Evidence for a secular change in obesity, height, and weight among Navajo Indian schoolchildren[1-3]

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ABSTRACT A survey measuring heights and weights of 1969 schoolchildren residing on the Navajo Indian Reservation was conducted in 1989. The findings were compared with National Center for Health Statistics (NCHS) reference data and with surveys of Navajo children from 1955, 1968, and 1981. Approximately twice as many children exceeded the 95th percentile of weight-for-age (11.2% of girls, 12.5% of boys) than would be expected for the NCHS reference population. The mean weight-for-height z scores exceeded those for the NCHS reference population for all ages in both sexes. Compared with data from 1955, mean heights increased 6.1% among boys and 4.4% among girls whereas mean weights increased 28.8% among boys and 18.7% among girls across all age groups. The data suggest that there has been a secular change in height, weight, and obesity in Navajo Indian children over the past 35 y. *Am J Clin Nutr* 1990;52:960–6.

KEY WORDS Anthropometry, child, nutritional status, obesity, ethnic groups, cross-sectional studies, North American Indians

Introduction

The prevalence of non-insulin-dependent diabetes mellitus (NIDDM) among Navajo Indians, the largest tribe in the United States, was recently found to be substantially higher than that reported only two decades previously (1). Increasing rates of NIDDM in other Indian tribes have been attributed to a rising prevalence of obesity, a major risk factor for the development of NIDDM (2). The current prevalence of obesity among adult Navajo Indians is much greater than that identified in surveys taken between 1955 and 1979 (1, 3, 4). However, there is a paucity of data regarding the distribution of obesity in contemporary Navajo children.

Indian Health Service (IHS) clinicians who provide health care for Navajo children have developed a clinical impression that levels of obesity have been rising over the past decade. These impressions have been supported by the recent findings of high rates of weight-for-height among Navajo infants and toddlers (5) and of high levels of obesity in a small study that included 60 Navajo fourth, fifth, and sixth graders (6). These studies suggest that a significant change in the nutritional status of Navajo children has occurred since the 1950s and 1960s, when nutritional surveys of children revealed high levels of malnutrition and few cases of obesity (7, 8).

Because of the concern that levels of obesity and overweight among Navajo children are increasing, we conducted a survey to determine the weights and heights of a large representative cohort of Navajo Indian schoolchildren and compared these data with those from previous studies. The findings from the survey are the subject of this report.

Subjects and methods

The Navajos comprise the largest Indian tribe in the United States with an estimated population, based on the extrapolation from the 1980 US census (9), of ~180 000 in 1988. Approximately 58% of the population residing on the 25 000-square-mile Navajo reservation in the southwestern United States is < 20 y of age. The reservation has undergone significant epidemiologic and demographic change over the past half century, with a transition from an economy based on livestock and subsistence farming to one based on wage work capitalizing on the reservation's natural resources and government programs (10). Nearly 50% of the population was below the federal poverty level according to the 1980 US census, with an average per capita income of $2414.

Three types of schools are available to Navajo children residing on or around the Navajo Indian Reservation. First, most larger communities have public schools. Second, there are a number of schools administered by the Bureau of Indian Affairs (BIA). Students in BIA schools either live in on-campus dormitories or commute daily from their homes. Third, there are a number of privately sponsored schools, most of which are affiliated with religious institutions. At least one class for every grade from each type of school was selected from a list of 53 BIA schools, 163 public- and community-controlled schools, and 22 private schools that serve Navajo students. Children from at least two grades were examined in each of the eight Navajo Area IHS Units. Thus the study cohort was representative of Navajo children residing in all geographic regions of the Navajo Reservation.

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Although degree of Navajo heritage for each child was not assessed, 97.2% of Navajos using IHS facilities report that they are full heritage (4/4 blood quantum) according to IHS records (M Everett, personal communication, Office of Program Planning, Navajo Area IHS, 1990).

Measurements were obtained primarily by IHS nutritionists and dietitians, although other staff assisted in some schools. Heights (while children were not wearing shoes) were measured to the nearest 0.635 cm by use of either height boards or horizontal height bars on beam balances, with the child standing erect and the head placed in the Frankfort horizontal plane. Weights were measured to the nearest 0.227 kg while children were wearing light clothing and no shoes. Data are reported for children aged 5–17 y. The age (in years) attained at the last birthday was recorded for each child.

Measurements were converted from inches and pounds to centimeters and kilograms for comparison with reference populations. Height and weight values were compared with the Centers for Disease Control (CDC) standard deviation-derived growth reference curves derived from the National Centers for Health Statistics-CDC (NCHS-CDC) reference population of US children of the same age and sex. The Normalized NCHS-CDC Anthropometric Reference was constructed from observed growth curves to allow expression of anthropometric indicators in terms of standard deviations rather than in terms of a percentage of the reference median. The *CDC Anthropometric Software Package* (*CASP*), version 3.0 (11), was used to compute weight-for-age, height-for-age, and weight-for-height percentiles or z scores for selected age groups. Weight-for-height z scores are calculated for boys only through 138 mo of age and for girls through 120 mo of age. Because of the changes in body weight and composition that occur with puberty, weight-for-height is an inadequate assessment of obesity during puberty and beyond. The prevalence of anthropometric values below the 5th and above the 95th percentiles, as well as the mean percentiles, was calculated. For the purpose of comparison with earlier studies, mean weights and heights for each age and sex were calculated. When summary anthropometric indices for more than one age group are reported, unless otherwise indicated, data was weighted so that each age group contributed an equal weight to the summary statistic. Based on a comparison of weight-for-age and height-for-age z scores, no consistent trends in differences from the norm among types of school or geographic location were identified. Thus, the data are presented without regard to school type or location.

Body mass index (BMI, kg/m^2) was computed for all subjects. BMIs were compared with those derived from the second National Health and Nutrition Examination Survey (NHANES II) for the general US population (12).

We compared our data with three historical data sets. In 1955, a survey of 374 school-aged Navajo children was conducted in two reservation communities: Ganado, AZ, and Pinon, AZ. These communities were chosen because they represented extremes in accessibility and acculturation on the reservation. Although the subjects were not randomly selected from the populations studied, the subjects were thought by the authors to be generally representative of the communities studied. The reported mean heights and weights of these children were converted to metric units and compared with data from the present survey (3).

In 1968, a survey of schoolchildren in lower grades was carried out in the Navajo community of Fort Defiance, AZ. (Plesset M, unpublished observation, Navajo Area Indian Health Service, 1990; summarized in ref 7). All full-heritage Navajo children attending one of nine preschools operated by the Office of Navajo Economic Opportunity were studied. In addition, Navajo students at seven boarding schools operated by the BIA were evaluated. Entire classes were measured in five schools, and a simple random sample was obtained at two larger schools. Although the original data are no longer available, the manuscript provides data describing the proportion of children in various height and weight percentiles compared with a population of Iowa schoolchildren studied between 1930 and 1945 (13). The distribution of heights and weights in the present data set were compared with the same reference population to allow comparison with the 1968 Navajo data. Age groups in the original study were classified according to half-year intervals, eg, children between the ages of 5 y, 3 mo and 5 y, 9 mo were designated as 5.5 y old. Therefore, age groups in the present study were similarly adjusted for the purpose of this comparison. Adequate data were available in the earlier study for children aged 5–9.5 y.

Mean weights of 580 Navajo adolescents were collected from a cohort of BIA school students in 1981 (J Coulehan, unpublished observations, 1981). Approximately 90% of the students residing in BIA dormitories for Navajo high-school students in Tuba City, AZ, and in Flagstaff, AZ, were weighed. These weights were compared with those subjects of the same age and sex in the present survey.

Comparisons of means were performed by use of two-tailed *t* tests for independent samples. Differences in proportions were examined by chi-square analyses (14). Differences were considered to be significant when P values were ≤ 0.05.

Results

Complete data were obtained for 1969 children (951 boys, 1018 girls). The age and sex distribution of subjects is presented in **Table 1**. Two hundred thirteen subjects attended private schools, 791 attended BIA schools, and 965 attended public schools.

The percentile distributions by age and sex of height-for-age and weight-for-age compared with the reference population are

TABLE 1
Age and sex distribution of subjects

Age	Number of boys	Number of girls	Total
y			
5	54	47	101
6	70	59	129
7	60	49	109
8	48	51	99
9	78	92	170
10	119	140	259
11	125	110	235
12	91	99	190
13	73	94	167
14	50	51	101
15	59	68	127
16	69	89	158
17	55	69	124
Total	951	1018	1969

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TABLE 2
Percentile distribution of height-for-age for Navajo boys and girls compared with reference population*

	0–5		5.01–94.99		95–100	
Age	Boys	Girls	Boys	Girls	Boys	Girls
y			%			
5	13.0 [7]	2.1 [1]	81.5 [44]	89.4 [42]	5.6 [3]	8.5 [4]
6	8.6 [6]	6.8 [4]	88.6 [62]	86.4 [51]	2.9 [2]	6.8 [4]
7	3.3 [2]	0 [0]	86.7 [52]	95.9 [47]	10.0 [6]	4.1 [2]
8	8.3 [4]	2.0 [1]	85.4 [41]	84.3 [43]	6.3 [3]	13.7 [7]
9	0 [0]	3.3 [3]	94.9 [74]	93.5 [86]	5.1 [4]	3.3 [3]
10	2.5 [3]	5.0 [7]	93.3 [111]	94.3 [132]	4.2 [5]	0.7 [1]
11	7.2 [9]	5.5 [6]	91.2 [114]	94.5 [104]	1.6 [2]	0 [0]
12	13.2 [12]	7.1 [7]	83.5 [76]	92.9 [92]	3.3 [3]	0 [0]
13	2.7 [2]	7.4 [7]	93.2 [68]	91.5 [86]	4.1 [3]	1.1 [1]
14	4.0 [2]	3.9 [2]	94.0 [47]	96.1 [49]	2.0 [1]	0 [0]
15	10.2 [6]	8.8 [6]	89.8 [53]	91.2 [62]	0 [0]	0 [0]
16	14.5 [10]	12.5 [12]	85.5 [59]	86.5 [77]	0 [0]	0 [0]
17	23.6 [13]	14.5 [10]	74.5 [41]	81.2 [56]	1.8 [1]	4.3 [3]
Total	8.1 [76]	6.5 [66]	88.4 [842]	91.1 [927]	3.5 [33]	2.4 [25]

* *n* in brackets.

presented in **Tables 2 and 3.** Approximately twice as many children exceeded the 95th percentile of weight-for-age (11.2% of girls, 12.5% of boys) than would be expected for the reference population. Only 1.8% of girls and 2.7% of boys were below the 5th percentile for weight-for-age. Despite the high prevalence of high weight-for-age, only 2.4% of girls and 3.5% of boys exceeded the 95th percentile of height-for-age, whereas 6.5% of girls and 8.1% of boys had height-for-age below the 5th percentile of the reference population. The weighted mean height-for-age z scores for boys (−0.22) and girls (−0.21) were slightly lower than those expected for the reference population, whereas the mean weight-for-age z scores for boys (0.21) and girls (0.35) were higher than those expected for the reference population. In all age groups for which reference weight-for-height z scores could be calculated, the mean z scores exceeded the norms for the reference population. The mean weight-for-height z score was 0.59 for boys and 0.34 for girls.

The mean BMIs of Navajo boys and girls compared with those of the NHANES II population are shown in **Figure 1.** In all age groups in both sexes (with the exception of 7-y-old girls), the mean BMI of Navajo children exceeds that of children in the general US population. As shown in **Figure 2,** the mean heights and weights have increased among Navajo children when compared with data collected in 1955. Mean heights increased 6.1%

TABLE 3
Percentile distribution of weight-for-age for Navajo boys and girls compared with reference population*

	0–5		5.01–94.99		95–100	
Age	Boys	Girls	Boys	Girls	Boys	Girls
y			%			
5	0 [0]	0 [0]	92.6 [50]	87.2 [41]	7.4 [4]	12.8 [6]
6	1.4 [1]	3.4 [2]	88.6 [62]	86.4 [51]	10.0 [7]	10.2 [6]
7	1.7 [1]	0 [0]	86.7 [52]	87.8 [43]	11.7 [7]	12.2 [6]
8	0 [0]	3.9 [2]	79.2 [38]	78.4 [40]	20.8 [10]	17.6 [9]
9	0 [0]	1.1 [1]	83.3 [65]	89.1 [82]	16.7 [13]	9.8 [9]
10	0.8 [1]	1.4 [2]	83.2 [99]	87.9 [123]	16.0 [19]	10.7 [15]
11	3.2 [4]	2.7 [3]	84.0 [105]	87.3 [96]	12.8 [16]	10.0 [11]
12	4.4 [4]	2.0 [2]	83.5 [76]	85.9 [85]	12.1 [11]	12.1 [12]
13	2.7 [2]	1.1 [1]	78.1 [57]	83.0 [78]	19.2 [14]	16.0 [15]
14	6.0 [3]	5.9 [3]	80.0 [40]	86.3 [44]	14.0 [7]	7.8 [4]
15	5.1 [3]	0 [0]	91.5 [54]	91.2 [62]	3.4 [2]	8.8 [6]
16	4.3 [3]	1.1 [1]	89.9 [62]	91.0 [81]	5.8 [4]	7.9 [7]
17	7.3 [4]	1.4 [1]	83.6 [46]	87.0 [60]	9.1 [5]	11.6 [8]
Total	2.7 [26]	1.8 [18]	84.8 [806]	87.0 [886]	12.5 [119]	11.2 [114]

* *n* in brackets.

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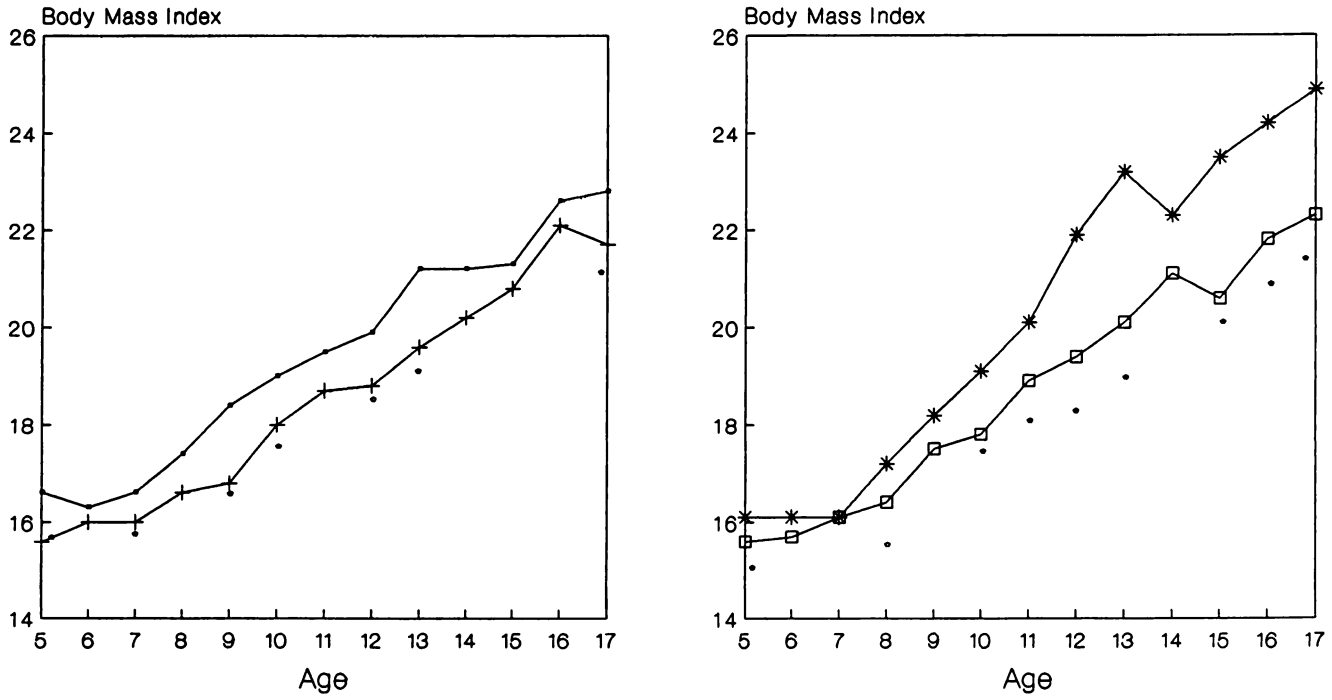

FIG 1. Mean body mass index (kg/m^2) in Navajo boys (□) compared with boys (+) in the general population (left panel) and Navajo girls (*) compared with girls (□) in the general population (right panel) [US data from NHANES II (12)]. *$P < 0.05$.

among boys and 4.4% among girls whereas mean weights increased an average of 28.8% among males and 18.7% among females across all age groups.

The proportions of children with heights and weights above the 90th and below the 10th percentiles for height and weight (by use of the reference population of Iowa schoolchildren) were

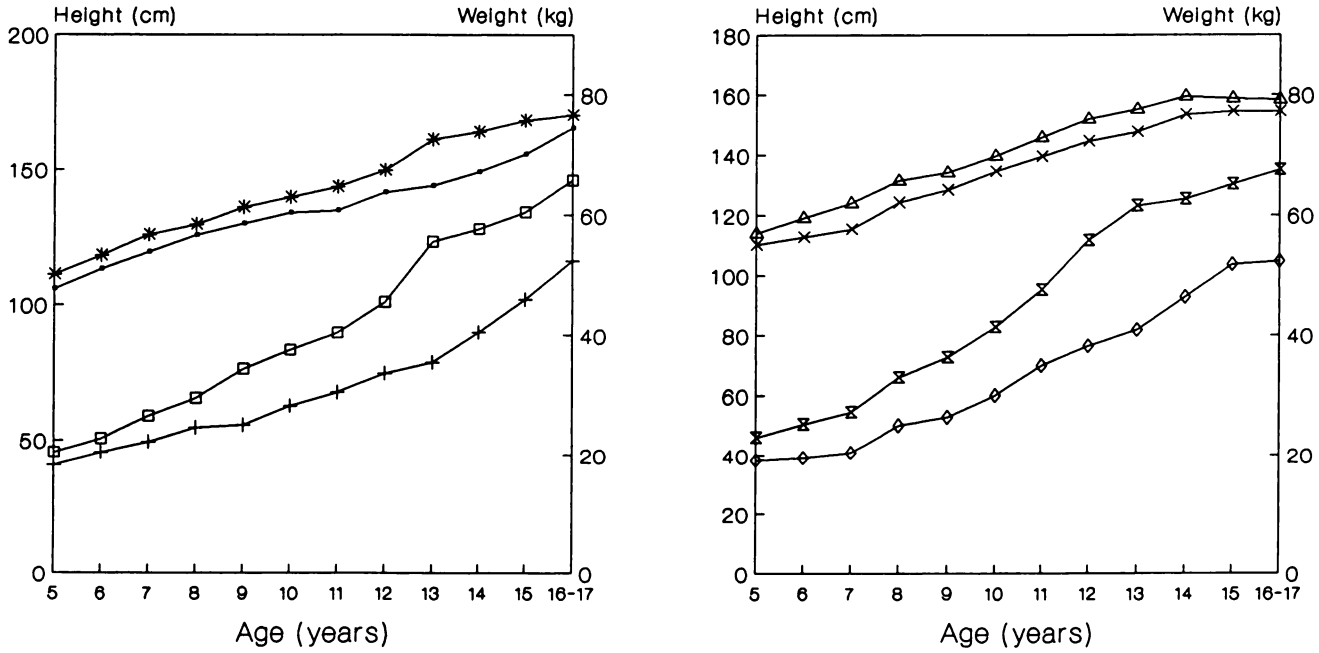

FIG 2. Left panel: average height in 1955 (□) and in 1989 (*) and average weight in 1955 (+) and in 1989 (□) in Navajo schoolboys; right panel: average height in 1955 (×) and in 1989 (△) and average weight in 1955 (◇) and in 1989 (⧖) in Navajo schoolgirls.

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substantially different in the current survey compared with those reported in the 1968 survey of Navajo children aged 5–9.5 y. For instance, 54.7% (268 of 490) of children were below the 10th percentile in height in 1968, compared with 14.6% (82 of 561) in the current study ($P < 0.0001$). Conversely, 4.1% (2 of 490) were above the 90th percentile in height in the earlier study, compared with 8.2% (46 of 561) in the present study ($P < 0.0001$). Although 2.9% (14 of 490) of children were above the 90th percentile for weight in 1968, 15.2% (85 of 561) currently exceed the 90th percentile ($P < 0.001$). The age-specific numbers and proportions of children with percentiles less than or exceeding selected Iowa percentiles are available in the Appendix.

A comparison between mean weights among Navajo adolescents from 1981 and those from the present study is presented in **Table 4.** The mean weights are consistently higher in the present cohort. Mean weights for 17-y-olds in the present survey are ~4.6 kg greater for boys and 6.4 kg greater for girls ($P < 0.05$).

Discussion

The clinical impression that levels of overweight and obesity among Navajo children have been increasing is substantiated by the results of this study. Although the Navajo children in this study are shorter than children of the same age and sex in the general US population, BMI and weight-for-height indices suggest that there is excess adiposity among Navajos compared with the reference population.

The coexistence of high rates of linear growth stunting (low height-for-age) and obesity (high weight-for-height) was previously described among Native American children in reviews of CDC nutrition surveillance data (15). Similar findings were recently reported for Navajo children aged ≤ 2 y who attended the Navajo Nation Special Supplemental Program for Women, Infants, and Children (WIC) (5). In that cohort, Navajo children had low mean percentiles of height-for-age and weight-for-age, but high percentiles of weight-for-height compared with the NCHS-CDC reference population. Between 1975 and 1980 there was a slight increase in length-for-age among children with normal birth weight, although not among children with low birth weight. Infants with birth weights < 2500 g were found to be shorter and thinner than those with higher birth weights. Among 28 377 infants delivered in Navajo Area IHS hospitals between October 1, 1982, and September 30, 1988, 1505 (5.3%) weighed < 2500 g, and 2174 (7.7%) weighed > 4000 g. However, the proportion of infants weighing > 4000 g increased from 7.5% during fiscal years (FY) 1983–1985 to 9.0% during FY 1986–1988 ($P < 0.001$) (J Sugarman, unpublished observations, 1990). Thus, there may be a trend toward increasing rates of large-for-gestational age Navajo newborns.

In 1985 and 1986 a group of 60 Navajo fourth, fifth, and sixth graders from public and BIA schools was examined for height and weight (6). The average age was ~10 y, although specific age and sex distributions were not reported. The mean BMIs were reported to be 18.2 ± 3.2 ($\bar{x}$ ± SD) and 18.3 ± 3.4 for boys and girls, respectively. These BMIs were not significantly different from those reported for 10-y-olds in the present study ($P = 0.26$ for girls and boys). In that study, Navajo children were found to have lower percentages of body fat than Acoma and Laguna Indian children. On the basis of skinfold-thickness measurements, however, Navajo children, especially girls, were found to have higher levels of fatness than the reference population.

These findings in contemporary Navajo children are in sharp contrast with those found over the past three decades. Van Duzen et al (7) identified high levels of protein and calorie malnutrition, including numerous cases of kwashiorkor and marasmus among Navajo children in Tuba City, AZ, between 1963 and 1967. Sixty-five percent of 944 Navajo children aged 4–7 y attending Head Start programs had heights below the 25th percentile for a contemporary reference population, and 35% had weights below the 25th percentile. Although a follow-up evaluation in 1973 revealed improvements in nutritional status, there was still a significant difference from the growth curves for the reference population (8). In the present study we documented substantial increases in height- and weight-for-age compared with data collected in 1955 and 1967 among several Navajo communities.

In studies of White Mountain Apache children conducted in 1969 and 1976, no secular change in height-for-age, weight-for-age, or weight-for-height was identified (16). The Apaches are closely related to Navajos, having descended from Athapaskan tribes who migrated to the American Southwest from Alaska in the 16th century (17). Although only 7 y elapsed between the two studies, it is notable that few anthropometric changes, other than slight increases in head circumference and thoracic fatfold thickness, were identified despite significant changes in living conditions. However, children in other American Indian communities have high rates of obesity. For instance, Cherokee Indian teen-agers in North Carolina were found to have high rates of obesity compared with several US reference data sets (18).

Studies in the general US population have also suggested that there has been a secular change in pediatric obesity among young children over the past several decades (19). Even upon exami-

TABLE 4
Mean weights of Navajo adolescents: comparison between data from 1981 and 1989*

	Males			Females		
Age	1981	1989	*P*	1981	1989	*P*
y	*kg*			*kg*		
14	51.9 ± 7.5 [32]	57.6 ± 15.8 [50]	0.056	54.4 ± 8.9 [32]	57.0 ± 10.7 [51]	0.27
15	55.5 ± 7.3 [47]	60.4 ± 11.3 [59]	0.012	54.9 ± 5.7 [55]	59.1 ± 11.3 [68]	0.013
16	60.1 ± 7.8 [55]	65.0 ± 17.4 [69]	0.055	56.6 ± 7.7 [49]	60.4 ± 11.0 [89]	0.032
17	62.1 ± 8.0 [58]	66.7 ± 15.7 [55]	0.051	56.1 ± 6.0 [55]	62.6 ± 12.7 [69]	0.008

* $\bar{x}$ ± SD.

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nation of the same data sets, however, different investigators arrived at conflicting conclusions regarding the existence of secular trends in obesity among adolescents (20). Because these studies are based on anthropometric data that are not available in the earlier studies of Navajo children that we reviewed, it is not possible to directly compare trends among Navajo children with those in the general population.

There are some limitations to the present data. First, because heights and weights were measured by different observers using different equipment, some degree of variability between sites might be expected. However, the mean weights and heights for age increased in a smooth fashion for both sexes (Fig 2), and increases in BMI appear to be parallel to those identified in NHANES II (Fig 1). Thus, the technical limitations in data collection appear not to have adversely affected the quality of the data.

A more serious limitation is the reliance on relative height, weight, and BMI as indices of obesity. It would have been preferable to utilize skinfold-thickness measurements to better evaluate body fatness. However, because resources were not available to us to appropriately train multiple observers over a 25 000-sq-mi area to obtain accurate skinfold-thickness measurements, we relied on the BMI to evaluate overweight. In addition, BMI is generally considered to be a more reliable measurement in field studies than is skinfold thickness data, which are more difficult to accurately and reliably collect. The correlations between BMI and percent body fat in children aged 6–12.9 y are 0.68 and 0.55 for boys and girls, respectively, and 0.61 and 0.77 for boys and girls aged 13–17.9 y (21), respectively. The correlation coefficients between triceps skinfold thickness and percent body fat are ~0.8 for children. Thus, the general conclusions regarding obesity allowed for by comparison of BMIs would probably not be changed significantly by using skinfold-thickness measurements.

It is possible, at least in theory, that some of the observed secular trend may be an artifact of different sampling frames used for the various historical cohorts. However, the historical samples were collected in several geographically separate areas of the reservation. We did not observe major differences in obesity in different areas of the reservation in the present study (data not shown).

Trowbridge (22) emphasized that high weight-for-height may not be associated with obesity in all populations. For instance, although Peruvian children have short stature and high weight-for-height, body composition as assessed by $H_2{}^{18}O$ stable-isotope dilution showed low levels of body fat compared with US reference values. Thus, it remains to be conclusively demonstrated that the high mean percentiles of weight-for-height among young Navajo schoolchildren are definitely associated with high levels of obesity per se. However, because of the current rarity of clinical malnutrition among Navajo children, the caveats that apply to the Peruvian cohort studied by Trowbridge may not be applicable.

These data provide convincing evidence that the height and weight of Navajo Indian schoolchildren have undergone a secular change over the past several decades. It is likely that this change has resulted from a complex mixture of changes in nutrition, daily energy expenditure, and the availability of health care. Accurate data allowing a comparison of the diet of contemporary Navajo schoolchildren with those in the 1950s and 1960s are not available. The traditional Navajo diet of wild game, corn, berries, fruits, and other plants had been essentially abandoned by the 1950s, and prepared foods and soft drinks were readily available at trading posts. However, Darby et al (3) noted in 1955 that fried potatoes, tortillas, and roast mutton were dietary staples for most families. The same foods were noted to be major components of the diet in the 1980s, along with sweetened carbonated beverages, fruit-flavored juices, and chips (23).

The contributions of supplemental food programs to the diets of contemporary Navajo children are also noteworthy. Approximately 35% of schoolchildren in a population including a significant proportion of Navajo indians reported that their families received food through the WIC or commodity food programs (24). These data are consistent with a recent General Accounting Office report that found that 38% of Navajos residing on the reservation participated in federal food stamp and food distribution programs (25).

The offspring of women with pregnancies complicated by diabetes have higher rates of subsequent obesity than do offspring of nondiabetic women and women who subsequently develop diabetes, even when controlled for birth weight (26). The prevalence of diabetes during pregnancy among Navajos is approximately twice that among the general US population (27). Thus, increasing rates of diabetes during pregnancy may account for some proportion of the increase in childhood obesity among Navajos.

The clinical impression of increasing obesity in Navajo children is supported by the results of this survey. Because of concern regarding the consequences of obesity among Navajos later in life, particularly with regard to NIDDM, programs to encourage exercise and appropriate nutrition among Navajo children are currently being developed. In addition, detailed nutritional surveys of dietary consumption among Navajo children are currently under way.

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References

1. Sugarman J, Percy C. Prevalence of diabetes in a Navajo Indian Community. Am J Public Health 1989;79:511–3.
2. Knowler WC, Pettitt DJ, Bennett PH, Williams RC. Diabetes mellitus in the Pima Indians: genetic and evolutionary considerations. Am J Phys Anthropol 1983;62:107–14.
3. Darby WJ, Salsbury CG, McGanity WJ, et al. A study of the dietary background and nutriture of the Navajo Indian. J Nutr 1956;60(suppl 2):1–86.
4. Sugarman JR, Hickey M, Hall T, Gohdes D. The changing epidemiology of diabetes mellitus among Navajo Indians. West J Med 1990;153:140–5.
5. Peck RE, Marks JS, Dibley MJ, Lee S, Trowbridge FL. Birth weight and subsequent growth among Navajo children. Public Health Rep 1987;102:500–7.
6. Heyward VH, Harris MB. Physical characteristics related to coronary heart disease risk factors: comparison of Hispanics and Navajo, Acoma and Laguna Indians in New Mexico. Am J Health Promot 1988;3:25–32.
7. Van Duzen J, Carter JP, Secondi J, Federspiel C. Protein and calorie malnutrition among preschool Navajo Indian children. Am J Clin Nutr 1969;22:1362–70.
8. Van Duzen J, Carter JP, Vander Zwagg R. Protein and calorie malnutrition among Navajo Indian children, a follow-up. Am J Clin Nutr 1976;29:657–62.
9. US Department of Health and Human Services. Indian Health Service chart series book. Rockville, MD: Indian Health Service, 1984.

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10. Broudy DW, May PA. Demographic and epidemiologic transition among the Navajo Indians. Soc Biol 1983;30:1–16.
11. Jordan MD. Anthropometric software package, tutorial guide and handbook. Version 3.0. Atlanta: Centers for Disease Control, 1986.
12. National Center for Health Statistics. Najjar MF, Rowland M. Anthropometric reference data and prevalence of overweight, United States, 1976–1980. Vital Health Stat [11] 1987;238. [DHHS publication (PHS)87-1688.]
13. Stuart HC, Meredith HV. Use of body measurements in the school health program. Part I. General considerations and the selection of measurements. Am J Public Health 1946;36:1365–86.
14. Armitage P, Berry G. Statistical methods in medical research. 2nd ed. Oxford: Blackwell Scientific Publications, 1987.
15. Trowbridge FL. Prevalence of growth stunting and obesity: pediatric nutrition surveillance system, 1982. CDC Surveillance Summaries 1983;32:23–6.
16. Owen GM, Garry PJ, Seymoure RD, Harrison GG, Acosta PB. Nutrition studies with White Mountain Apache preschool children in 1976 and 1969. Am J Clin Nutr 1981;34:266–77.
17. Woodbury R. Prehistory: introduction. In: Ortiz A, ed. Handbook of the North American Indians. Vol 9, Southwest. Washington, DC: Smithsonian Institution, 1979:22–30.
18. Story M, Tompkins RA, Bass MA, Wakefield LM. Anthropometric measurements and dietary intakes of Cherokee Indian teenagers in North Carolina. J Am Diet Assoc 1986;86:1555–60.
19. Gortmaker SL, Dietz WH, Sobol AM, Wehler CA. Increasing pediatric obesity in the United States. Am J Dis Child 1987;141:535–40.
20. Harlan WR, Landis JR, Flegal KM, Davis CS, Miller ME. Secular trends in body mass in the United States, 1960–1980. Am J Epidemiol 1988;128:1065–74.
21. Roche AF, Siervogel RM, Chumlea WC, Webb P. Grading body fatness from limited anthropometric data. Am J Clin Nutr 1981;34:2831–8.
22. Trowbridge FL. Body composition of Peruvian children with short stature and high weight-for-height. II Implications for the interpretation for weight-for-height as an indicator of nutritional status. Am J Clin Nutr 1987;46:411–8.
23. Koehler KM, Harris MB, Davis SM. Core, secondary, and peripheral foods in the diets of Hispanic, Navajo, and Jemez Indian children. J Am Diet Assoc 1989;89:538–40.
24. Harris MB, Koehler KM, Davis SM. Food intake in a multicultural southwestern population: I. General patterns. Ecol Food Nutr 1988;20:251–61.
25. General Accounting Office. Food assistance programs. Nutritional adequacy of primary food programs on four Indian reservations. Washington, DC: General Accounting Office, 1989. (GAO/RCED-89-177.)
26. Pettitt DJ, Baird R, Aleck KA, Bennett PH, Knowler WC. Excessive offspring of Pima Indian women with diabetes during pregnancy. N Engl J Med 1983;308:242–5.
27. Sugarman JR. Prevalence of gestational diabetes in a Navajo Indian Community. West J Med 1989;150:548–51.

APPENDIX

Heights and weights of Navajo Indian schoolchildren in 1968 versus 1989—numbers and proportions less than or exceeding selected Iowa percentiles*

	5 y		5.5 y		6 y		6.5 y		7 y	
Percentile	1968	1989	1968	1989	1968	1989	1968	1989	1968	1989
					%					
Height										
< 10	47 [26]	5 [1]	57 [42]	18 [9]	57 [40]	17 [10]	57 [51]	10 [7]	59 [13]	11 [8]
> 50	18 [10]	55 [12]	8 [6]	35 [18]	7 [5]	32 [19]	9 [8]	48 [32]	9 [2]	44 [32]
> 75	7 [4]	46 [10]	1 [1]	20 [10]	0 [0]	9 [5]	0 [0]	21 [14]	0 [0]	15 [11]
> 90	2 [1]	36 [8]	0 [0]	4 [2]	0 [0]	0 [0]	0 [0]	12 [8]	0 [0]	4 [3]
Weight										
< 10	31 [17]	5 [1]	39 [29]	10 [5]	24 [17]	3 [2]	29 [26]	6 [4]	32 [7]	11 [8]
> 50	22 [12]	68 [15]	14 [10]	41 [21]	20 [14]	34 [20]	17 [15]	45 [30]	36 [8]	46 [33]
> 75	11 [6]	41 [9]	50 [4]	26 [13]	9 [6]	19 [11]	7 [6]	27 [18]	9 [2]	22 [16]
> 90	9 [5]	18 [4]	0 [0]	10 [5]	4 [3]	5 [3]	3 [3]	13 [9]	0 [0]	11 [8]
Total *n*	55	22	74	51	70	59	89	67	22	72

	7.5 y		8 y		8.5 y		9 y		9.5 y	
	1968	1989	1968	1989	1968	1989	1968	1989	1968	1989
					%					
Height										
< 10	74 [14]	26 [12]	48 [26]	8 [4]	46 [31]	16 [8]	61 [19]	14 [6]	67 [6]	17 [17]
> 50	5 [1]	34 [16]	19 [10]	43 [22]	4 [3]	51 [25]	3 [1]	35 [15]	0 [0]	30 [30]
> 75	0 [0]	15 [7]	4 [2]	22 [11]	3 [2]	24 [12]	0 [0]	16 [7]	0 [0]	12 [12]
> 90	0 [0]	9 [4]	0 [0]	14 [7]	1 [1]	12 [6]	0 [0]	7 [3]	0 [0]	5 [5]
Weight										
< 10	42 [8]	19 [9]	28 [15]	10 [5]	13 [9]	18 [9]	42 [13]	19 [8]	22 [2]	8 [8]
> 50	5 [1]	38 [18]	22 [12]	49 [25]	18 [12]	53 [26]	13 [4]	47 [20]	11 [1]	55 [55]
> 75	5 [1]	17 [8]	6 [3]	33 [17]	9 [6]	39 [19]	0 [0]	30 [13]	0 [0]	40 [40]
> 90	0 [0]	11 [5]	0 [0]	22 [11]	4 [3]	20 [10]	0 [0]	16 [7]	0 [0]	23 [23]
Total *n*	19	47	54	51	67	49	31	43	9	100

* See text for details regarding reference population. *n* in brackets.

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