Obesity Among Navajo Adolescents

Relationship to Dietary Intake and Blood Pressure

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• We evaluated anthropometric measurements, blood pressures, dietary intakes, and self-perceived body image of 352 Navajo Indian adolescents. Thirty-three percent of the girls and 25% of the boys were obese according to a body mass index criterion. Navajo youth tended to have larger skinfolds than their white (National Health and Nutrition Examination Survey II) and Mexican American (Hispanic Health and Nutrition Examination Survey) counterparts, with the greater difference in the subscapular skinfolds indicating a greater amount of truncal rather than peripheral fat. When divided into lower, middle, and upper thirds of body mass index, systolic and diastolic blood pressures were positively related with increasing body mass index for girls, and systolic blood pressure and body mass index were related among boys. The high prevalence of obese adolescents and the apparent effect of the increased weight on blood pressure in this population indicate the need for interventions aimed at improving dietary habits and fitness levels.

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The increasing prevalence of chronic diseases among American Indians/Alaska Natives is a growing concern among health-care providers. In particular, increasing rates of obesity, diabetes and its complications, and heart disease are well documented among Navajo Indian adults.[1-4] Although little information is available on the contemporary diets of Navajo adults, it is believed that changes in life-style

See also p 285.

from a traditional diet and subsistence-related activities to a more westernized diet and decreased physical activity can account for much of the changes in disease patterns. In 1955, Darby et al[5] noted that the Navajo diet consisted chiefly of corn, wild game, mutton or goat meat, and a large variety of wild plants. Present-day Navajos have access to a variety of food sources on the reservation such as trading posts, convenience stores, fast-food restaurants, and supermarket chains. In addition, a recent US Government Accounting Office report indicated that 38% of the total reservation population participates in either the Food Stamp Program or the Food Distribution Program on Indian Reservations.[6]

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Notwithstanding rapid changes in life-style and socioeconomic status, little quantitative data are available regarding the antecedents of adult obesity among American Indians, especially concerning anthropometric status and dietary habits among adolescents. Recent studies of the physical growth and nutritional status of southwestern American Indian children indicate changes in the nutritional and anthropometric profiles of these children (Fern R. Hauck, MD, MPH, unpublished data, 1988). The prevalence of obesity among Navajo school children has been estimated to be twice that expected for the National Center for Health Statistics–Centers for Disease Control reference population.[7] The risks and health implications of obesity among adults are well documented[8]; however, no recent data exist for Navajo adolescents regarding the nutritional status, dietary habits and patterns, or health effects associated with being overweight and obese.

This school-based study was undertaken among a cross-sectional cohort of Navajo adolescents to: (1) assess the prevalence of obesity among adolescents using different anthropometric indexes; (2) describe body-weight self-perceptions, and to correlate these perceptions with actual body weight; (3) identify dietary patterns that may contribute to overnutrition; (4) determine what effect(s) being obese might have on blood pressure; and (5) establish baseline data with which to develop objectives and evaluate future interventions.

SUBJECTS AND METHODS

The Navajo Nation is the largest Indian reservation and the largest Indian population in the United States. The 65 000-km^2 reservation is located in northern Arizona, western New Mexico, and southern Utah. Based on the 1980 census, the Navajo population in 1989 is estimated to be 185 822. The median age of the Navajos for fiscal Year 1988 was 19.3 years compared with 30 years for the general population of the United States, with approximately 37% of the population being younger than 15 years.[9]

The Navajo Adolescent Dietary Assessment Project was conducted in the northeastern portion of the reservation in four different high schools (three public and one private, hereafter referred to as S1, S2, S3, and S4). Interviews of each participant were carried out on two randomly selected nonconsecutive days between October 1988 and January 1990. All anthropometric measurements were collected during the first interview, and a questionnaire and 24-hour dietary recall were administered. Questions were asked regarding self-perception of body weight and desire to lose or maintain weight, weight-loss practices, and use of vitamin or mineral supplements. During the second interview, blood pressure measurements were taken, and a second 24-hour dietary recall was administered. Interviews were arranged so that both a weekday and a weekend dietary recall could be obtained from each student, thus representing diet intakes while at school and at home.

Samples

The schools were selected to reflect the geographic and cultural diversity of Navajo adolescents, with S1 (the private school) being in an off-reservation community with an estimated 1988 population of 35 200. The second school (S2) lay just within the reservation boundaries, and schools S3 and S4 were 88 and 232 km deeper into the reservation, respectively. The total enrollment for the beginning of the study period for all four schools was approximately 1900, with at least a 95% enrollment of Indian students in each school. Two schools (S1 and S3) supplied detailed student rosters from which random samples were selected from grades 9 through 12. Schools S2 and S4 allowed sampling of entire classrooms from which subjects were selected based on differing grade levels, subjects being taught, and gender mix. Approval to carry out the study was obtained from the local school board.

Measurements

Skinfold measurements were obtained by one interviewer for girls and another for boys. The triceps skinfold (TSF) thickness was measured as a vertical fold over the belly of the triceps halfway between the acromion and olecranon processes. The subscapular skinfold (SSF) thickness was measured using a diagonal fold just under the lower angle of the scapula, halfway between the spine and the side of the body. All skinfold measurements were obtained on the right side of the body and recorded to the nearest 0.5 mm using Lange skinfold calipers (Cambridge [Md] Scientific Instruments Inc). The mean of three measurements for each area was used in these analyses. Height was measured without shoes to the nearest 0.1 cm using a portable stadiometer (Shorr Productions, Woonsocket, RI), with the child standing erect and his or her head in the Frankfort plane. Weight was measured without shoes and in light clothing to the nearest 0.1 kg using a digital scale (model 770, Seca Corp, Columbia, Md). Height and weight measurements and administration of the questionnaire and 24-hour dietary recalls were conducted by nutritionists, nurses, or trained health technicians following standardized written protocols. The 24-hour dietary recalls were obtained after interviewers received intensive training in interviewing and probing techniques for gathering dietary information from one of us (T.J.G.); standardized food models were used.

Blood Pressure

Two blood pressure measurements were obtained with the subject in a sitting position after a 10- to 15-minute rest with attention to cuff size, with the observer recording the first and fifth Korotkoff phases using a random-zero sphygmomanometer (Hawksley & Sons Limited, Sussex, England). If there was difficulty in obtaining one of the two blood pressure measurements for any reason, a third reading was taken. The mean blood pressure for each participant was used in the analyses. Mean diastolic and/or systolic blood pressure greater than the 90th percentile cutoff values developed by the Second Task Force on Blood Pressure Control in Children were defined as *high normal.*[10]

Analysis

Mean anthropometric and blood pressure measurements for each age and sex group were compared with those from the second National Health and Nutrition Examination Survey, white only (NHANES II, 1976-1980) and with those from the Mexican-American (MA) subset of the Hispanic Health and Nutrition Examination Survey (HHANES, 1982-1984). Median values for TSF and SSF were also compared with the above reference populations.[11] Body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, was computed for both sexes. A BMI exceeding the 85th percentile on the NHANES II was considered to be obese. Body mass index thirds were created for each sex based on cumulative percent distribution. Coincidentally, the upper third for boys and girls was approximately equivalent to the proportion of subjects who were obese based on the BMI criterion. Age-adjusted estimates of the prevalence of obesity among adolescents were obtained by direct standardization against the combined age distribution. The following weights were used for boys and girls respectively: .10 and .11 (14 years), .25 and .24 (15 years), .26 and .29 (16 years), .19 and .23 (17 years), and .19 and .13 (18 years). Analysis of variance was used to determine the association of body mass (BMI thirds) with blood pressure; fat distribution (SSF-TSF ratio thirds) with blood pressure; and with the exception of the nutrient variables noted below, differences in energy and nutrient intake among BMI thirds. The chronologic age at the time of the interview was used to label each age group in the Tables. Therefore, "14 years" refers to subjects aged 14.00 to 14.99 years.

Dietary data were coded by a nutritionist for entry in Nutritionist III, Version 5 (N-Squared Computing, Salem, Ore). Quantitative recipes were gathered from the schools as necessary and added to the nutrient database, as were the nutritive values of traditional foods.[12] To determine if the variables noted in Table 4 had underlying normal (Gaussian) distributions necessary for use of one-way analysis of variance, frequency distributions were plotted for all variables. In addition, a formal test of the validity of the normal model (with the same mean and variance as the sample) was conducted using the Kolmogorov-Smirnov test, using the Statistical Package for the Social Sciences (SPSS/PC+ V2.0, SPSS Inc, Chicago, Ill).[13] For boys, all variables except sodium and soda pop (in milliliters), and for girls, all variables except energy, fat, and soda pop had underlying normal distributions. For those variables not meeting the normal distribution assumption, the nonparametric Kruskal-Wallis test was used in place of the parametric one-way analysis of variance.[14]

RESULTS

Anthropometric Findings

A total of 373 students (55% girls and 45% boys) from all the schools participated, with fewer than 1% refusing participation. However, because too few subjects were in the 13- and 19-year or older age groups, anthropometric data are reported for subjects aged 14 to 18 years only (n = 352). Table 1 shows the age and sex distribution of the students, along with the mean (±SD) anthropometric measurements and systolic and diastolic blood pressures. The number and percentage of Navajo boys and girls for each age category with BMIs and TSF and SSF thicknesses greater than the 85th percentile cutoff values for NHANES II are shown in Table 2. The age-adjusted prevalence of obesity in boys and girls using BMI as the criterion was 25% and 33%, respectively; using TSF thickness as the criterion was 26% and 21%, respectively; and using SSF thickness as the criterion was 60% and 41%, respectively.

Figure 1 shows a comparison of the median TSF thicknesses of the Navajos with those of the MA and white subjects. The overall differences in median TSF values were greater between Navajo and white girls, with Navajo values 11% higher than those of their white counterparts. Median TSF values were 22% and 42% higher in Navajo boys than in MA and white boys, respectively. A comparison of the median SSF thickness values for Navajo boys and girls with those for MA and white subjects is shown in Fig 2. The differences in median SSF values between Navajo children and MA and white children are more pronounced for both sexes and in all age groups. Median SSF values for boys were 74% and 97% higher than those of their MA and white counterparts, respectively, and those for girls were 38% and 79% higher, respectively. Table 1 shows the SSF-TSF ratio by age and sex. The mean SSF-TSF ratio for boys (1.56±0.59) was significantly greater than that for girls (1.04±0.26) ($P<.001$).

Body Image

Among both sexes, 8.7% considered themselves to be *underweight*, 50% to be *just right*, and 41.3% to be *obese*. More girls than boys felt they were obese (50.5% vs 26.3%); however, the boys' weight perception was more

Table 2.—Mean (±SD) Anthropometric and Blood Pressure (BP) Measurements Among Navajo, Mexican-American (MA), and White Adolescents*

Age, y	No. of Subjects	Height, cm	Weight, kg	BMI	S/TSF, mm	S/TSF, mm	SSF-TSF Ratio	Systolic BP, mm/Hg	Diastolic BP, mm/Hg
Boys									
14									
Navajo	16	168.9±5.3	69.2±19.6	24.1±5.9	17.4±9.3	24.0±15.7	1.29±.44	111.9±16.5	62.1±15.0
MA	90	165.4±7.2	57.8±13.2	21.2±4.4	12.9±7.8	11.3±8.4	0.73±.97	109.7±10.7	65.6±11.1
White	124	167.5±8.6	56.8±12.3	20.2±3.2	11.1±6.3	9.4±6.4	0.76±.97	114.8±14.1	70.6±9.0
15									
Navajo	39	170.1±5.5	62.3±9.6	21.6±3.2	11.9±5.6	17.2±8.3	1.47±.53	111.5±11.2	65.8±7.5
MA	76	168.1±7.6	58.9±10.2	20.9±3.1	11.2±6.0	10.1±6.1	0.84±.99	110.7±10.8	67.3±8.6
White	129	170.9±7.0	60.2±11.1	20.7±3.0	10.9±7.9	10.2±8.7	0.91±1.0	115.8±14.0	70.3±9.8
16									
Navajo	40	171.3±5.0	69.8±13.4	23.7±4.0	13.8±6.3	22.5±13.4	1.59±.59	115.7±11.6	70.1±8.3
MA	70	170.0±6.5	63.6±12.5	22.1±3.9	11.7±6.8	11.9±7.4	1.09±1.0	112.2±13.0	68.9±8.3
White	133	173.7±6.8	65.5±11.4	21.8±3.0	10.7±6.6	10.5±6.7	1.10±1.0	120.2±15.4	74.4±10.8
17									
Navajo	30	170.6±4.9	68.8±13.8	23.6±4.4	12.9±6.4	20.1±9.2	1.58±.47	115.4±10.1	67.9±8.7
MA	66	170.7±7.1	63.3±10.6	21.9±3.5	10.8±6.1	12.1±7.2	1.42±.98	114.0±9.4	69.2±8.9
White	119	175.2±6.7	65.9±11.1	21.6±3.0	9.0±5.3	10.1±5.4	1.50±.91	117.8±14.1	72.4±9.6
18									
Navajo	30	170.5±6.0	65.3±13.8	22.3±3.8	11.8±6.0	17.4±7.9	1.53±.48	115.1±10.5	69.7±10.0
MA	67	170.1±6.2	66.5±11.2	23.2±3.8	11.6±6.2	13.6±8.1	1.34±1.0	113.0±11.0	67.1±9.3
White	106	177.6±6.7	69.9±12.0	22.3±3.3	10.8±6.3	11.3±6.3	1.32±.95	121.2±14.5	74.8±9.8
Girls									
14									
Navajo	21	158.8±5.5	58.2±10.9	23.1±4.4	19.7±6.2	17.6±6.1	0.85±.17	105.9±11.1	66.9±9.4
MA	80	156.9±5.4	53.6±9.6	21.9±3.5	19.2±7.0	15.2±7.5	0.35±.76	105.0±9.8	66.0±8.7
White	115	161.8±5.6	54.6±10.0	21.0±3.9	17.7±7.8	12.6±7.6	0.22±.64	108.6±13.3	69.9±9.5
15									
Navajo	48	160.4±6.1	62.8±14.5	24.3±5.4	21.2±7.8	23.3±10.2	1.03±.19	105.7±10.2	63.2±7.4
MA	84	160.4±5.6	56.6±10.4	22.1±3.7	19.7±7.1	17.2±8.1	0.64±.94	106.5±10.9	66.1±8.4
White	93	163.6±6.3	54.9±9.3	20.6±2.9	17.6±6.8	12.9±7.3	0.19±.59	111.2±11.5	70.4±8.6
16									
Navajo	57	159.4±5.0	61.3±11.5	24.2±4.4	20.9±6.2	22.8±7.9	1.06±.27	106.4±11.5	64.5±10.0
MA	94	157.7±7.0	57.0±15.0	22.9±5.2	20.2±8.7	17.5±11.2	0.51±.88	106.8±9.2	67.0±9.9
White	119	162.8±6.7	57.1±9.3	21.7±3.1	19.6±6.8	14.4±8.2	0.24±.65	109.8±12.7	69.2±9.4
17									
Navajo	45	161.4±5.1	61.5±10.3	23.6±3.6	20.5±6.1	21.9±8.5	1.02±.27	105.2±8.1	62.8±7.8
MA	70	159.1±5.8	56.3±10.1	22.4±3.7	19.8±6.9	18.5±8.9	0.77±.98	105.3±11.1	65.7±9.3
White	96	163.5±6.0	58.6±10.7	22.0±3.6	20.3±8.0	15.6±9.3	0.38±.78	114.8±12.4	73.7±9.6
18									
Navajo	26	158.8±5.4	64.6±19.7	25.6±7.2	21.9±8.5	26.2±11.5	1.16±.28	105.1±9.5	61.1±9.0
MA	81	158.0±5.7	57.7±9.6	23.3±3.5	21.3±7.1	19.0±8.3	0.64±.94	105.2±9.3	65.5±8.0
White	109	162.8±7.1	58.5±11.2	22.2±3.7	20.1±7.6	14.8±8.5	0.33±.75	109.6±12.4	70.0±9.4

*Data for MA and white children are from Hispanic Health and Nutrition Examination Survey and National Health and Nutrition Examination Survey II, respectively (personal communication, Tim Byers, MD, MPH, March 1991). Body mass index (BMI) is calculated as weight in kilograms divided by height in meters squared. The ratio of subscapular skinfold thickness to triceps skinfold thickness (SSF-TSF ratio) was calculated as mean subscapular skinfold(s) divided by triceps skinfold for each age and sex group.

accurate when actual BMIs were compared with the 85th percentiles for NHANES II ($\chi^2=43.8$ and 34.8 for girls and boys, respectively; $P<.01$). Twenty-four percent of the girls perceived themselves to be obese when, in fact, their BMIs were between the 15th and 85th percentiles for NHANES II; 9% of the boys were in this category.

Dietary Intake

The mean (±SD) energy and selected nutrient intake, mean percentage of recommended daily allowances, and percentage that consumed less than two thirds the 1989 recommended daily allowance[15] for boys and girls are shown in Table 3. Mean energy intake was significantly greater in boys than in girls ($P<.001$). No significant differences in dietary intake were noted between age groups for either sex. Mean intake of energy and selected nutrients among BMI thirds for each sex is shown in Table 4. For girls, there were no significant differences in any of the selected nutrients among the thirds, although energy and sodium intakes approached significance ($P=.06$ and $P=.05$, respectively). For boys, differences were observed for energy and sodium intakes ($P<.05$). No difference was found for the use of vitamin or mineral supplements between sexes (21% for boys and 18% for girls).

Regular-sweetened soda pop was the most commonly reported food or drink for both sexes. Of the entire sample, 86% of girls and 93% of boys reported drinking soda pop at least once during the two 24-hour periods covered by the dietary recalls, with 32% of all subjects drinking at least 720 mL per day. The mean intakes of regularly sweetened soda pop

Age, y	BMI Boys	BMI Girls	No. (%) of Subjects M	No. (%) of Subjects F	TSF M	TSF F	No. (%) of Subjects M	No. (%) of Subjects F	SSF M	SSF F	No. (%) of Subjects M	No. (%) of Subjects F
14	23.1	24.5	7 (44)	4 (19)	15.0	25.0	7 (44)	3 (14)	12.0	22.0	9 (56)	3 (14)
15	23.0	22.6	9 (23)	22 (45)	14.5	24.5	9 (23)	15 (31)	12.0	20.5	28 (70)	26 (53)
16	25.4	25.4	11 (28)	19 (34)	18.5	27.0	7 (18)	9 (16)	14.5	23.5	24 (60)	25 (45)
17	24.6	25.1	8 (27)	12 (27)	12.5	26.5	14 (47)	9 (20)	14.0	27.0	19 (63)	13 (29)
18	26.0	25.5	4 (13)	7 (28)	17.5	27.0	4 (13)	6 (23)	16.0	22.0	11 (37)	14 (54)
Age-adjusted averages, %	...	...	25	33	...	...	26	21	...	...	60	41

Table 2.—Navajo Adolescents With Body Mass Index (BMI), Triceps Skinfold (TSF), and Subscapular Skinfold (SSF) Greater Than the 85th Percentile*

*Eighty-fifth percentile cutoff values are based on unweighted National Health And Nutrition Examination Survey II reference data (personal communication, Tim Byers, MD, MPH, March 1991).

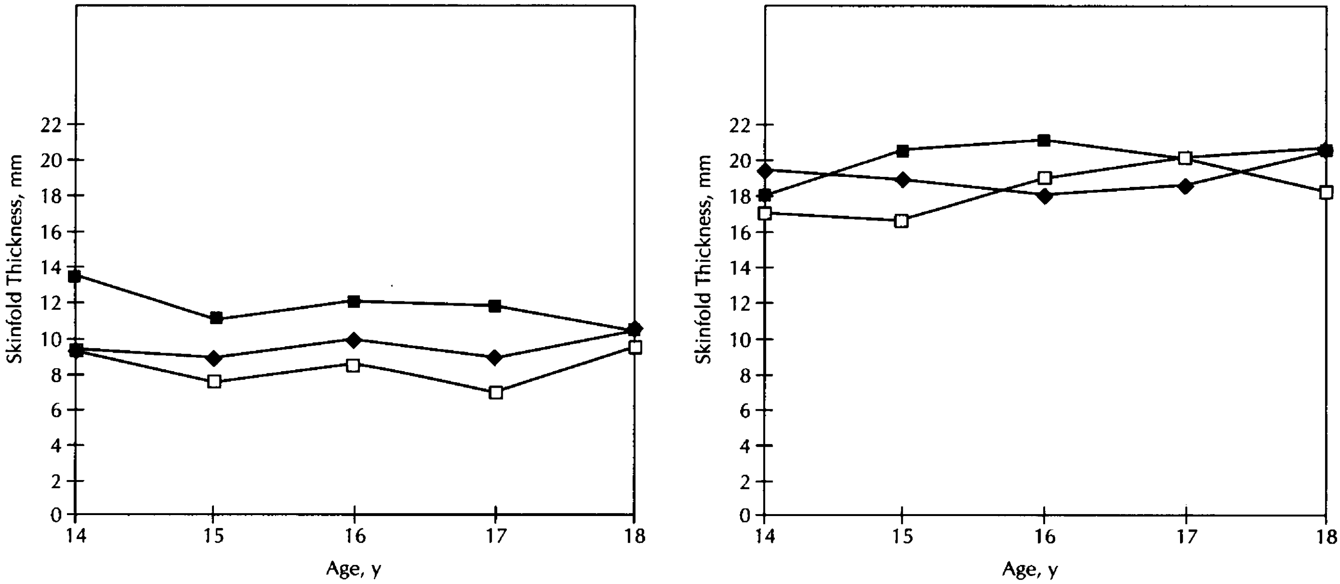

Fig 1.—*Median triceps skinfold thickness among Navajo (closed squares), Mexican American (diamonds), and white (open squares) boys (left) and girls (right). Median skinfold values for Mexican Americans and whites are from Ryan et al.*[11]

for Navajo adolescent pop drinkers were greater for both sexes than those of other American adolescents (621 and 510 mL for Navajo boys and girls, respectively, compared with 361 and 215 mL for other American boys and girls, respectively) (Susan Krebs-Smith, PhD, RD, personal communication, December 1990). No difference was found in the mean percentage of energy from regular pop between boys (10.9% of kilojoules; range, 2% to 36%) and girls (11.2% of kilojoules; range, 1% to 41%). Diet soda accounted for less than 2% of the total soda pop consumed in the present study compared with 7% for other American adolescent males and 23% for other American adolescent females.

Blood Pressure

Mean systolic and diastolic blood pressure values by age and sex are shown in Table 1. Both systolic and diastolic blood pressure values were significantly higher in boys (114 and 68 mm/Hg, respectively) than in girls (106 and 63 mm/Hg, respectively). Among all subjects, 10.4% of boys and 6% of girls had a mean diastolic and/or systolic blood pressure that would be considered high normal (higher than the 90th percentile). Among those identified as having high normal blood pressure, 36% of the boys and 64% of the girls were obese based on the BMI criterion. Mean blood pressures by BMI thirds are shown in Table 4. For boys, systolic blood pressure increased with increasing BMI ($F=9.0$; $P<.0001$). Among girls, both systolic and diastolic blood pressure values increased with increasing BMI ($F=10.3$ and $F=7.9$, respectively; $P<.001$). When mean blood pressures were analyzed by thirds of SSF-TSF ratio for each sex, only systolic blood pressure for Navajo boys increased significantly ($P=.008$).

COMMENT

We found that a high proportion of Navajo adolescents were overweight, regardless of whether BMI or TSF or SSF criteria were used. The use of BMI to screen for obesity is common because of its high correlation with total body fat ($r=.88$ for boys and .89 for girls). In addition, SSF thicknesses among children correlate well with percentage of body fat.[16] These data strongly indicate that the number of obese children (about twice that expected of the National Center for Health Statistics–Centers for Disease Control reference population) and the percentage of body fat are high among Navajo adolescents of both sexes.

The risk of subsequent disease associated with obesity ap-

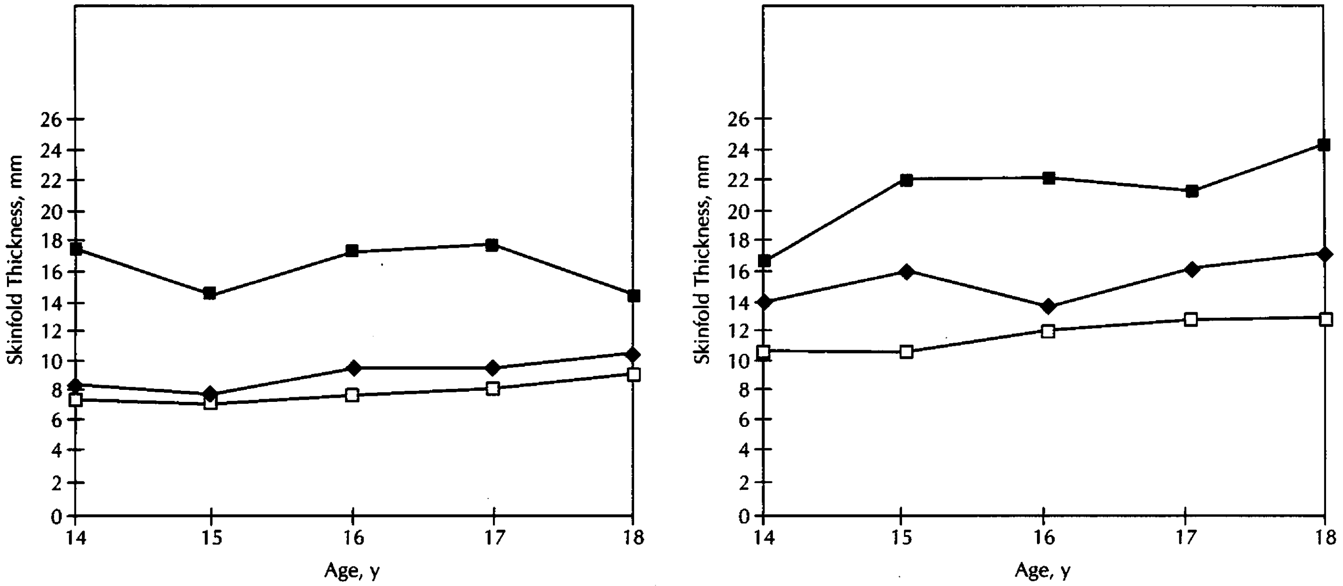

Fig 2.—*Median subscapular skinfold thickness among Navajo (closed squares), Mexican American (diamonds), and white (open squares) boys (left) and girls (right). Median skinfold values for Mexican Americans and whites are from Ryan et al.*[11]

Table 3.—Intake of Nutrients, Percentage of 1989 Recommended Dietary Allowances (RDA), and Percentage Consuming Less Than Two Thirds the RDA for Navajo Adolescents

	Boys			Girls		
Nutrient	Mean (±SD) Daily Intake	Mean % RDA	Cumulative % <Two Thirds of RDA	Mean (±SD) Daily Intake	Mean % RDA	Cumulative % <Two Thirds of RDA
Energy, kJ	10508±3318	. . .	. . .	8203±3481	. . .	. . .
Protein, g	92±34	162	1	66±27	148	5
Fat, g	93±34	. . .	. . .	71±35	. . .	. . .
Carbohydrate, g	333±116	. . .	. . .	269±120	. . .	. . .
Fiber, g	4.5±2.6	. . .	. . .	3.7±2	. . .	. . .
Cholesterol, mg	340±204	. . .	. . .	222±140	. . .	. . .
Sodium, mg	3309±1496	. . .	. . .	2431±1906	. . .	. . .
Vitamin A, IU	6814±7378	205	4	4518±4174	171	3
Vitamin C, mg	174±132	299	6	140±112	238	9
Thiamin, mg	1.9±.9	127	9	1.3±.7	119	20
Riboflavin, mg	2.2±1.1	125	8	1.5±.6	115	14
Niacin, mg	23.2±10.5	119	10	15.7±6.7	105	19
Folacin, μg	318±202	165	9	240±137	136	22
Calcium, mg	1018±555	86	41	720±354	61	63
Iron, mg	15.6±8	133	7	11.6±5	78	43
Zinc, mg	11.8±5	80	39	8.4±4	70	52

pears to be higher for centralized than for peripheral fat distribution in adults.[17,18] After examining data from the third cycle of the Health Examination Survey (1966-1970), Sangi and Mueller[19] suggested that a skinfold index of centrality may be more associated with cardiovascular risk factors, including blood pressure, than the waist-hip ratio in adolescents. The high SSF-TSF ratios suggest that the central fat distribution evident among Navajo adults[20] is discernible in the present cohort of adolescents. Studies among southwestern MA adolescents also indicate a greater degree of truncal obesity and differences in fat patterning than in the National Center for Health Statistics–Centers for Disease Control reference population.[21,22] The extent to which adolescent central fat distribution is associated with adult central fat distribution in Navajos, however, is unknown.

This study showed a positive relationship between body mass and blood pressure in Navajo adolescents. Coulehan et al[23] recently reported elevated blood pressures in 11.1% of males and 1.6% of females in a cohort of Navajo adolescents surveyed nearly 10 years ago. In that study, mean systolic blood pressures for both sexes were approximately 7% higher than those reported here, and diastolic blood pressures were 3% and 6.5% higher for boys and girls, respectively. However, the mean weights for both

Table 4.—Mean Body Mass Index (BMI), Nutrient Variables, and Blood Pressure by BMI Thirds for Navajo Adolescents*

	Boys				Girls			
	Lower	Middle	Upper	F (3,136)	Lower	Middle	Upper	F (3,180)
Mean BMI	19.3	21.9	27.9	. . .	19.8	23.2	29.1	. . .
Energy, kj	10941	11193	9551	3.5†	8715	8543	7346	4.9‡
Fat, g	94	96	89	0.57	74	75	64	3.4‡
Sodium, mg	3605	3462	2901	3.1†	2648	2358	2250	3.0
Calcium, mg	1085	1157	833	4.7§	725	731	710	0.06
% kj/protein	15	14	15	0.23	13	14	14	0.65
% kj/carbohydrate	53	53	51	1.9	56	54	54	0.32
% kj/fat	32	32	34	2.6	31	32	32	0.34
Pop drinkers, %	96	91	92	. . .	91	84	84	. . .
Soda pop, mL	615	657	600	1.06‡	555	525	444	4.76‡
Systolic BP, mm/Hg	109.0	115.3	118.3	9.1‖	101.8	105.3	109.7	10.3§
Diastolic BP, mm/Hg	65.0	68.5	69.2	2.7	60.5	63.1	66.6	7.9§
SSF-TSF ratio	1.36	1.66	1.79	8.6§	1.04	1.07	1.15	2.8

*For boys, differences in systolic blood pressure (BP) were found between the lower and middle thirds ($P = .004$), and the lower and upper thirds ($P = .0004$). For girls, differences in systolic BP existed between the lower and middle thirds ($P = .042$), and middle and upper thirds ($P = .032$). Differences in diastolic BP were also noted between middle and upper ($P = .024$) and lower and upper ($P = .0002$) for girls.

†$P < .05$.

‡Kruskal-Wallis one-way analysis of variance (nonparametric.)

§$P < .01$.

‖$P < .001$.

sexes and in each age group were greater in the present study; sampling frames may account for these discrepancies. While it is possible that increased TSF thickness had an effect on blood pressure levels in the present study, it was likely minimized with the use of a proper size cuff. In addition, mean TSF values in the Navajos were similar to those in their white NHANES II counterparts, while both mean systolic and diastolic values were lower among Navajos of both sexes in all age groups.

Similarities in total energy intake in boys and girls were observed between Navajo and North Carolina Cherokee adolescents[24] and 12- to 15-year-old non-Indian American adolescents participating in NHANES II.[25] However, no significant differences were found in energy intakes between "fat" and "lean" Cherokee adolescents. In the present study, an inverse relationship was found between BMI and energy intake, with the heavier adolescents (upper thirds) reporting lower intakes than their "leaner" counterparts. The variances in energy intake among the thirds were also found to be homogeneous for both boys and girls, indicating that energy intake was not more variable among the heavier adolescents. The cross-sectional nature of this study does not lend itself to cause-effect associations such as obesity caused by overeating. Furthermore, it has been argued that reported energy intake in obese and nonobese adolescents is not representative of energy expenditure or energy requirements and that such data should not be used to assess the role of energy intake in the development of obesity.[26] However, to the extent that current dietary habits and patterns were present during the development of increased weight, close examination of current dietary practices should be helpful at the time of intervention. It is also noteworthy that obese subjects in the present study may be able to maintain a heavier weight with a lower energy intake.

The high consumption of regular sweetened soda pop is a concern for a population with increasing rates of obesity and related chronic diseases. Although no significant differences were noted in the percentage of pop drinkers or mean intake of regular sweetened sodas between schools, the most isolated school (S4) reported the greatest proportion and highest mean intake (95.5% and 609 mL, respectively), while those from the least isolated school (S1) reported the least proportion and lowest mean intake (78.8% and 525 mL, respectively). Lactose intolerance, a condition observed among adult members of other southwest minority groups,[27,28] may, in part, account for Navajos choosing other beverages over milk. Tordoff and Alleva[29] showed that drinking high-fructose, corn syrup–sweetened soda pop significantly increased the energy intake and body weight of both boys and girls, while drinking soda sweetened with aspartame reduced caloric intake and decreased the body weight of boys. Guentther[30] found seasonal variation in beverage consumption among non-Indian American adolescents, with milk being consumed less frequently in the summer months and soft drinks consumed more frequently, and suggested an inverse relationship between milk and soft-drink intake. Since the data from the present study were obtained in the autumn, winter, and spring months, the average intake of soda pop is most likely underestimated.

There are limitations to the present study. First, since interviews were conducted at school during class, the data are representative of nutritional status and dietary patterns during the school year only. The logistics and distances associated with home visits made a school-based study the most practical. Dietz and Gortmaker[31] have suggested that the physical environment can account for as much as a twofold to threefold variation on the prevalence of obesity. The effect of both season and region (ie, portion of the reservation), may indeed affect the estimates for higher weight and obesity prevalence in this population. We attempted to reduce the effect of season by spreading the interviews out from the autumn to spring months (beginning to end of two school years); however, the summer months cannot be accounted for by the present study. The effect of region was in part accounted for by the selection of schools based on their location relative to one another and within the reservation.

A second limitation related to the school-based design of the study was the difficulty of obtaining information on sexual maturation or secondary sex characteristics. In studying a sample of biracial girls, Kozinetz[32] showed that early maturers could be at a higher risk for hypertension and that the stage of sexual maturation should be assessed at the time of blood pressure measurement. It is possible that the stage of sexual maturation may have had an effect on both the amount of subcutaneous fat deposits and blood pressure levels in the present study.

A third limitation is the lack of information on physical fitness or activity levels. Because time was an important consideration during assessment tool development and pretesting, determination of fitness through standardized tests was not possible. Current information indicates that lack of physical activity or energy expenditure and the amount of television viewing may be important contributors to the development of obesity,[33,34] both of which may be significant factors in the development of increased weight and obesity among Navajo youth.

In past decades the diets of Navajo youth were frequently inadequate in energy and nutrients. In 1969, Van Duzen et al[35] reported 616 cases of Navajo children younger than 5 years with diagnoses of malnutrition from the period 1963 to 1967. A later report showed significant improvements with declines in the reporting of marasmus and kwashiorkor, and reductions in the number of patients with deficits in weight-for-age.[36] Within the last 25 years, the availability and variety of foods have increased in communities across the reservation. This, combined with a probable decrease in physical activity, may account for the increase in weight and obesity. Currently, funding has been obtained to focus on the prevention of obesity among Navajo youth with an emphasis on behavior and life-style changes.

The opinions expressed in this article are those of the authors and do not necessarily reflect the views of the Indian Health Service.

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References

1. Sugarman JR, Percy CP. Prevalence of diabetes in a Navajo community. *Am J Public Health.* 1989;79:511-513.
2. Sugarman JR, Hickey M, Hall T, Gohdes D. The changing epidemiology of diabetes mellitus among Navajo Indians. *West J Med.* 1990;153:140-145.
3. Sugarman JR. Prevalence of diagnosed hypertension among diabetic Navajo Indians. *Arch Intern Med.* 1990;150:359-362.
4. Klain M, Coulehan JL, Arena VC, Janett R. More frequent diagnosis of acute myocardial infarction among Navajo Indians. *Am J Public Health.* 1988;78:1351-1352.
5. Darby WJ, Salsbury CG, McGainity WJ, et al. A study of the dietary background and nutriture of the Navajo Indian. *J Nutr.* 1956;60(suppl):1-86.
6. General Accounting Office. *Food Assistance Programs: Nutritional Adequacy of Primary Food Programs on Four Indian Reservations.* Washington, DC: General Accounting Office; 1989. Publication GAO/RCED-89-177.
7. Sugarman JR, White L, Gilbert TJ. Evidence for a secular change in obesity, height and weight among Navajo Indian schoolchildren. *Am J Clin Nutr.* 1990;52:960-966.
8. Van Itallie TB. Health implications of overweight and obesity in the United States. *Ann Intern Med.* 1985;103:983.
9. Office of Program Planning and Development. *Navajo Area Indian Health Service Area Profile, Fiscal Year 1989.* Window Rock, Ariz: Navajo Area Indian Health Service; 1989.
10. Task Force on Blood Pressure Control in Children. Report of the Second Task Force on Blood Pressure Control in Children-1987. *Pediatrics.* 1987;79:1-25.
11. Ryan AS, Martinez GA, Baumgartner RN, et al. Median skinfold thickness distributions and fat-wave patterns in Mexican-American children from the Hispanic Health and Nutrition Examination Survey (HHANES 1982-1984). *Am J Clin Nutr.* 1990;51(suppl):925-935.
12. Wolfe WS, Weber CW, Arviso KD. Use and nutrient composition of traditional Navajo foods. *Ecol Food Nutr.* 1985;17:323-344.
13. Statistical Package for the Social Sciences. *SPSS/PC+ V2.0 Base Manual.* Chicago, Ill: SPSS Inc; 1988.
14. Emrich LJ, Dennison D, Dennison KF. Distributional shape of nutrition data. *J Am Diet Assoc.* 1989;89:665-670.
15. Food and Nutrition Board. *Recommended Dietary Allowances.* 10th ed. Washington, DC: National Academy Press; 1989.
16. Roche AF, Siervogel RM, Chumlea WC, Webb P. Grading body fatness from limited anthropometric data. *Am J Clin Nutr.* 1981;34:2831-2838.
17. Haffner SM, Stern MP, Hazuda HP, Rosenthal MR, Knapp JA, Malina RM. Role of obesity and fat distribution in non-insulin dependent diabetes mellitus in Mexican American and non-Hispanic whites. *Diabetes Care.* 1986;9:153-160.
18. Selby JV, Friedman GD, Quensenberry CP. Precursors of essential hypertension: the role of body fat distribution. *Am J Epidemiol.* 1989;129:43-53.
19. Sangi H, Mueller W. Which measure of body fat distribution is best for epidemiologic research among adolescents? *Am J Epidemiol.* 1991;133:870-883.
20. Hall TR, Hickey ME, Young TB. The relationship of body fat distribution to non-insulin dependent diabetes in a Navajo community. *Am J Hum Biol.* 1991;3:119-126.
21. Baumgartner RN, Roche AF, Guo S, Chumlea WC, Ryan AS. Fat patterning and centralized obesity in Mexican American children in the Hispanic Health and Nutrition Examination Survey (HHANES 1982-1984). *Am J Clin Nutr.* 1990;51(suppl):936-943.
22. Mueller WH, Joos SK, Hanis CL, Zavaleta AN, Eichner J, Schull WJ. The diabetes alert study: growth, fatness, and fat patterning, adolescence through adulthood in Mexican Americans. *Am J Phys Anthropol.* 1984;64:389-399.
23. Coulehan JL, Topper MD, Arena VC, Welty TK. Determinants of blood pressure in Navajo adolescents. *Am Ind Alaska Native Mental Health Res.* 1990;3:27-36.
24. 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;86:1555-1560.
25. Life Sciences Research Office, Federation of American Societies for Experimental Biology. *Nutrition Monitoring in the United States: An Update Report on Nutrition Monitoring.* Washington, DC: US Dept of Health and Human Services publication PHS 89-1255, 1989.
26. Bandani LG, Schoeller DA, Cyr HN, Dietz WH. Validity of reported energy intake in obese and nonobese adolescents. *Am J Clin Nutr.* 1990;52:421-425.
27. Johnson JD, Simoons FJ, Hurwitz R, et al. Lactose malabsorption among the Pima Indians of Arizona. *Gastroenterology.* 1977;73:1299-1304.
28. Woteki CE, Weser E, Young EA. Lactose malabsorption in Mexican-American adults. *Am J Clin Nutr.* 1977;30:470-475.
29. Tordoff MG, Alleva AM. Effect of drinking soda sweetened with aspartame or high-fructose corn syrup on food intake and body weight. *Am J Clin Nutr.* 1990;51:963-969.
30. Guentther PM. Beverages in the diets of American teenagers. *J Am Diet Assoc.* 1986;86:493-499.
31. Dietz WH, Gortmaker SL. Factors within the physical environment associated with childhood obesity. *Am J Clin Nutr.* 1984;39:619-624.
32. Kozinetz CA. Sexual maturation and blood pressure levels of a biracial sample of girls. *AJDC.* 1991;145:142-147.
33. Ravussin E, Lillioja S, Knowler WC, et al. Reduced rate of energy expenditures as a risk factor for body-weight gain. *N Engl J Med.* 1988;318:467-472.
34. Dietz WH, Gortmaker SL. Do we fatten our children at the television set? obesity and television viewing in children and adolescents. *Pediatrics.* 1985;75:807-812.
35. Van Duzen J, Carter JP, Secondi J, Federspiel C. Protein and calorie malnutrition among preschool Navajo Indian children. *Am J Clin Nutr.* 1969;22:1362-1370.
36. Van Duzen J, Carter P, Vander Zwagg R. Protein and calorie malnutrition among preschool Navajo Indian children: a follow-up. *Am J Clin Nutr.* 1976;29:657-662.