	Bologna	Carrots	Green Beans	French Fries
"Meat for Lunch"	Cheese	Grits	Lettuce	Soup
Cold Cereal	Dried Beans/Peas	Doughnuts	Celery	Chili
Rice	*Lemonade	Corn Bread	Oranges	Cheddar Cheese
Potatoes	Fritos	Oatmeal	Bananas	Veal
Ice Cream	*Pancakes, Waffles	*Milk Puddings	Fruit Cocktail	Lamb
Cookies	Sweet Rolls	Peaches	Spaghetti	Fish Sticks
Candy	Macaroni	*Bananas	Salad Dressing	White Fish
*Bacon	Pork	*Mashed Potatoes	Corn Flakes	Perch
Whole Milk	*Apples	*French Fries	Cheerios	Bass
*Beef	*Orange Juice	*Lettuce	Cream of Wheat	Butter Beans
*Hot Dogs	Canned Fruit	American Cheese	Peanut Butter Sand.	Northern Beans
*Hamburgers		Ham (for breakfast)	Ritz Crackers	Navy Beans
*Doughnuts		Sausage (for breakfast)	Custards	Chocolate Milk
*Spaghetti			*Cream Soups	Grapefruit Juice
Pies		Saltines	Grape Juice	Pineapple Juice
*Cakes		Noodles	Canned Fruit	*Hi-C
*Potato Chips		Coke	Frozen Strawberries	All Kinds Juice
Peanuts		Regular Kool-Aid	Grapes	Canned Pears
Cooked Cereals		Pretzels	Peas	Canned Pineapple
*Crackers			Spinach	Fresh Pears
*"Meat for Breakfast"			Corn	Fresh Peaches
Fruit Juice			Kidney	Most Kinds Fresh Frutt
Fresh Fruit			Black-eyed Peas	
Cooked Vegetables			Lima Beans	Baked Potatoes
			Frozen Fruit	Boiled Potatoes
			Pinto Beans	Creamed Potatoes
			Perch	Green Beans

Foods Eaten by
More Than 10% (cont'd.)

String Beans
Cucumbers
Cole Slaw
Sugar Pops
Rice Krispies
Sugar Smacks
Cocoa Wheats
*Maypo
Lunch Meat
*Graham Crackers
Chocolate Candy
Suckers

TABLE III

	Hb (Hb vols.%)	Hct (Hb vols.%)	Iron Binding Capacity (mcg %)	Serum Iron (mcg %)	Total Protein (gm %)	Albumin (gm %)	Ascorbic Acid (mg %)	Vitamin A (mcg %)
Mean Values	11.2	38.0	259.9	93.9	10.8	4.8	1.23	82.8
Range	9.8-13.0	37-43	165-370	73-134	6.1-7.6	4.5-5.5	.15-2.15	35-175
Minimum Standards (42)	Less than 10.0	Less than 30	More than 600	Less than 45	6.5-7.5 (17) (normal)	Less than 3.0	Less than 0.3	Less than 10 (deficiency) Less than 20 (low stores)
No. of Children Below Minimum	2	0	0	0	1	0	0	0

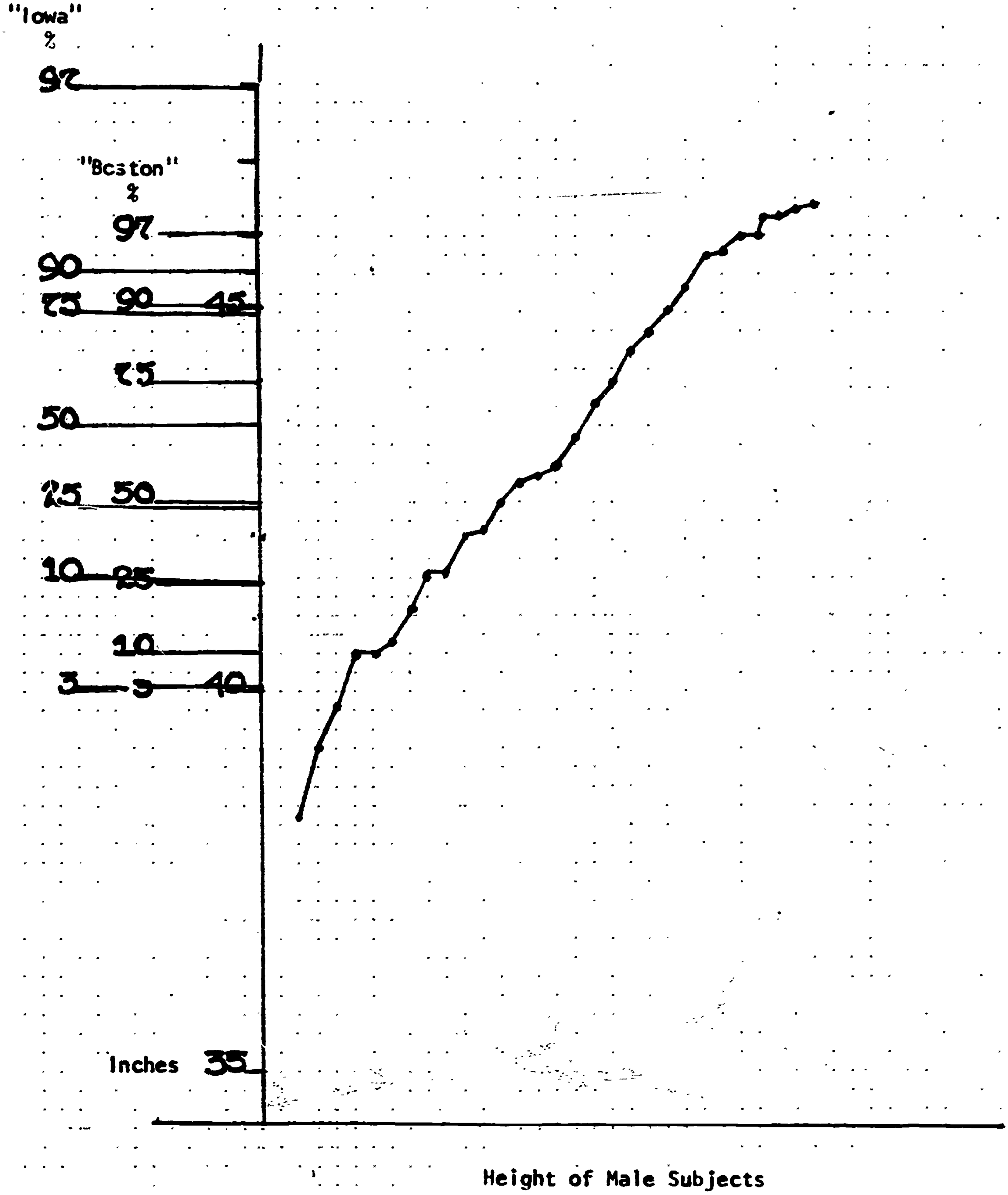

Fig. 1 Heights of Male Subjects Compared
to "Iowa" and "Boston" males

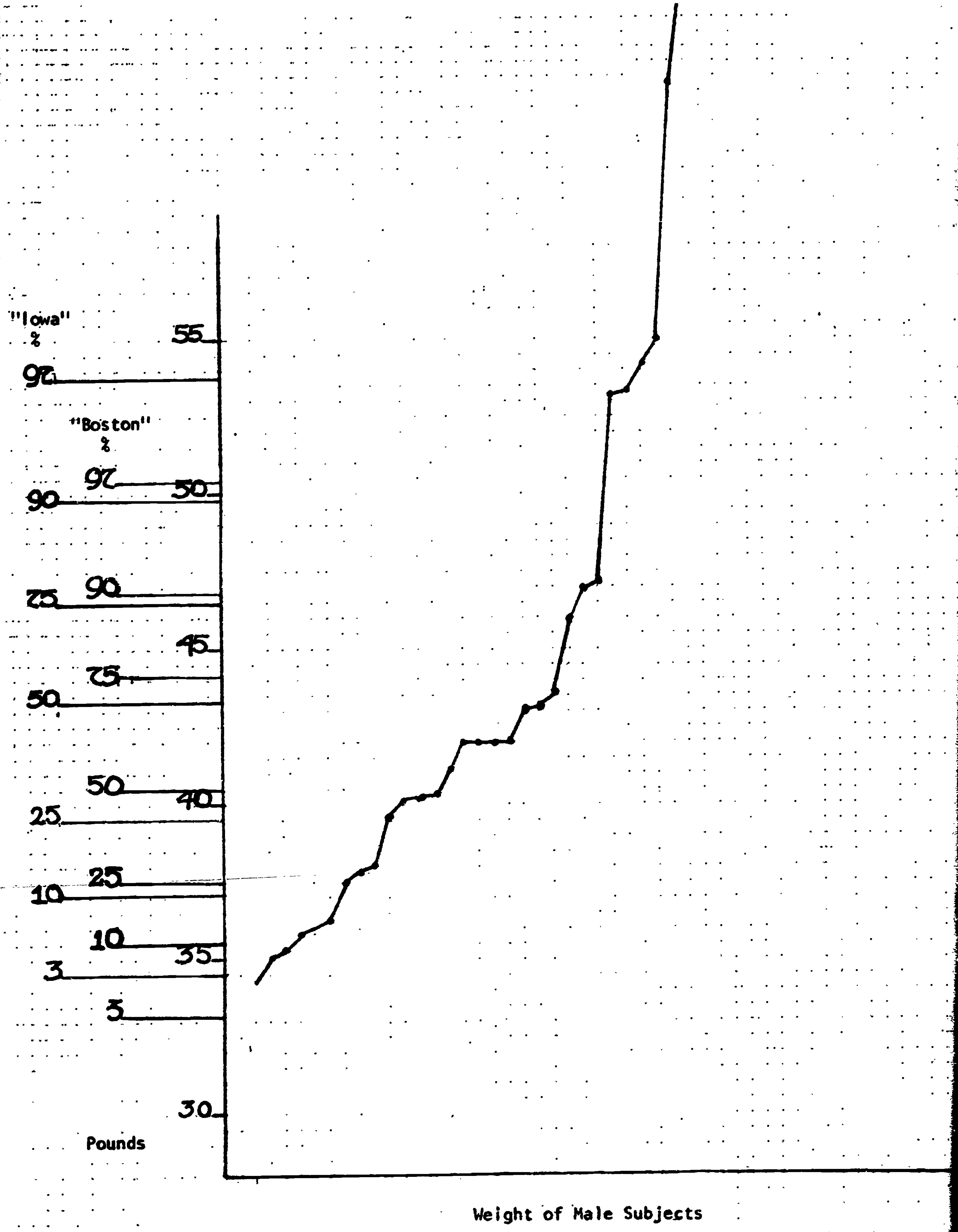

Fig. 2 Weights of Male Subjects Compared to "Iowa" and "Coston" Males

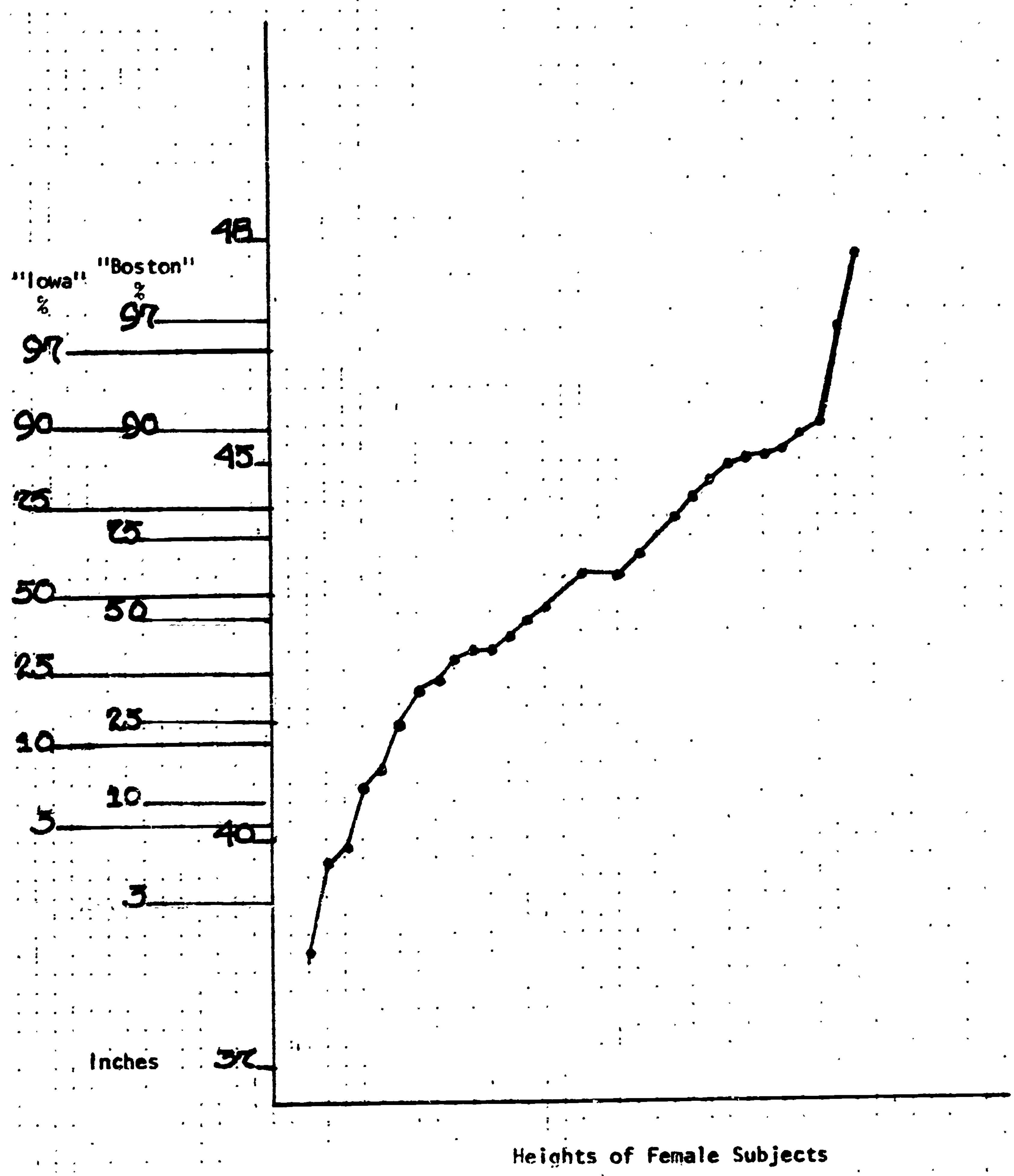

Fig. 3 Heights of Female Subjects Compared to "Iowa" and "Boston" Females

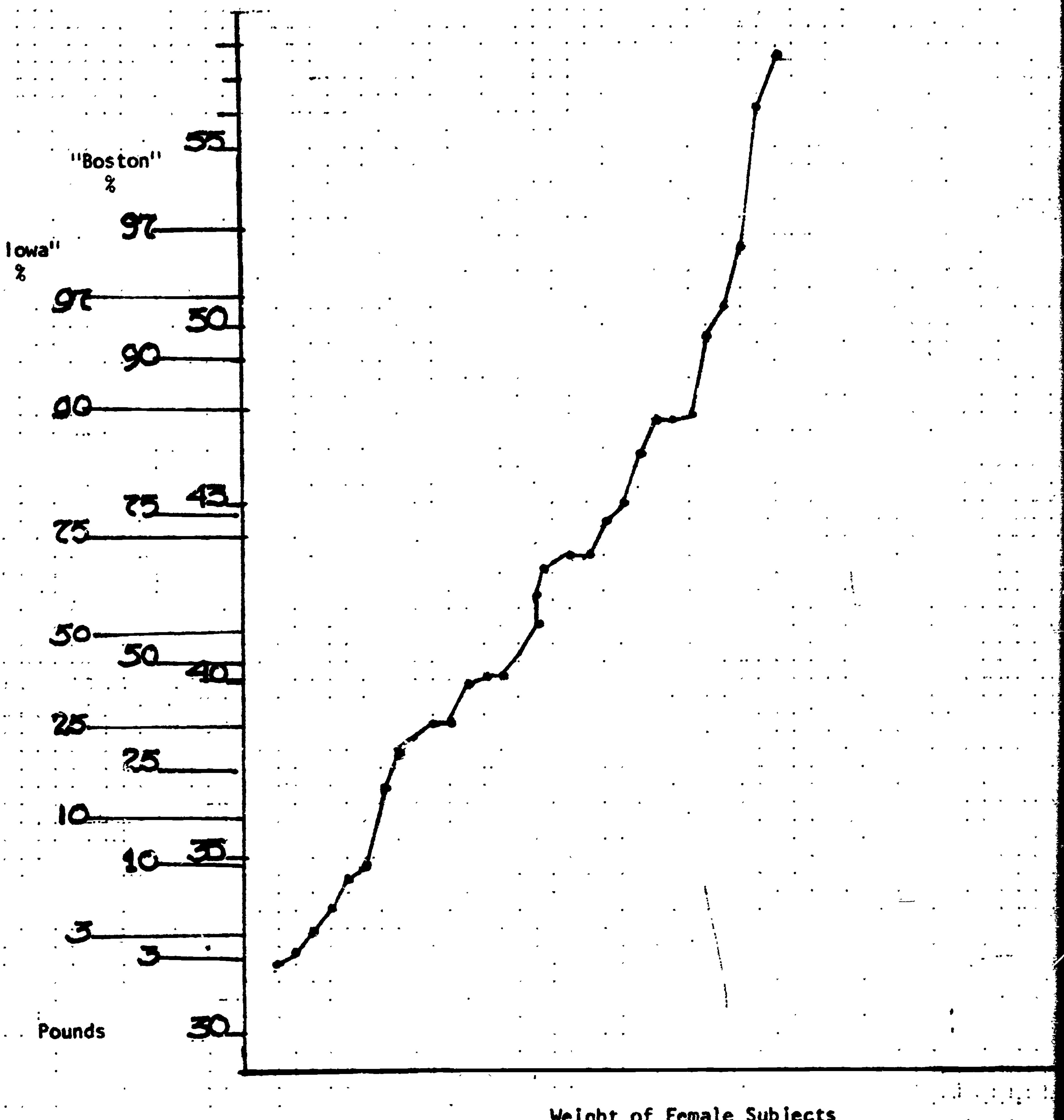

Fig. 4 Weights of Females Compared to "Iowa" and "Boston" Females

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